ISSN 1301-0336 • E-ISSN 2147-5903

turkishspine

JOURNAL OF TURKISH SPINAL SURGERY

JANUARY
2020
VOLUME: 31
ISSUE: 1

galenos yayınevi
www.jtss.org

JOURNAL OF TURKISH SPINAL SURGERY

Journal of Turkish Spinal Surgery

galenos yayınevi

Galenos Publishing House
Owner and Publisher
Derya Mor
Erkan Mor

Publication Coordinator
Burak Sever

Web Coordinators
Fuat Hocalar
Turgay Akpınar

Graphics Department
Ayda Alaca
Çiğdem Birinci
Gülşah Özgül

Finance Coordinator
Sevinç Çakmak

Project Coordinators
Gamze Aksoy
Hatice Sever
Melike Eren
Saliha Tuğçe Evin
Duygu Yıldırm

Project Assistants
Pınar Akpınar

Research&Development
Mevlüde Özlem Akgüney
Mert Can Köse

Publisher Contact
Address: Molla Gürani Mah. Kaçamak Sk. No: 21/1
34093 İstanbul, Turkey
Phone: +90 (212) 621 99 25 **Fax:** +90 (212) 621 99 27
E-mail: info@galenos.com.tr/yayin@galenos.com.tr
Web: www.galenos.com.tr | Publisher Certificate Number: 14521

Printing Date: January 2020
ISSN 1301-0336 • E-ISSN 2147-5903
International scientific journal published quarterly.

JOURNAL OF TURKISH SPINAL SURGERY

JOURNAL OF TURKISH SPINAL SURGERY

JOURNAL OF TURKISH SPINAL SURGERY

JOURNAL OF TURKISH SPINAL SURGERY

About Us

Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Surgery Society. First journal was printed on January, in 1990. It is a double-blind peer-reviewed multidisciplinary journal for the physicians who deal with spinal diseases and publishes original studies which offer significant contributions to the development of the spinal knowledge. The journal publis¬hes original scientific research articles, invited reviews and case reports that are accepted by the Editorial Board, in English.

The journal is published once in every three months and a volume consists of four issues. Journal of Turkish Spinal Surgery is published four times a year: on January, April, July, and October.

The Turkish Spinal Surgery Society was established in 1989 in Izmir (Turkey) by the pioneering efforts of Prof. Dr. Emin Alıcı and other a few members. The objectives of the society were to: - establish a platform for exchange of information/ experience between Orthopedics and Traumatology Specialists and Neurosurgeons who deal with spinal surgery - increase the number of physicians involved in spinal surgery and to establish spinal surgery as a sophisticated medical discipline in Turkey - follow the advances in the field of spinal surgery and to communicate this information to members - organize international and national congresses, symposia and workshops to improve education in the field - establish standardization in training on spinal surgery - encourage scientific research on spinal surgery and publish journals and books on this field - improve the standards of spinal surgery nationally, and therefore make contributions to spinal surgery internationally.

The main objective of the Journal is to improve the level of knowledge and experience among Turkish medical society in general and among those involved with spinal surgery in particular. Also, the Journal aims at communicating the advances in the field, scientific congresses and meetings, new journals and books to its subscribers. Journal of Turkish Spinal Surgery is as old as the Turkish Spinal Surgery Society.

The first congress organized by the Society took place in Çeşme, Izmir, coincident with the publication of the first four issues. Authors were encouraged by the Society to prepare original articles from the studies presented in international congresses organized by the Society every two years, and these articles were published in the Journal. The Journal publishes clinical or basic research, invited reviews, and case presentations after approval by the Editorial Board. Articles are published after at least two reviewers review them. Editorial Board has the right to accept, to ask for revision, or to refuse manuscripts.

The Journal is issued every three months, and one volume is completed with every four issue. Associate Editors and Editor in Chief are responsible in reviewing and approving material that is published. Responsibility for the problems associated with research ethics or medico-legal issues regarding the content, information and conclusions of the articles lies with the authors, and the editor or the editorial board bears no responsibility. In line with the increasing expectations of scientific communities and the society, improved awareness about research ethics and medico-legal responsibilities forms the basis of our publication policy.

Citations must always be referenced in articles published in our journal. Our journal fully respects to the patient rights, and therefore care is exercised in completion of patient consent forms; no information about the identity of the patient is disclosed; and photographs are published with eye-bands. Ethics committee approval is a prerequisite. Any financial support must clearly be disclosed. Also, our Journal requests from the authors that sponsors do not interfere in the evaluation, selection, or editing of individual articles, and that part or whole of the article cannot be published elsewhere without written permission.

Journal of Turkish Spinal Surgery is available to the members of the society and subscribers free of charge. Membership fees, congresses, and the advertisements appearing in the journal meet the publication and distribution costs.

The advertisement fees are based on actual pricing. The Editorial Board has the right for signing contracts with one or more financial organizations for sponsorship. However, sponsors cannot interfere in the scientific content and design of the journal, and in selection, publication order, or editing of individual articles.

Journal of Turkish Spinal Surgery agrees to comply with the "Global Compact" initiative of the UN, and this has been notified to the UN. Therefore, VI our journal has a full respect to human rights in general, and patient rights in particular, in addition to animal rights in experiments; and these principles are an integral part of our publication policy.

Recent advances in clinical research necessitate more sophisticated statistical methods, well-designed research plans, and more refined reporting. Scientific articles, as in other types of articles, represent not only an accomplishment, but also a creative process.

The quality of a report depends on the quality of the design and management of the research. Well-designed questions

or hypotheses are associated with the design. Well-designed hypotheses reflect the design, and the design reflects the hypothesis. Two factors that determine the efficiency of a report are focus and shortness. Drawing the attention to limited number of subjects allows the author to focus on critical issues. Avoidance from repetitions (apart from a few exceptions), a simple language, and correct grammar are a key to preparing a concise text. Only few articles need to exceed 3000 words, and longer articles may be accepted when new methods are being reported or literature is being reviewed.

Although authors should avoid complexity, the critical information for effective communication usually means the repetition of questions (or hypotheses or key subjects). Questions must be stated in Abstract, Introduction and Discussion sections, and the answers should be mentioned in Abstract, Results, and Discussion sections. Although many journals issue written instructions for the formatting of articles, the style of the authors shows some variance, mainly due to their writing habits.

Journal of Turkish Spinal Surgery adopts the AMA style as a general instruction for formatting. However, not many authors have adequate time for learning this style. Thus, our journal is tolerant to personal style within the limitations of correct grammar and plain and efficient communication.

JOURNAL OF TURKISH SPINAL SURGERY

Instructions to Authors

Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Society. It is a double-blind peer-reviewed multidisciplinary journal for the physicians who deal with spinal diseases and publishes original studies which offer significant contributions to the development of the spinal knowledge. The journal publishes original scientific research articles, invited reviews and case reports that are accepted by the Editorial Board, in English.

The journal is published once in every three months and a volume consists of four issues.

Journal of Turkish Spinal Surgery is published four times a year: on January, April, July, and October.

PEER REVIEW

Article is reviewed by secretaries of the journal after it is uploaded to the web site. Article type, presence of the all sections, suitability according to the number of words, name of the authors with their institutions, corresponding address, mail addresses, telephone numbers and ORCID numbers are all evaluated and shortcomings are reported to the editor. Editor request the all defect from the authors and send to vice editors and native English speaker editor after completion of the article. Vice editors edit the blinded article and this blinded copy is sent to two referees. After reviewing of the article by the referees in maximum one month, the review report evaluating all section and his decision is requested, and this blinded report is sent to the author. In fifteen days, revision of the article is requested from the authors with the appreciate explanation. Revised blinded copy is sent to the referees for the new evaluation. Editor if needed may sent the manuscript to a third referee. Editorial Board has the right to accept, revise or reject a manuscript.

-Following types of manuscripts related to the field of "Spinal Surgery" with English Abstract and Keywords are accepted for publication: I- Original clinical and experimental research studies; II- Case presentations; and III- Reviews.

AUTHOR'S RESPONSIBILITY

The manuscript submitted to the journal should not be previously published (except as an abstract or a preliminary report) or should not be under consideration for publication elsewhere. Every person listed as an author is expected to have been participated in the study to a significant extent. All authors should confirm that they have read the study and agreed to the submission to Journal of Turkish Spinal Surgery for publication. This should be notified with a separate document as shown in the "Cover Letter" in the appendix. Although the editors and referees make every effort to ensure the validity of published manuscripts, the final responsibility rests with the authors, not with the Journal, its editors, or the publisher. The source of any financial support for the study should be clearly indicated in the Cover Letter.

It is the author's responsibility to ensure that a patient's anonymity be carefully protected and to verify that any experimental investigation with human subjects reported in the manuscript was performed upon the informed consent of the patients and in accordance with all guidelines for experimental investigation on human subjects applicable at the institution(s) of all authors.

Authors should mask patients' eyes and remove patients' names from figures unless they obtain written consent to do so from the patients; and this consent should be submitted along with the manuscript.

CONFLICTS OF INTEREST

Authors must state all possible conflicts of interest in the manuscript, including financial, institutional and other relationships that might lead to bias or a conflict of interest. If there is no conflict of interest, this should also be explicitly stated as none declared. All sources of funding should be acknowledged in the manuscript. All relevant conflicts of interest and sources of funding should be included on the title page of the manuscript with the heading "Conflicts of Interest and Source of Funding".

ARTICLE WRITING

Clinically relevant scientific advances during recent years include use of contemporary outcome measures, more sophisticated statistical approaches, and increasing use and reporting of well-formulated research plans (particularly in clinical research).

Scientific writing, no less than any other form of writing, reflects a demanding creative process, not merely an act: the process of writing changes thought. The quality of a report depends on the quality of thought in the design and the rigor of conduct of the research. Well-posed questions or hypotheses interrelate with the design. Well-posed hypotheses imply design and design implies the hypotheses. The effectiveness of a report relates to brevity and focus. Drawing the attention to a few points will allow authors to focus on critical issues. Brevity is achieved in part by avoiding repetition (with a few exceptions to be noted),

clear style, and proper grammar. Few original scientific articles need to be longer than 3000 words. Longer articles may be accepted if substantially novel methods are reported, or if the article reflects a comprehensive review of the literature.

Although authors should avoid redundancy, effectively communicating critical information often requires repetition of the questions (or hypotheses/key issues) and answers. The questions should appear in the Abstract, Introduction, and Discussion, and the answers should appear in the Abstract, Results, and Discussion sections.

Although most journals publish guidelines for formatting a manuscript and many have more or less established writing styles (e.g., the American Medical Association Manual of Style), styles of writing are as numerous as authors. Journal of Turkish Spinal Surgery traditionally has used the AMA style as a general guideline. However, few scientific and medical authors have the time to learn these styles. Therefore, within the limits of proper grammar and clear, effective communication, we will allow individual styles.

Permissions: As shown in the example in the appendix (Letter of Copyright Transfer) the authors should declare in a separate statement that the study has not been previously published and is not under consideration for publication elsewhere. Also, the authors should state in the same statement that they transfer copyrights of their manuscript to our Journal. Quoted material and borrowed illustrations: if the authors have used any material that had appeared in a copyrighted publication, they are expected to obtain written permission letter and it should be submitted along with the manuscript.

Review articles: The format for reviews substantially differs from those reporting original data. However, many of the principles noted above apply. A review still requires an Abstract, an Introduction, and a Discussion. The Introduction still requires focused issues and a rationale for the study. Authors should convey to readers the unique aspects of their reviews which distinguish them from other available material (e.g., monographs, book chapters). The main subject should be emphasized in the final paragraph of the Introduction. As for an original research article, the Introduction section of a review typically need not to be longer than four paragraphs. Longer Introductions tend to lose focus, so that the reader may not be sure what novel information will be presented. The sections after the Introduction are almost always unique to the particular review, but need to be organized in a coherent fashion. Headings (and subheadings when appropriate) should follow parallel construction and reflect analogous topics (e.g., diagnostic categories, alternative methods, alternative surgical interventions). If the reader considers only the headings, the logic of the review (as reflected in the Introduction) should be clear. Discussion synthesizes the reviewed literature as a whole coherently and within the context of the novel issues stated in the Introduction.

The limitations should reflect those of the literature, however, rather than a given study. Those limitations will relate to gaps in the literature which preclude more or less definitive assessment of diagnosis or selection of treatment, for example. Controversies in the literature should be briefly explored. Only by exploring limitations will the reader appropriately place the literature in perspective. Authors should end the Discussion by abstract statements similar to those which will appear at the end of the Abstract in abbreviated form.

In general, a review requires a more extensive literature review than an original research article, although this will depend on the topic. Some topics (e.g., osteoporosis) could not be comprehensively referenced, even in an entire monograph. However, authors need to ensure that a review is representative of the entire body of literature, and when that body is large, many references are required.

Original Articles: Original articles should contain the following sections: “Title Page”, “Abstract”, “Keywords”, “Introduction”, “Materials and Methods”, “Results”, “Discussion”, “Conclusions”, and “References”. “Keywords” sections should also be added if the original article is in English.

- Title (80 characters, including spaces): Just as the Abstract is important in capturing a reader’s attention, so is the title. Titles rising or answering questions in a few brief words will far more likely do this than titles merely pointing to the topic. Furthermore, such titles as “Bisphosponates reduce bone loss” effectively convey the main message and readers will more likely remember them. Manuscripts that do not follow the protocol described here will be returned to the corresponding author for technical revision before undergoing peer review. All manuscripts in English, should be typed double-spaced on one side of a standard typewriter paper, leaving at least 2.5 cm. margin on all sides. All pages should be numbered beginning from the title page.

- Title page should include: a) informative title of the paper, b) complete names of each author with their institutional affiliations, c) name, address, fax and telephone number, e-mail of the corresponding author, d) address for the reprints if different from that of the corresponding author, e) ORCID numbers of the authors. It should also be stated in the title

page that informed consent was obtained from patients and that the study was approved by the ethics committee.

The "Level of Evidence" should certainly be indicated in the title page (see Table-1 in the appendix). Also, the field of study should be pointed out as outlined in Table-2 (maximum three fields).

- Abstract: A150 to 250 word abstract should be included at the second page. The abstract should be written in English and for all articles. The main topics to be included in Abstract section are as follows: Background Data, Purpose, Materials- Methods, Results and Conclusion. The Abstract should be identical in meaning. Generally, an Abstract should be written after the entire manuscript is completed. The reason relates to how the process of writing changes thought and perhaps even purpose. Only after careful consideration of the data and a synthesis of the literature can author(s) write an effective abstract. Many readers now access medical and scientific information via Web-based databases rather than browsing hard copy material. Since the reader's introduction occurs through titles and abstracts, substantive titles and abstracts more effectively capture a reader's attention regardless of the method of access. Whether reader will examine an entire article often will depend on an abstract with compelling information. A compelling Abstract contains the questions or purposes, the methods, the results (most often quantitative data), and the conclusions. Each of these may be conveyed in one or two statements. Comments such as "this report describes…" convey little useful information.

-Key Words: Standard wording used in scientific indexes and search engines should be preferred. The minimum number for keywords is three and the maximum is five.

- Introduction (250 – 750 words): It should contain information on historical literature data on the relevant issue; the problem should be defined; and the objective of the study along with the problem solving methods should be mentioned.

Most studies, however, are published to: (1) report entirely novel findings (frequently case reports, but sometimes substantive basic or clinical studies); (2) confirm previously reported work (eg, case reports, small preliminary series) when such confirmation remains questionable; and (3) introduce or address controversies in the literature when data and/or conclusions conflict. Apart from reviews and other special articles, one of these three purposes generally should be apparent (and often explicit) in the Introduction.

The first paragraph should introduce the general topic or problem and emphasized its importance, a second and perhaps a third paragraph should provide the rationale of the study, and a final paragraph should state the questions, hypotheses, or purposes.

One may think of formulating rationale and hypotheses as Aristotelian logic (a modal syllogism) taking the form: If A, B, and C, then D, E, or F. The premises A, B, and C, reflect accepted facts whereas D, E, or F reflect logical outcomes or predictions. The premises best come from published data, but when data are not available, published observations (typically qualitative), logical arguments or consensus of opinion can be used. The strength of these premises is roughly in descending order from data to observations or argument to opinion. D, E, or F reflects logical consequences. For any set of observations, any number of explanations (D, E, or F) logically follows. Therefore, when formulating hypotheses (explanations), researchers designing experiments and reporting results should not rely on a single explanation.

With the rare exception of truly novel material, when establishing rationale authors should generously reference representative (although not necessarily exhaustive) literature. This rationale establishes novelty and validity of the questions and places it within the body of literature. Writers should merely state the premises with relevant citations (superscripted) and avoid describing cited works and authors` names. The exceptions to this approach include a description of past methods when essential to developing rationale for a new method, or a mention of authors` names when important to establish historic precedent. Amplification of the citations may follow in the Discussion when appropriate. In establishing a rationale, new interventions of any sort are intended to solve certain problems. For example, new implants (unless conceptually novel) typically will be designed according to certain criteria to eliminate problems with previous implants. If the purpose is to report a new treatment, the premises of the study should include those explicitly stated problems (with quantitative frequencies when possible) and they should be referenced generously.

The final paragraph logically flows from the earlier ones, and should explicitly state the questions or hypotheses to be addressed in terms of the study (independent, dependent) variables. Any issue not posed in terms of study variables cannot be addressed meaningfully. Focus of the report relates to focus of these questions, and the report should avoid questions for which answers are well described in the literature (e.g., dislocation rates for an implant designed to minimize stress shielding). Only if there are new and unexpected information should data reported apart from that essential to answer the stated questions.

- Materials - Methods (1000-1500 words): Epidemiological/ demographic data regarding the study subjects; clinical and radiological investigations; surgical technique applied; evaluation methods; and statistical analyses should be described in detail.

In principle, the Materials and Methods should contain adequate detail for another investigator to replicate the study. In practice, such detail is neither practical nor desirable because many methods will have been published previously (and in greater detail), and because long descriptions make reading difficult. Nonetheless, the Materials and Methods section typically will be the longest section. When reporting clinical studies authors must state approval of the institutional review board or ethics committees according to the laws and regulations of their countries. Informed consent must be stated where appropriate. Such approval should be stated in the first paragraph of Materials and Methods. At the outset the reader should grasp the basic study design. Authors should only briefly escribe and reference previously reported methods. When authors modify those methods, the modifications require additional description.

In clinical studies, the patient population and demographics should be outlined at the outset. Clinical reports must state inclusion and exclusion criteria and whether the series is consecutive or selected; if selected, criteria for selection should be stated. The reader should understand from this description all potential sources of bias such as referral, diagnosis, exclusion, recall, or treatment bias. Given the expense and effort for substantial prospective studies, it is not surprising that most published clinical studies are retrospective.

Such studies often are criticized unfairly for being retrospective, but that does not negate the validity or value of a study. Carefully designed retrospective studies provide most of the information available to clinicians. However, authors should describe potential problems such as loss to follow-up, difficulty in matching, missing data, and the various forms of bias more common with retrospective studies.

If authors use statistical analysis, a paragraph should appear at the end of Materials and Methods stating all statistical tests used. When multiple tests are used, authors should state which tests are used for which sets of data. All statistical tests are associated with assumptions, and when it is not obvious the data would meet those assumptions, the authors either should provide the supporting data (e.g., data are normally distributed, variances in gro-ups are similar) or use alternative tests. Choice of level of significance should be justified. Although it is common to choose a level of alpha of 0.05 and a beta of 0.80, these levels are somewhat arbitrary and not always appropriate. In the case where the implications of an error are very serious (e.g., missing the diagnosis of a cancer), different alpha and beta levels might be chosen in the study design to assess clinical or biological significance.

- Results (250-750 words): "Results" section should be written in an explicit manner, and the details should be described in the tables. The results section can be divided into sub-sections for a more clear understanding.

If the questions or issues are adequately focused in the Introduction section, the Results section needs not to be long. Generally, one may need a paragraph or two to persuade the reader of the validity of the methods, one paragraph addressing each explicitly raised question or hypothesis, and finally, any paragraphs to report new and unexpected findings. The first (topic) sentence of each paragraph should state the point or answer the question. When the reader considers only the first sentence in each paragraph in Results, the logic of the authors` interpretations should be clear. Parenthetic reference to all figures and tables forces the author to textually state the interpretation of the data; the important material is the authors` interpretation of the data, not the data.

Statistical reporting of data deserves special consideration. Stating some outcome is increased or decreased(or greater or lesser) and parenthetically stating the p (or other statistical) value immediately after the comparative terms more effectively conveys information than stating something is or is not statistically significantly different from so-mething else (different in what way? the readermay ask). Additionally, avoiding the terms 'statistically different' or 'significantly different' lets the reader determine whether they will consider the statistical value biologically or clinically significant, regardless of statistical significance.

Although a matter of philosophy and style, actual p values convey more information than stating a value less than some preset level. Furthermore, as Motulsky notes, "When you read that a result is not significant, don't stop thinking... First, look at the confidence interval... Second, ask about the power of the study to find a significant difference if it were there." This approach will give the reader a much greater sense of biological or clinical significance.

- Discussion (750 - 1250 words): The Discussion section should contain specific elements: a restatement of the problem or question, an exploration of limitations and as-sumptions, a comparison and/or contrast with information (data, opinion) in the literature, and a synthesis of the comparison and the

author's new data to arrive at conclusions. The restatement of the problem or questions should only be a brief emphasis. Exploration of assumptions and limitations are preferred to be next rather than at the end of the manuscript, because interpretation of what will follow depends on these limitations. Failure to explore limitations suggests the author(s) either do not know or choose to ignore them, potentially misleading the reader. Exploration of these limitations should be brief, but all critical issues must be discussed, and the reader should be persuaded they do not jeopardize the conclusions.

Next the authors should compare and/or contrast their data with data reported in the literature. Generally, many of these reports will include those cited as rationale in the Introduction. Because of the peculiarities of a given study the data or observations might not be strictly comparable to that in the literature, it is unusual that the literature (including that cited in the Introduction as rationale) would not contain at least trends. Quantitative comparisons most effectively persuade the reader that the data in the study are "in the ballpark," and tables or figures efficiently convey that information. Discrepancies should be stated and explained when possible; when an explanation of a discrepancy is not clear that also should be stated. Conclusions based solely on data in the paper seldom are warranted because the literature almost always contains previous information.

Finally, the author(s) should interpret their data in the light of the literature. No critical data should be overlooked, because contrary data might effectively refute an argument. That is, the final conclusions must be consistent not only with the new data presented, but also that in the literature.

- Conclusion: The conclusions and recommendations by the authors should be described briefly. Sentences containing personal opinions or hypotheses that are not based on the scientific data obtained from the study should be avoided.

- References: References are numbered (Arabic numerals) consecutively in the order in which they appear in the text (note that references should not appear in the abstract) and listed double-spaced at the end of the manuscript. The preferred method for identifying citations in the text is using within parentheses. Use the form of the "Uniform Requirements for Manuscripts" (http://www.icmje.org/about-icmje/faqs/icmje-recommendations/). If number of authors exceeds seven, list first 6 authors followed by et al.

Use references found published in peer-reviewed publications that are generally accessible. Unpublished data, personal communications, statistical programs, papers presented at meetings and symposia, abstracts, letters, and manuscripts submitted for publication cannot be listed in the references. Papers accepted by peer-reviewed publications but not yet published ("in press") are not acceptable as references.

Journal titles should conform to the abbreviations used in "Cumulated Index Medicus".

Please note the following examples of journal, book and other reference styles:

Journal article:

1. Berk H, Akçalı Ö, Kıter E, Alıcı E. Does anterior spinal instrument rotation cause rethrolisthesis of the lower instrumented vertebra? J Turk Spinal Surg. 1997; 8 (1): 5-9.

Book chapter:

2. Wedge IH, Kirkaldy-Willis WH, Kinnard P. Lumbar spinal stenosis. Chapter 5. In: Helfet A, Grubel DM (Eds.). Disorders of the Lumbar Spine. JB Lippincott, Philadelphia 1978; pp: 61-8.

Entire book:

3. Paul LW, Juhl IH (Eds.). The Essentials of Roentgen Interpretation. Second Edition, Harper and Row, New York 1965; pp: 294-311.

Book with volume number:

4. Stauffer ES, Kaufer H, Kling THF. Fractures and dislocations of the spine. In: Rock-wood CA, Green DP (Eds.). Fractures in Adults. Vol. 2, JB Lippincott, Philadelphia 1984; pp: 987-1092.

Journal article in press:

5. Arslantaş A, Durmaz R, Coşan E, Tel E. Aneurysmal bone cysts of the cervical spine. J Turk Spinal Surg. (In press).

Book in press:

6. Condon RH. Modalities in the treatment of acute and chronic low back pain. In: Finnison BE (Ed.). Low Back Pain. JB Lippincott (In press).

Symposium:

7. Raycroft IF, Curtis BH. Spinal curvature in myelomeningocele: natural history and etiology. Proceedings of the American Academy of Orthopaedic Surgeons Symposium on Myelomeningocele, Hartford, Connecticut, November 1970, CV Mosby, St. Louis 1972; pp: 186- 201.

Papers presented at the meeting:

8. Rhoton AL. Microsurgery of the Arnold-Chiari malformation with and without hydromyelia in adults. Presented at the

Annual Meeting of the American Association of Neuro-logical Surgeons, Miami, Florida, April 7, 1975.

- Tables: They should be numbered consecutively in the text with Arabic numbers. Each table with its number and title should be typed on a separate sheet of paper. Each table must be able to stand alone; all necessary information must be contained in the caption and the table itself so that it can be understood independent from the text. Information should be presented explicitly in "Tables" so that the reader can obtain a clear idea about its content. Information presented in "Tables" should not be repeated within the text. If possible, information in "Tables" should contain statistical means, standard deviations, and t and p values for possibility. Abbreviations used in the table should be explained as a footnote.

Tables should complement not duplicate material in the text. They compactly present information, which would be difficult to describe in text form. (Material which may be succinctly described in text should rarely be placed in tables or figures.) Clinical studies for example, often contain complementary tables of demographic data, which although important for interpreting the results, are not critical for the questions raised in the paper. Well focused papers contain only one or two tables or figures for every question or hypothesis explicitly posed in the Introduction section. Additional material may be used for unexpected results. Well-constructed tables are self-explanatory and require only a title. Every column contains a header with units when appropriate.

- Figures: All figures should be numbered consecutively throughout the text. Each figure should have a label pasted on its back indicating the number of the figure, an arrow to show the top edge of the figure and the name of the first author. Black-and-white illustrations should be in the form of glossy prints (9x13 cm). The letter size on the figure should be large enough to be readable after the figure is reduced to its actual printing size. Unprofessional typewritten characters are not accepted. Legends to figures should be written on a separate sheet of paper after the references.

The journal accepts color figures for publication if they enhance the article. Authors who submit color figures will receive an estimate of the cost for color reproduction. If they decide not to pay for color reproduction, they can request that the figures be converted to black and white at no charge. For studies submitted by electronic means, the figures should be in jpeg and tiff formats with a resolution greater than 300 dpi. Figures should be numbered and must be cited in the text.

- Style: For manuscript style, American Medical Association Manual of Style (9th edition). Stedman's Medical Dictionary (27th edition) and Merriam Webster's Collegiate Dictionary (10th edition) should be used as standard references. The drugs and therapeutic agents must be referred by their accepted generic or chemical names, without abbreviations. Code numbers must be used only when a generic name is not yet available. In that case, the chemical name and a figure giving the chemical structure of the drug should be given. The trade names of drugs should be capitalized and placed in parentheses after the generic names. To comply with trademark law, the name and location (city and state/country) of the manufacturer of any drug, supply, or equipment mentioned in the manuscript should be included. The metric system must be used to express the units of measure and degrees Celsius to express temperatures, and SI units rather than conventional units should be preferred.

The abbreviations should be defined when they first appear in the text and in each table and figure. If a brand name is cited, the manufacturer's name and address (city and state/country) must be supplied.

The address, "Council of Biology Editors Style Guide" (Council of Science Editors, 9650 Rockville Pike, Bethesda, MD 20814) can be consulted for the standard list of abbrevia-tions.

-Acknowledgments: Note any non-financial acknowledgments. Begin with, "The Authors wish to thank..." All forms of support, including pharmaceutical industry support should also be stated in Acknowledgments section.

Authors are requested to apply and load including the last version of their manuscript to the manuscript submission in the official web address (www.jtss.org). The electronic file must be in Word format (Microsoft Word or Corel Word Perfect). Authors can submit their articles for publication via internet using the guidelines in the following address: www.jtss.org.

- Practical Tips:

1. Read only the first sentence in each paragraph throughout the text to ascertain whether those statements contain all critical material and the logical flow is clear.

2. Avoid in the Abstract comments such as, "... this report describes..." Such statements convey no substantive information for the reader.

3. Avoid references and statistical values in the Abstract.

4. Avoid using the names of cited authors except to establish historical precedent. Instead, indicate the point in the manuscript by providing citation by superscripting.

5. Avoid in the final paragraph of the Introduction purposes such as, "... we report our data..." Such statements fail to focus

the reader's (and author's!) attention on the critical issues (and do not mention study variables).

6. Parenthetically refer to tables and figures and avoid statements in which a table of figure is either subject or object of a sentence. Parenthetic reference places interpretation of the information in the table or figure, and not the table or figure.

7. Regularly count words from the Introduction through Discussion.

TABLE-1. LEVELS OF EVIDENCE

LEVEL- I .

1) Randomized, double-blind, controlled trials for which tests of statistical significance have been performed

2) Prospective clinical trials comparing criteria for diagnosis, treatment and prognosis with tests of statistical significance where compliance rate to study exceeds 80%

3) Prospective clinical trials where tests of statistical ignificance for consecutive subjects are based on predefined criteria and a comparison with universal (gold standard) reference is performed

4) Systematic meta-analyses which compare two or more studies with Level I evidence using pre-defined methods and statistical comparisons.

5) Multi-center, randomized, prospective studies

LEVEL –II.

1) Randomized, prospective studies where compliance rate is less than 80%

2) All Level-I studies with no randomization

3) Randomized retrospective clinical studies

4) Meta-analysis of Level-II studies

LEVEL– III.

1) Level-II studies with no randomization (prospective clinical studies etc.)

2) Clinical studies comparing non-consecutive cases (without a consistent reference range)

3) Meta-analysis of Level III studies

LEVEL- IV.

1) Case presentations

2) Case series with weak reference range and with no statistical tests of significance

LEVEL – V.

1) Expert opinion and review articles

2) Anecdotal reports of personal experience regarding a study, with no scientific basis

TABLE-2. CLINICAL AREAS

Anatomy

Morphometric analysis

Anesthesiology

Animal study

Basic Science

Biology

Biochemistry

Biomaterials

Bone mechanics

Bone regeneration

Bone graft

Bone graft sustitutes

Drugs

Disc

Disc Degeneration

Herniated Disc

Disc Pathology

Disc Replacement

IDET

Disease/Disorder

Congenital

Genetics

Degenerative disease

Destructive (Spinal Tumors)

Metabolic bone disease

Rheumatologic

Biomechanics Cervical Spine

Cervical myelopathy

Cervical reconstruction

JOURNAL OF TURKISH SPINAL SURGERY

Cervical disc disease
Cervical Trauma
Degenerative disease
Complications
Early
Late
Postoperative
Deformity
Adolescent idiopathic scoliosis
Kyphosis
Congenital spine
Degenerative spine conditions
Diagnostics
Radiology
MRI
CT scan
Others
Epidemiology
Etiology
Examination
Experimental study
Fusion
Anterior
Posterior
Combined
With instrumentation
Infection of the spine
Postoperative
Rare infections
Spondylitis
Spondylodiscitis
Tuberculosis
Instrumentation
Meta-Analysis
Osteoporosis
Bone density
Fractures
Kyphoplasty
Medical Treatment
Surgical Treatment
Outcomes
Conservative care
Patient Care
Primary care
Quality of life research
Surgical
Pain
Chronic pain
Discogenic pain
Injections
Low back pain
Management of pain
Postoperative pain
Pain measurement
Physical Therapy
Motion Analysis
Manipulation
Non-Operative Treatment
Surgery
Minimal invasive
Others
Reconstructive surgery
Thoracic Spine
Thoracolumbar Spine
Lumbar Spine
Lumbosacral Spine
Psychology
Trauma

Fractures

Dislocations

Spinal cord

Spinal Cord Injury

Spinal stenosis

Cervical

Lumbar

Lumbosacral

Tumors

Metastatic tumors

Primary benign tumors

Primary malign tumors

APPLICATION LETTER EXAMPLE:

Editor-in-Chief

Journal of Turkish Spinal Surgery

Dear Editor,

We enclose the manuscript titled '....' for consideration to publish in Journal of Turkish Spinal Surgery.

The following authors have designed the study (AU: Parenthetically insert names of the appropriate authors), gathered the data (AU: Parenthetically insert names of the appropriate authors), analyzed the data (AU: Parenthetically insert names of the appropriate authors), wrote the initial drafts (AU: Parenthetically insert initials of the appropriate authors), and ensure the accuracy of the data and analysis (AU: Parenthetically insert names of the appropriate authors).

I confirm that all authors have seen and agree with the contents of the manuscript and agree that the work has not been submitted or published elsewhere in whole or in part.

As the Corresponding Author, I (and any other authors) understand that Journal of Turkish Spinal Surgery requires all authors to specify any contracts or agreements they might have signed with commercial third parties supporting any portion of the work. I further understand such information will be held in confidence while the paper is under review and will not influence the editorial decision, but that if the article is accepted for publication, a disclosure statement will appear with the article. I have selected the following statement(s) to reflect the relationships of myself and any other author with a commercial third party related to the study:

1) All authors certify that they not have signed any agreement with a commercial third party related to this study which would in any way limit publication of any and all data generated for the study or to delay publication for any reason.

2) One or more of the authors (initials) certifies that he or she has signed agreements with a commercial third party related to this study and that those agreements allow commercial third party to own or control the data generated by this study and review and modify any manuscript but not prevent or delay publication.

3) One or more of the authors (AU: Parenthetically insert initials of the appropriate authors) certifies that he or she has signed agreements with a commercial third party related to this study and that those agreements allow commercial third party to own or control the data and to review and modify any manuscript and to control timing but not prevent publication. Sincerely,

Date:
Corresponding Author:
Address:
Phone:
Fax-mail:
GSM:
E-mail:

AUTHORSHIP RESPONSIBILITY, FINANCIAL DISCLOSURE, AND COPYRIGHT TRANSFER

MANUSCRIPT TITLE:
CORRESPONDING AUTHOR:
MAILING ADDRESS:
TELEPHONE / FAX NUMBERS:

Each author must read and sign the following statements; if necessary, photocopy this document and distribute to coauthors for their original ink signatures. Completed forms should be sent to the Editorial Office.

CONDITIONS OF SUBMISSION

RETAINED RIGHTS:

Except for copyright, other proprietary rights related to the Work shall be retained by the authors. To reproduce any text, figures, tables, or illustrations from this Work in future works of their own, the authors must obtain written permission from Journal of Turkish Spinal Surgery; such permission cannot be unreasonably withheld by Journal of Turkish Spinal Surgery.

JOURNAL OF TURKISH SPINAL SURGERY

ORIGINALITY:

Each author warrants that his or her submission to the Work is original and that he or she has full power to enter into this agreement. Neither this Work nor a similar work has been published nor shall be submitted for publication elsewhere while under consideration by this Publication.

AUTHORSHIP RESPONSIBILITY:

Each author certifies that he or she has participated sufficiently in the intellectual content, the analysis of data, if applicable, and the writing of the Work to take public responsibility for it. Each has reviewed the final version of the Work, believes it represents valid work, and approves it for publication. Moreover, should the editors of the Publication request the data upon which the work is based, they shall produce it.

DISCLAIMER:

Each author warrants that this Work contains no libelous or unlawful statements and does not infringe on the rights of others. If excerpts (text, figures, tables, or illustrations) from copyrighted works are included, a written release will be secured by the authors prior to submission, and credit to the original publication will be properly acknowledged. Each author warrants that he or she has obtained, prior to submission, written permissions from patients whose names or photographs are submitted as part of the Work. Should Journal of Turkish Spinal Surgery request copies of such written releases, authors shall provide them to Journal of Turkish Spinal Surgery in a timely manner.

TRANSFER OF COPYRIGHT

AUTHORS' OWN WORK:

In consideration of Journal of Turkish Spinal Surgery's publication of the Work, the authors hereby transfer, assign, and otherwise convey all copyright ownership worldwide, in all languages, and in all forms of media now or hereafter known, including electronic media such as CD-ROM, Internet, and Intranet, to Journal of Turkish Spinal Surgery.

If Journal of Turkish Spinal Surgery should decide for any reason not to publish an author's submission to the Work, Journal of Turkish Spinal Surgery shall give prompt notice of its decision to the corresponding author, this agreement shall terminate, and neither the author nor Journal of Turkish Spinal Surgery shall be under any further liability or obligation.

The authors grant Journal of Turkish Spinal Surgery the rights to use their names and biographical data (including professional affiliation) in the Work and in its or the Publication's promotion.

WORK MADE FOR HIRE:

If this work has been commissioned by another person or organization, or if it has been written as part of the duties of an employee, an authorized representative of the commissioning organization or employer must also sign this form stating his or her title in the organization.

FINANCIAL DISCLOSURE:

Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article, except as disclosed on a separate attachment. All funding sources supporting the Work and all institutional or corporate affiliations of the authors are acknowledged in a footnote in the Work.

INSTITUTIONAL REVIEW BOARD/ANIMAL CARE COMMITTEE

APPROVAL:

Each author certifies that his or her institution has approved the protocol for any investigation involving humans or animals and that all experimentation was conducted in conformity with ethical and humane principles of research.

Signature Printed Name Date

Signature Printed Name Date

Signature Printed Name Date

JOURNAL OF TURKISH SPINAL SURGERY

Dear Colleagues,

I feel very privileged to be the person responsible for publishing this, the 1st issue, of our professional journal this year. It includes several clinical research studies, a couple of case reports, and a review article. I hope that each of you will take the time to review this issue very carefully, and add the information and insights contained herein, to your already very well informed knowledge bases.

The Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spine Society. JTSS is currently indexed in Ulakbim and Atıf Dizin. However, we are very happy to announce that JTSS will now, in addition, be indexed by two international indexes; J-Gate and Europub. We would like to remind you that, should you choose to submit a manuscript to the Turkish Journal of Spinal Surgery, it is free of charge, and the Pleksus system is being used.

In this issue, there are nine clinical research studies, three case reports and one review article. The first study is a retrospective clinical study giving the results on ankylosing spondylitis patients who had deformity correction with combined osteotomies. The second is about 12 patients who had painful scoliosis and osteoid osteoma of the spine. In the third, one can read about a retrospective clinical study entitled, Comparison of Three Different Surgical Treatment Procedures Used in the Treatment of Lumbar Spinal Stenosis. The fourth article is a technical report about whether a minimal superior articular process removal of a facet joint, using a lateral interpedicular approach, could provide a better exposure in treatment of far lateral disc herniations. The authors of the fifth study examined the alteration of sagittal lumbosacral alignment, after posterior stabilization-fusion, in lumbar spondylolisthesis. The sixth study discusses unintended dural injury in degenerative lumbar spinal surgery while, in the seventh, the authors wrote about how recurrent laryngeal nerve palsy, after cervical spinal surgery, can be prevented. The eighth article is a retrospective single-centre study about the incidence and mortality of osteoporotic insufficient sacral fractures. The ninth article is about giant cell tumors of the sacrum, and current treatment strategies. The tenth study is a two-case series about distal migration of the rods of a constrained poly-axial pedicle screw system. The eleventh article is composed of a case report about giant cell tumor of the thoracal spine, while the thirteenth is a review of current concepts on spinal tuberculosis.

I hope you found this issue stimulating and informative. It's my goal to provide you with the latest, and most up-to-date information in our field. I do this in an effort to keep all of us on the cutting edge of the latest research and developments.

I wish all our Turkish spinal surgeons and their families a healthy, peaceful, and prosperous year.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

JOURNAL OF TURKISH SPINAL SURGERY

Contents

J Turk Spinal Surg 2020;31(1):1-5
DOI: 10.4274/jtss.galenos.2020.16

ORIGINAL ARTICLE
1

DEFORMITY CORRECTION IN SEVERE ANKYLOSING SPONDYLITIS WITH COMBINED OSTEOTOMIES

Görkem KIYAK[1], Murat BEZER[2]

[1]Academic Hospital, Clinic of Orthopaedic Surgery, İstanbul, Turkey
[2]Marmara University Faculty of Medicine, Department of Orthopaedic Surgery, İstanbul, Turkey

ABSTRACT

Objective: To evaluate the effects of single-level lumbar decancellation osteotomy combined with multiple level polysegmental posterior osteotomies involving the whole thoracal spine in severe ankylosing spondylitis.

Materials and Methods: Between 2008 and 2017, 14 patients (12 men and two women) were included in the study. The indication for surgery was a progressive loss of horizontal sight due to whole spine kyphosis (chin-brow angle over 90°). The mean age at the time of operation was 47 years. Preoperatively and postoperatively, the cobb angle was measured on standing lateral radiographs of the whole spine. The chin-brow angle correction was recorded.

Results: The mean surgical time was 281 minutes, and the average blood loss was 1870 mL. Preoperative mean chin-brow angle was 97.5°. Postoperative chin-brow angle was 18° (p<0.0001). The preoperative mean thoracic cobb angle was 69°, and the postoperative thoracic cobb angle was 37.5° (p<0.0001). The preoperative mean lumbar lordosis angle was -1.2°, and the postoperative mean lumbar lordosis angle was -29° (p<0.0001). There were no major perioperative and postoperative complications. Two patients had minor wound healing problems. Bone healing was satisfactory in all patients. Three patients had a loss of correction in thoracal regions of 5, 7, and 8 degrees at the final follow-up visit. Reduction losses were acceptable, and we did not plan any revision surgeries.

Conclusion: Our study showed that this surgical method is as effective as two-level lumbar osteotomies used in severe cases and is also a safer procedure as the latter.

Keywords: Ankylosing spondylitis, osteotomy, deformity

INTRODUCTION

There are two subtypes of kyphotic deformity in ankylosing spondylitis: Thoracic kyphosis with either preservation of lumbar lordosis or loss of lumbar lordosis resulting in a prolonged C flexion deformity of the whole spine.

When the whole trunk becomes a long C curve to maintain the visual arc, patients have to flex their knees. This results in a very uncomfortable and energy-demanding posture. When patients try to extend their knees, stiff cervical and upper thoracic spinal regions limit the forward visual to only a few meters in front of them.

The correction of lumbar kyphosis in ankylosing spondylitis was first popularized by Smith-Petersen et al.[1]. Multiple inverted V-shaped posterior osteotomies were closed by spine extension, rupture of the anterior longitudinal ligament, and opening of the anterior part of the intervertebral disc.

Later, osteotomies involving vertebral bodies to gain more angular correction at a single-level were described by many authors[2-4]. Today, these osteotomies are frequently in use either as single-level osteotomy or interrupted two-level osteotomy to correct kyphotic deformity in ankylosing spondylitis[5-7].

These osteotomies are performed on the lumbar and thoracolumbar junction, where a surgeon can achieve the most angular correction, leaving the upper thoracic kyphosis untreated. This limits the correction of visual arc when there is a severe kyphotic deformity in the thoracic region.

This paper reports the results of the correction of whole spinal column kyphotic deformity using single-level lumbar decancellation osteotomy in combination with multiple level polysegmental posterior osteotomies and fixation with long posterior construct up to T2 level.

MATERIAL AND METHODS

Approval from the General Clinical Directorate of Academic Hospital was obtained before starting the data collection of

This study was presented in the XIII. International Turkish Spine Congress in 2019.

Address for Correspondence: Görkem Kıyak, Academic Hospital, Clinic of Orthopaedic Surgery, İstanbul, Turkey
Phone: +90 532 590 88 34 **E-mail:** drgorkemkiyak@gmail.com **Received:** 19.10.2019 **Accepted:** 10.01.2020
ORCID ID: orcid.org/0000-0001-7302-2145

patients included in the study. The study was performed by the ethical standards of the 1964 Declaration of Helsinki as revised in 2000 and those of Good Clinical Practice (approval number: 10/01/2019-12).

All subjects participating in this retrospective study received a thorough explanation of the risks and benefits of inclusion. Following this, they provided their oral and written informed consent to publish the data.

Between 2008 and 2017, 14 patients (12 men and two women) with secondary thoracic and thoracolumbar kyphosis due to ankylosing spondylitis were included in the study. The indication for surgery was a progressive loss of horizontal sight due to whole spine kyphosis (chin-brow angle over 90°). The mean age at the time of operation was 47 years (range=36-57 years) (Table 1).

To assess possible injuries to the spinal cord or spinal nerves during surgery, electrophysiological monitoring of somatosensory-evoked potentials and motor-evoked potentials was carried out under general anesthesia in all patients.

After surgical exposure from T2 to L4, bilateral pedicle screws were placed, excluding the lumbar osteotomy levels.

Classical Smith-Petersen osteotomy (SPO) involves the removal of the posterior bony elements, including the bilateral facet joints, the inferior portion of the lamina, and the inferior portion of the spinous process, and the removal of the posterior ligaments at the osteotomy level. Forceful closure of the posterior osteotomy elongates or partially ruptures the anterior longitudinal ligament and the anterior intervertebral disc. To achieve a global correction of the kyphotic deformity, we preferred to use multiple poly-segmental posterior osteotomies, which is a modification of the classic SPO at all thoracic levels (Figure 1).

Transpedicular decancellation osteotomy is a closing wedge osteotomy usually applied on L2 or L3 level. Using smaller curettes, decancellation was begun through the pedicle. Progressively larger curettes were used with care to preserve the medial pedicle wall and posterior wall of the vertebral body. Curettage was carried out across the midline. After the removal of the pedicle walls, sequential compression on the rods until the posterior elements touched completed the closing wedge osteotomy as described in the literature before[8,9] (Figure 2).

We started instrumentation from two levels below the lumbar osteotomy site and used bipedicular screws up to the T3 level (excluding the lumbar osteotomy site). We performed polysegmental posterior osteotomies to all thoracal levels up to T3. We used a temporary unilateral fixation of the rods when closing the wedges to prevent collapse and we used two rods for the final fixation.

Preoperatively and postoperatively, the cobb angle was measured from standing lateral radiographs of the whole spine. Operation time, blood loss, cobb angle measurements,

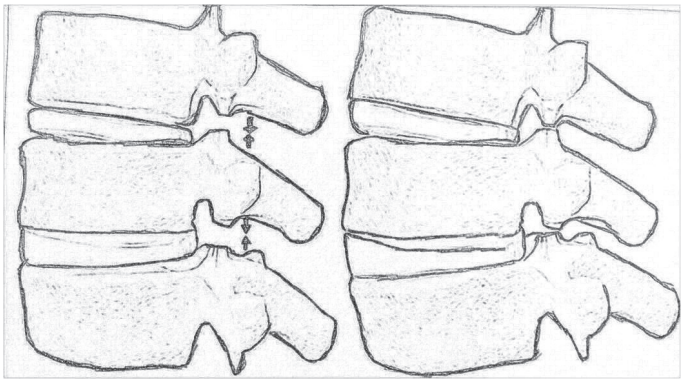


Figure 1. Schematic illustration of the polysegmental posterior osteotomy

Table 1. Patients' demographic data and individual angular measurements

Patient Number	Age	Gender	Preop chin-brow angle	Postop chin-brow angle	Preop thoracic kyphosis	Postop thoracic kyphosis	Preop lumbar lordosis	Postop lumbar lordosis
1	45	Female	95°	15°	75°	40°	10°	-20°
2	56	Male	104°	22°	95°	49°	0°	-25°
3	48	Female	98°	13°	62°	35°	-10°	-35°
4	55	Male	105°	20°	66°	38°	5°	-23°
5	36	Male	102°	25°	58°	35°	-15°	-38°
6	42	Male	93°	18°	70°	42°	-17°	-42°
7	40	Male	107°	30°	65°	38°	7°	-24°
8	54	Male	96°	25°	66°	32°	12°	-20°
9	48	Male	92°	12°	74°	30°	-6°	-33°
10	53	Male	94°	10°	63°	36°	9°	-25°
11	38	Male	100°	27°	60°	42°	-18°	-40°
12	44	Male	91°	7°	65°	34°	-13°	-35°
13	47	Male	94°	12°	88°	44°	6°	-27°
14	57	Male	95°	15°	72°	30°	13°	-22°

Preop: Preoperative, Postop: Postoperative

complications, chin-brow vertical angle, loss of correction at final follow-up, and early and late complications were recorded. Follow-up periods ended at the 24th month.

RESULTS

Angular data on deformity correction, surgical time, and blood loss are listed in Table 1 and 2. There were no major perioperative and postoperative complications. Two patients had minor wound problems. Bone healing was satisfactory in all patients. Three patients had a loss of correction in thoracal regions 5, 7, and 8 degrees at the final follow-up visit. Reduction losses were acceptable, and we did not plan any revision surgeries. Six patients had lumbar osteotomy at the L2 level, and eight had lumbar osteotomy at the L3 level.

Our patient sample did not include any patient with scoliotic deformity. Therefore, postoperative sagittal vertical axis and pelvic tilt measurements were within the normal range.

We did not encounter any implant-related or infection-related complications.

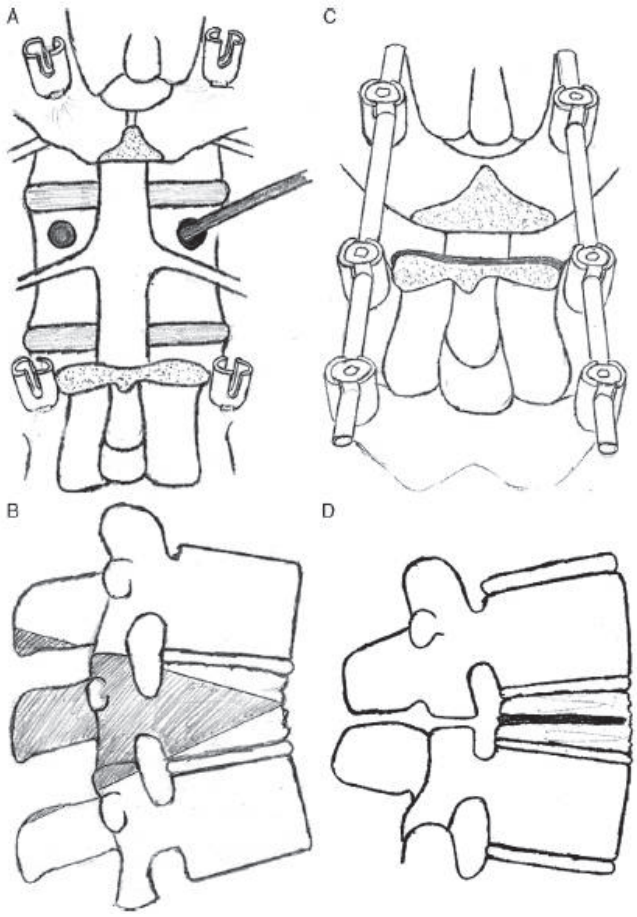


Figure 2. Schematic illustration of the lumbar decancellation osteotomy

DISCUSSION

The principle of a lumbar spinal osteotomy is to shift the center of gravity of the trunk of the hip axis. In severe cases of ankylosing spondylitis, single-level osteotomy usually does not provide adequate correction of the kyphotic deformity; therefore, a two-level lumbar osteotomy is required[10,5].

Smith-Petersen type osteotomy, pedicle subtraction osteotomy, and transpedicular bivertebrae wedge osteotomy procedures all aim to achieve a significant degree of correction at a single pivot point in the lumbar region[11,12]. Up to 45° of correction is possible with these posterior osteotomies. However, as the desired amount of correction increases, these become surgically demanding procedures and liable to complications.

Excessive lengthening of the anterior longitudinal ligament during SPO may injure abdominal vessels. This is a rare but lethal complication[13,14]. The most commonly reported postoperative complications in SPO are intraspinal hematoma, intestinal obstruction, and superior mesenteric ischemia[15]. On the other hand, pedicle subtraction and closing wedge osteotomies are known to cause reversible and irreversible neurological complications[16,17]. There is always a possibility of iatrogenic thecal sac or root compression during the closing of a wide wedge despite a careful surgical technique.

The safe upper limit for a closing wedge osteotomy to avoid vascular and neurological injury is considered to be 35° to 40° in the lumbar region[18-20]. This means that a single closing wedge osteotomy is not adequate for treating a severe kyphotic deformity in ankylosing spondylitis. In severe cases, a two-level osteotomy is required, and at least one of them needs to force the safe upper limit[5]. Magnetic resonance imaging investigation by Liu et al.[21] showed that closing wedge osteotomies in the lumbar region stretched the aorta and that spine surgeons should be aware of the potential vulnerability of aortic injury in ankylosing spondylitis patients undergoing closing wedge osteotomy.

Table 2. Angular data about deformity correction, surgical time, and blood loss

Surgical time	Blood loss	Preop chin-brow angle	Postop chin-brow angle	Preop thoracic kyphosis	Postop thoracic kyphosis	Preop lumbar lordosis	Postop lumbar lordosis
Mean: 281 min (range: 230-350)	Mean: 1870 mL (range: 1200-3000)	Mean: 97.5° (range: 91-107)	Mean: 18° (range: 7-30)	Mean: 69° (range: 58-95)	Mean: 37.5° (range: 30-49)	Mean: -1.2° (range: -18-13)	Mean: -29° [range: -20-(-42)]

Preop: Preoperative, Postop: Postoperative

In our study, we limited the correction obtained from transpedicular decancellation closing wedge osteotomy from 30° to 35°. This angle limit is below the safe upper limit prescribed in previous studies. We obtained the remaining correction from multiple polysegmental posterior osteotomies in the thoracic region (Figure 3A and 3B). By closing multiple posterior osteotomies over multiple segments with transpedicular fixation, a more gradual correction of the kyphosis can be achieved (Figure 4A and 4B)[22,23]. We managed to achieve 2° to 5° of correction for each level of polysegmental posterior osteotomy at the thoracic region. Angular correction varied depending on the anterior ligamentous ankylosis severity of the segment. This osteotomy also causes less distribution of the anterior longitudinal ligament and disc space. Hence it is safer than classic SPO, which has been known to cause a potentially high rate of complications[12]. Excessive one-level or two-level osteotomies at the lumbar region usually create a hyperlordotic posture, which is not a desired natural posture[24]. Gradual and global correction also avoided hyperlordosis in our patients.

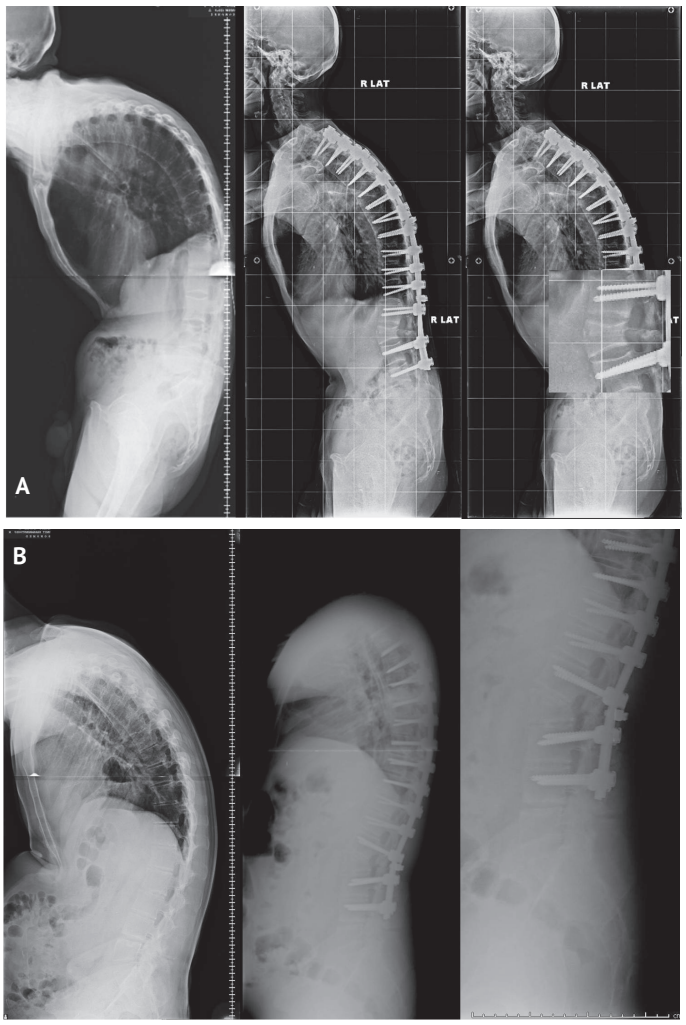


Figure 3. Preoperative **(A)** and final follow-up **(B)** radiographs of patients highlighting the lumbar osteotomies

We did not encounter any major or minor vascular-neurological complications in our study. We only encountered minor wound healing problems in two patients.

Study Limitations

There are some limitations in our study. Depending on our clinical experience and experimental studies, we used bipedicular screws up to the T3 level to distribute pull-out force on as many screws as possible[25]. However, we are unable to make a statement about the necessity of bipedicular screw placement of all levels. Also, although our results are promising, we are still collecting data of our patients and a larger patient sample will provide more data in future studies.

CONCLUSION

Although a longer construct is more prone to causing skin problems and is more costly, global and gradual correction of kyphosis in ankylosing spondylitis with our technique provided satisfactory correction without major vascular-neurologic complications. Our study has showed that this method is as effective as two-level lumbar osteotomies used in severe cases and a safer procedure. Using this procedure, we also avoided

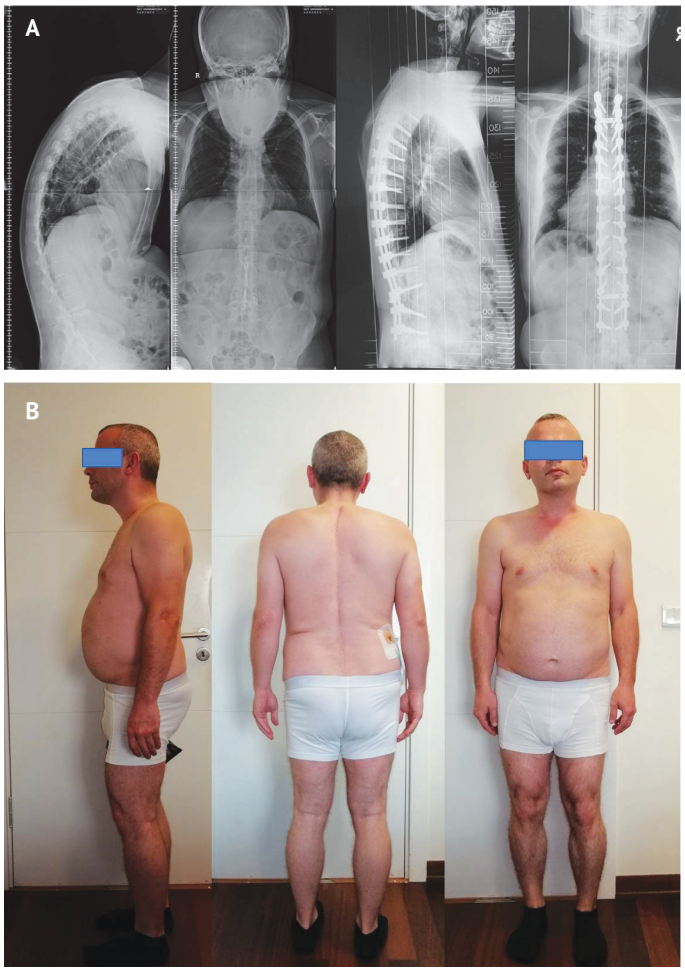


Figure 4. Gradual correction of the thoracic deformity **(A)** and patient posture in the final follow-up **(B)**

hyperlordotic posture, corrected thoracal kyphosis, and gained a more natural sagittal curvature in all the patients.

Ethics

Ethics Committee Approval: Approval from the General Clinical Directorate of Academic Hospital was obtained before starting the data collection of patients included in the study. The study was performed by the ethical standards of the 1964 Declaration of Helsinki as revised in 2000 and those of Good Clinical Practice (approval number: 10/01/2019-12).

Informed Consent: All subjects participating in this retrospective study received a thorough explanation of the risks and benefits of inclusion. Following this, they provided their oral and written informed consent to publish the data.

Authorship Contributions

Concept: M.B., Design: M.B., Data Collection or Processing: G.K., Analysis or Interpretation: G.K., Literature Search: G.K., Writing: G.K.,

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Smith-Petersen MN, Larson CB, Aufrance OE. Osteotomy of the spine for correction of flexion deformity in rheumatoid arthritis. Clin Orthop. 1969;66:6-9.
2. Jaffray D, Becker V, Elsenstein S. Closing wedge osteotomy with transpedicular Ş fixation in ankylosing spondylitis. Clin Orthop. 1992;279:122-6.
3. Thomasen E. Vertebral osteotomy for correction of kyphosis in ankylosing spondylitis. Clin Orthop. 1985;194:142-52.
4. Thiranant N, Netrawichien P. Transpedicular decancellation closed wedge vertebral osteotomy for treatment of Şfixed şflexion deformity of spine in ankylosing spondylitis. Spine (Phila Pa 1976). 1993;18:2517-22.
5. Zheng GQ, Song K, Zhang YG, Wang Y, Huang P, Zhang XS, et al. Two-level spinal osteotomy for severe thoracolumbar kyphosis in ankylosing spondylitis. Experience with 48 patients. Spine (Phila Pa 1976). 2014;39:1055-8.
6. Van Royen BJ, De Gast A. Lumbar osteotomy for correction of thoracolumbar kyphotic deformity in ankylosing spondylitis: a structured review of three methods of treatment. Ann Rheum Dis. 1999;58:399-406.
7. Chen IH, Chien JT, Yu TC. Transpedicular wedge osteotomy for correction of thoracolumbar kyphosis in ankylosing spondylitis experience with 78 patients. Spine (Phila Pa 1976). 2001;26:E354-60 .
8. Bezer M, Kucukdurmaz F, Guven O. Transpedicular decancellation osteotomy in the treatment of post tuberculous kyphosis. J Spinal Disord Tech. 2007;20:209-15.
9. Murrey DB, Brigham CD, Kiebzak GM, Finger F, Chewning SJ. Transpedicular decompression and pedicle subtraction osteotomy (eggshell procedure). Spine (Phila Pa 1976). 2002;27:2338-45.
10. Song K, Zheng GQ, Zhang YG, Zhang X, Mao K, Wang Y. A new method for calculating the exact angle required for spinal osteotomy. Spine (Phila Pa 1976). 2013;38:E616-20.
11. Wang Y, Zhang Y, Mao K, Zhang X, Wang Z, Zheng G, et al. Transpedicular bivertebrae wedge osteotomy and discectomy in lumbar spine for severe ankylosing spondylitis. J Spinal Disord Tech. 2010;23:186-91.
12. Ayhan S, Aykac B, Yuksel S, Guler UO, Pellise F, Alanay A, et al; ESSG European Spine Study Group. Safety and efficacy of osteotomies in adult spinal deformity: what happens in the first year? Eur Spine J. 2016;25:2471-9.
13. LiuH, YangC, ZhengZ, Ding W, Wang J, Wang H, et al. Comparison of Smith-Petersen osteotomy and pedicle subtraction osteotomy for the correction of thoracolumbar kyphotic deformity in ankylosing spondylitis: a systematic review and meta-analysis. Spine (Phila Pa1976). 2015;40:570-9.
14. Arun R, Dabke HV, Mehdian H. Comparison of three types of lumbar osteotomy for ankylosing spondylitis:a caseseries and evolution of a safe technique for instrumented reduction. Eur Spine J. 2011;20:2252-60.
15. Halim A, Kiester D, Lee YP. Smith-Petersen and pedicle subtraction osteotomies. Seminars in Spine Surgery. 2017;29:91-9.
16. KimK-T, LeeS-H, SukK-S, LeeJ-H, JeongB-O. Outcome of pedicle subtraction osteotomies for fixed sagittal imbalance of multiple etiologies: a retrospective review of 140 patients. Spine (PhilaPa1976). 2012;37:1667-75.
17. Cho K-J, Bridwell KH, Lenke LG, Berra A, Baldus C. Comparison ofSmith-Petersen versus pedicle subtraction osteotomy for the correction of fixed sagittal imbalance. Spine (PhilaPa 1976). 2005;30:2030-7.
18. Chang KW, Cheng CW, Chen HC, Chang KI, Chen TC. Closing-opening wedge osteotomy for the treatment of sagittal imbalance. Spine (Phila Pa 1976). 2008;33:1470-7.
19. Lehmer SM, Keppler L, Buscup RS, Enker P, Miller SD, Steffee AD. Posterior transvertebral osteotomy for adult thoracolumbar kyphosis. Spine (Phila Pa 1976). 1994;19:2060-7.
20. Gertzbein SD, Harris MB. Wedge osteotomy for the correction of posttraumatic kyphosis. Spine (Phila Pa 1976). 1992;17:374-9.
21. Liu H, Qian BP, Qiu Y, Mao SH, Qu Z, Wang B, et al. Does the Traversing Length of the Aorta Change After Closing Wedge Osteotomy for Ankylosing Spondylitis Patients With Thoracolumbar Kyphosis?: A Magnetic Resonance Imaging Investigation. Spine (Phila Pa 1976). 2017;42:106-12.
22. Sansur CA, Fu KM, Oskouian Jr RJ, Jagannathan J, Kuntz 4th C, Shaffrey CI. Surgical management of global sagittal deformity in ankylosing spondylitis. Neurosurg Focus. 2008;24:E8.
23. Dorward IG, Lenke LG. Osteotomies in the posterior- only treatment of complex adult spinal deformity: a comparative review. Neurosurg Focus. 2010;28:E4.
24. Kiaer T, Gehrchen M. Transpedicular closed wedge osteotomy in ankylosing spondylitis: results of surgical treatment and prospective outcome analysis. Eur Spine. J 2010;19:57-64.
25. Bezer M, Ketenci IE, Saygi B, Kiyak G. Bicortical versus unicortical pedicle screws in direct vertebral rotation: an in vitro experimental study J Spinal Disord Tech. 2012;25:E178-82.

ORIGINAL ARTICLE
6

J Turk Spinal Surg 2020;31(1):6-10
DOI: 10.4274/jtss.galenos.2020.57

PAINFUL SCOLIOSIS AND OSTEOID OSTEOMA OF THE SPINE

Ali ÖNER[1], Alper KÖKSAL[1], Osman ÇİMEN[1], Osman Emre AYCAN[1], Yunus Emre AKMAN[2]

[1]*Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Clinic of Orthopedics and Traumatology, İstanbul, Turkey*
[2]*İstanbul Bilim University Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul, Turkey*

ABSTRACT

Objective: Osteoid osteoma (OO) is a benign tumor seen mostly in the second decades of life. Posterior elements are usually affected, and atypical scoliosis can occur in these patients. Aim of this study is to evaluate the results of surgical treatment in OO and to evaluate the fate of scoliosis.

Materials and Methods: Between 2005 and 2018, online hospital database search was conducted for a diagnosis of OO in the spine. Patient records were evaluated for recurrence and called for last follow-up.

Results: There were twelve patients (eight male, four female) operated due to spinal OOs, included in the study. Mean follow-up was 67.8 (13 to 139.7) months. Open surgery or radiofrequency ablation (RFA) were used for surgical treatment. Scoliosis was present in seven patients, and spontaneous correction was achieved postoperatively.

Conclusion: Atypical scoliosis may be the presenting symptom in juvenile and adolescents. Patients can be successfully treated by classic open surgery, and with RFA in last decade with a low recurrence rate. If the duration of symptoms is not prolonged and structural changes not occurred at diagnosis, spontaneous correction of scoliosis is achievable after treatment of spinal OOs.

Keywords: Osteoid osteoma, spine, atypical scoliosis, painful scoliosis

INTRODUCTION

Osteoid osteoma (OO) is the most common benign spinal tumor in children. OO comprises around 12% of benign bone tumors[1]. The etiology is unknown, and there is no report of malignant transformation. The presentation is in the first three decades of life, mostly in the second decade with male to female ratio of 2:1[2,3].

Tumor radius is less than 15 mm, most often localized in cortical bone, while it can be in subperiosteal, intraarticular, or in cancellous bone. Due to the small size and the complex anatomy of the spine, it can be hard to see on plain radiographs. However, an isolated area of reactive cortical thickening from periosteal bone formation can be seen. Thin slice computerized tomography (CT) or bone scintigraphy should be used if there is a high suspicion of OO clinically and the diagnosis with plain radiographs fails. In axial CT view, the nidus is seen as mineralized with a lucent halo and surrounded by a thick spherical or ovoid sclerosis. Bone scintigraphy shows increased activity. Magnetic resonance imaging (MRI) shows a large area of bone marrow and soft tissue edema, sometimes it can be confusing, which can lead to unnecessary further investigation for malignancy or infection[4].

Ten to twenty percent of OOs occur in the spine, localized in the posterior elements of the spine (pedicles, superior and inferior articular processes, lamina, transverse, and spinous processes) in 93% of cases, and the remaining lesions in the corpus[5]. Elevated cyclooxygenase expression and subsequent increased synthesis of prostaglandin is thought to be the reason for pathogenesis of pain in OOs[6,7]. Localized pain in the spine is the most prominent symptom that worsens at night and coronal deformity may accompany[2,8]. Atypical scoliosis is thought to be the result of muscle spam secondary to inflammatory effect around the tumor, and the lesion is usually on the concave side of the curvature[8-10]. Pain relief responds well to acetylsalicylic acid (ASA) or non-steroidal anti-inflammatory drugs (NSAID).

Preferred treatment depends on the intensity of the pain, and the presence of coronal deformity in spinal OOs. Conservative treatment with anti-inflammatory drugs (ASA or NSAIDs) is generally not acceptable due to the severity of pain and morbidity of analgesics. Lately, radiofrequency ablation (RFA) is used in the treatment of OOs[11]. Average duration of symptoms until surgical treatment is around 17 months-2.6 years[8,10]. Even though painful scoliosis develops at presentation in majority of cases, the incidence is quite variable[5,8,10,12-14]. Coronal shift or scoliosis secondary to OOs may become persistent or be

Address for Correspondence: Ali Öner, Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Clinic of Orthopedics and Traumatology, İstanbul, Turkey
E-mail: mail@alioner.com.tr **Received:** 22.12.2019 **Accepted:** 06.02.2020
ORCID ID: orcid.org/0000-0002-0438-8335

resolved in time, depending on the duration of symptoms and the age of the patient[8].

The purpose of this retrospective study was to evaluate the clinical and radiological results of the treatment and to evaluate the fate of scoliosis in the patients with surgically treated OO of the spine at a single center.

MATERIALS AND METHODS

After obtaining ethical committee approval from Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital Ethics Committee (date: 23.12.2019, decision no: 375), our tertiary hospital online database system was used to conduct a retrospective search. Patients with a diagnosis of OOs of the spine between 2005 and 2018 years were searched. Patients with insufficient data or patients with less than 12 months of follow-up were excluded.

Sixteen patients who were diagnosed as spinal OOs were found between the years of 2005 and 2018. Four patients were excluded from the study: two patients continued treatment at another center, another two patients had incomplete data and lost to follow-up. Therefore, twelve patients were included in the study. There were eight male and four female patients, with a mean age of 17.8 (7-34) years. The mean follow-up was 67.8 (13-139.7) months.

Radiographs, MRI and CT were used for radiological evaluation. Cobb angle and coronal shift measurements were performed on full spine PA and lateral radiographs. Physical examination, duration of symptoms till surgery, and neurological examination findings were recorded.

The patients were assessed according to the Enneking system for primary benign spine tumors[15], in which all patients had stage 2 lesions. Stage 2 lesion was defined as combined osteolytic and osteosclerotic image, with well-defined borders. Weinstein-Boriani-Biagini (WBB) surgical staging system was also used for preoperative planning[16]. Axial spine image was divided into 12 sections, beginning from left side of spinous process, turning clockwise, and also A to F defining soft tissue involvement.

OOs of the spine who could not comply with anti-inflammatory treatment or who had coronal deformity were all treated surgically until 2013. However, in selected cases of OOs, RFA has been the preferred method in our clinic, yet surgical excision has been used for RFA-inappropriate cases since 2013. Surgical excision with a posterior only approach was performed in nine patients and RFA was performed in four patients. The follow-up examinations were carried out in the 2nd week, 6th week, 3rd month, 6th month, and 1st year, then annually if there was no sign of recurrence.

Surgical Procedure

All patients were operated under general anesthesia. The lesion site was marked under fluoroscopy guidance. After appropriate antisepsis preparations and posterior midline approach to spine, fluoroscopy was used to control the spine level again. If tumor was at the inner cortex or in pedicle, high speed burr was used to remove the outer cortex/lamina to reach the OO. After the identification of the tumor tissue, aggressive curettage was performed. High speed burr was used to finish the borders of the tumor. If tumor location was suitable for en bloc resection, such as at the inferior or superior margin of lamina, osteotome or ultrasonic bone cutter (Misonix, Farmingdale, NY, USA) was used. If RFA was used, percutaneous kirschner wire or drill was used to approach the lesion under fluoroscopic guidance. The choice for the length of the probe, temperature and application time were determined according to the suggestions of RFA manufacturer.

RESULTS

Medical records of 12 patients were retrospectively reviewed, and the patients were called for last follow-up. Patient demographics, tumor locations, choice of treatment type, recurrence, preoperative and postoperative Cobb angles in scoliotic patients, follow-up and duration of symptoms were given in Table 1.

Scoliosis was present in seven patients preoperatively and was regressed at least 50% in six patients, and 40% regression was achieved in one patient.

There was recurrence in two lesions, both were treated primarily with RFA. In the first patient, the location of tumor was in the upper end plate, close to posterior cortex of the vertebral body of L4. Due to the difficulty in approaching the midline, posterior instrumentation was performed due to iatrogenic local instability after surgical resection. The lesion was placed in the right sacroiliac joint in the second patient. The pain was relieved for 6 months after RFA; however, due to progressive pain, a revision RFA was performed in the sacroiliac joint, and there was no recurrence in last follow-up for both patients.

Besides recurrences, there were no complications of surgical site infection and neurologic impairment.

DISCUSSION

Osteoid osteoma is a common benign primary bone tumor described by Bergstrand[17] in 1935 and Jaffe[18] described it as a distinct clinical entity. Nearly 3% of primary bone tumors are OO, which has a male predominance, yet a variety of male to female ratio was described previously (male to female ratio: 3:2 to 3:1)[5,12,14,19], with an incidence of 10% to 25% in the spine[14]. Even though the predilection sites of OOs in the spine involve the posterior column, the vertebral body can also be the location. Patients with osteoid osteoma in the spine usually have spinal stiffness in addition to pain.

X-ray examination has limitations in the diagnosis of OOs as the tumor is located in the posterior elements of the spine. Due to the complex anatomy of the spine, the diagnosis with X-ray alone was delayed historically. CT and MRI have been used more

Table 1. Patient demographics and study data were given in detail

No	Age	Gender	Tumor location	Treatment	Duration of symptoms (Months)	Primary surgery date	Recurrence	Follow up (Months)	Preop Cobb angle	Postop Cobb angle
1	15	M	L4 left lamina	Open surgery	4	13.06.2011	-	102	-	-
2	19	M	Sacroiliac, right	Primary: RFA Revision: RFA	7	12.11.2013	+	73	-	-
3	34	M	L4 Corpus upper endplate	Primary surgery: RFA Revision surgery: resection, posterior instrumentation	12	1.01.2017	+	36	-	-
4	16	M	T12	Resection	36	11.09.2013	-	75	50	30
5	14	M	L1 Right pedicle - lamina junction	Resection	5	29.09.2014	-	63	45	16
6	10	F	T11 Right pedicle	RFA	5	21.08.2919	-	13	21	0
7		F	L3	Resection	3	1.05.2008	-	140	16	5
8	21	M	T11 lamina	Resection	6	29.11.2017	-	25	12	5
9	23	M	L2 Corpus	RFA	16	23.05.2016	-	43	12	0
10	20	M	L4 Right pedicle - foramen	Resection	9	15.11.2018	-	13	10	8
11	7	F	T10	Resection	18	26.02.2009	-	130	-	-
12	18	F	L2 Left pedicle - corpus	Resection	31	20.07.2011	-	101	-	-

M: Male, F: Female, RFA: Radiofrequency ablation

frequently to diagnose patients with back pain in the last two decades, yet it is still difficult to diagnose OO in certain patients. Therefore, a bone scintigraphy should be obtained for diagnosis[5,20] before CT and MRI studies, or in cases where diagnosis failed with already studied CT and/or MRI, yet high clinical suspicion of OO persists. Bone scintigraphy reveals the osteoblastic activity of OO as "hot spot" and it is helpful in localizing the tumor, it directs the CT examination to the pathology level[5]. The nidus is best seen by CT as a lytic nidus surrounded by a margin of dense sclerotic rim.

RFA has gained popularity in the last decade. A single session of RFA eliminates 80% of lesions. If there is failure or recurrence of symptoms, RFA can be applied again, and 96% are treated with a second session. Recurrence is mostly seen in 6 months[21]. In our clinical experience, RFA was first used in 2013. However, we used RFA in only four out of eight patients later. Preoperative evaluation of thin CT slices and the location of the lesion determine the choice of surgical excision or RFA. According to WBB surgical staging system, soft tissue involvement is described as A. Extraosseous soft tissues, B. Intraosseous (superficial), C. Intraosseous (deep), D. Extraosseous (extradural), E. Extraosseous (intradural), and F. Vertebral artery involvement. We have been using the WBB system, especially soft tissue involvement part, to answer the following questions to decide the treatment: 1. Neurologically safe for RFA treatment? 2. Easy to reach with RFA? If answer is yes to both questions, RFA is preferred. In 2019, Yu et al.[22] reported the RFA indications as no neurological deficits, presence of intact cortical bone around lesions, and presence of cerebrospinal fluid (>1 mm) between the lesion and the nerve root (or spinal cord) on MRI. Since 2013, we have been using the same protocol. If the location of the pathology is close to the neural structures, where neural tissue damage is the focus of concern due to the thermal injury of RFA, such as the subperiosteal region of spinal canal or neural foramen, or inner cortex of the lamina, superior or inferior articular processes (WBB D-E lesions), we prefer surgical excision. RFA is the preferred method in cases where the tumor is inside the pedicle, vertebral body, the subperiosteal region of outer cortex or the outer cortex (WBB A-C lesions).

Neurologic deficit rate is between 0% and 37% of patients with OOs at presentation[5,10,12-14,23,24]. There were no cases with neurologic symptoms in our series. Neurologic symptoms appear in cases where tumor location is at the cortex or subperiosteal area of the inner cortex of posterior elements, or superior–inferior articular processes by the direct impingement of the tumor on neural tissue or by inflammation caused by the prostaglandins (PG) secreted from OOs (WBB staging D-E).

Aggravating nocturnal pain is the typical clinical manifestation. Even though nonsteroidal anti-inflammatory drugs (NSAIDs) or salicylates inhibit PG synthesis and are the first-line of treatment in extremity OOs, it is not always the case in spinal OOs. It takes about 33 months to resolve the symptoms with NSAIDs[25]. However, in patients with spinal deformity, the risk of structural transformation of the deformity becomes higher after 22 months[8], which canalizes the treatment to percutaneous or open surgical techniques. Yet, OOs of the spine without spinal deformity may be treated with NSAIDs, with careful monitoring for spinal deformity development and possible systemic complications for long-term use of NSAIDs. Patients in our series used NSAIDs for a short period. However, some of them complained that pain was not resolved to an acceptable level, and the rest of the patients who had less pain after NSAIDs objected using pain killer for a few years as a treatment of OO. For patients at the early stages of OO, pain may not be the main presenting symptom[26]. Coronal imbalance may accompany patients without pain in the early stages. Therefore, atypical scoliosis may still alert the clinician for search of OO in cases without pain.

The lumbar spine is the most commonly affected area, followed by the cervical, thoracic, and sacral regions. Distributions of anatomic location in our series were as one at the sacroiliac joint, seven in lumbar, four in thoracic spine, and none in the cervical region. Torticollis may accompany scoliosis or can be the sole symptom in cervical cases[5,24]. While there was no report of coronal imbalance in cases of sacral OOs, thoracolumbar spine OOs may present with coronal shift or scoliosis. The incidence of atypical scoliosis secondary to OO varies from 20% to 70% and scoliosis is mainly due to muscle spasms and chronic inflammatory reactions surrounding the tumor. There were seven patients (58.3%) with scoliosis in our series. Scoliosis was resolved spontaneously after RFA or open surgical excision in six patients (Figure 1), in whom the duration of symptoms was between 3 and 16 months, yet only 40% improvement was achieved in one case (from 50° preoperatively to 30° last follow-up) in which the duration of the symptoms was 36 months (Figure 2). Scoliosis seen in spinal OOs is usually postural and resolution of the curve is achieved by excision of the lesion. Since the most frequent presentation period of spinal OOs is the adolescence, an initial postural scoliosis may transform to structural scoliosis which has vertebral rotation[27]. The duration of symptoms and the age at the presentation time are the most important factors in the development of associated vertebral rotation, a structural scoliosis with a high magnitude of curve[8,27]. The expected ratio of spontaneous correction of scoliosis is lower when the duration of symptoms is longer.

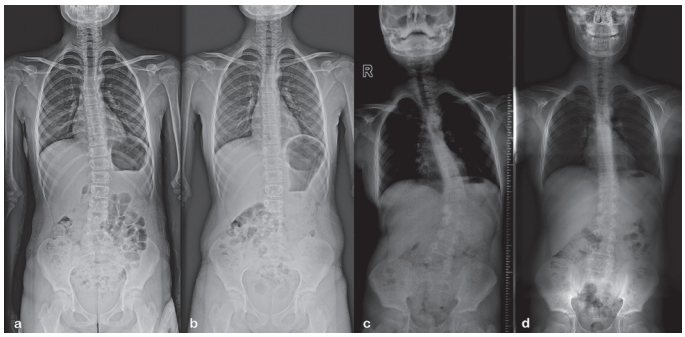


Figure 1. **a.** Female, 10 years old, lesion was at right pedicle of T11. Duration of symptoms was 5 months and RFA was preferred as treatment. **b.** Scoliosis regressed spontaneously after treatment from 21 degrees to normal in 13 months. **c.** Male, 14 years old, tumor was located at right pedicle–lamina junction. Cobb angle was 43 degrees preoperatively. Open surgery was performed. **d.** Scoliosis regressed to 12 degrees in 43 months
RFA: Radiofrequency ablation

Study Limitations

The limitations of the present study are the retrospective design, heterogeneity of the patients' group and the small sample size. Also, there is no information about the superiority of one treatment over the other, and upper limit for duration of symptoms is still in debate about spontaneous scoliosis correction. Therefore, multi-center prospective studies are necessary to evaluate these questions.

CONCLUSION

The upper limit for duration of symptoms to achieve spontaneous scoliosis correction depends on the location of the tumor, presence of neural symptoms, and skeletal maturity. After surgical excision or RFA treatment of scoliosis, total spontaneous correction of deformity is expected in patients without structural changes, and in patients with structural changes, scoliosis deformity can regress to some degree.

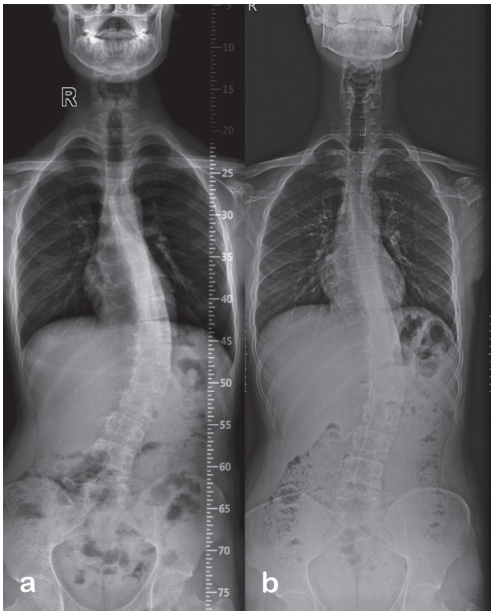


Figure 2. **a.** Male, 16 years old, tumor was located at T12, and duration of symptoms was 36 months. Open surgery was performed. **b.** Scoliosis regressed to 30 degrees

Ethics

Ethics Committee Approval: Ethical committee approval was obtained from Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital Ethics Committee (date: 23.12.2019, decision no: 375).

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: A.Ö., A.K., O.Ç., O.E.A., Y.E.A., Concept: A.Ö., Y.E.A., Design: A.Ö., Data Collection or Processing: O.Ç., O.E.A., A.K., Analysis or Interpretation: O.Ç., O.E.A., Literature Search: A.K., O.Ç., O.E.A., Writing: A.Ö., Y.E.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Greenspan A. Benign bone-forming lesions: osteoma, osteoid osteoma, and osteoblastoma. Clinical, imaging, pathologic, and differential considerations. Skeletal Radiology. 1993;22:485-500.
2. Jackson RP, Reckling FW, Mantz FA. Osteoid osteoma and osteoblastoma. Similar histologic lesions with different natural histories. Clin Orthop Relat Res. 1977:303-13.
3. Healey JH, Ghelman B. Osteoid Osteoma and Osteoblastoma Current Concepts and Recent Advances. Clin Orthop Relat Res. 1986:76-85.
4. Davies M, Cassar-Pullicino VN, Davies AM, McCall IW, Tyrrell PN. The diagnostic accuracy of MR imaging in osteoid osteoma. Skeletal Radiol. 2002:559-69.
5. Azouz EM, Kozlowski K, Marton D, Sprague P, Zerhouni A, Asselah F. Osteoid osteoma and osteoblastoma of the spine in children. Report of 22 cases with brief literature review. Pediatric Radiology. 1986;16:25-31.
6. Greco F, Tamburrelli F, Ciabattoni G. Prostaglandins in osteoid osteoma. Int Orthop. 1991;15:35-37.
7. Mungo DV, Zhang X, O'Keefe RJ, Rosier RN, Puzas JE, Schwarz EM. COX-1 and COX-2 expression in osteoid osteomas. J Orthop Res. 2002;20:159-62.
8. Balioglu MB, Albayrak A, Atici Y, Sökücü S, Tacal MT, Kaygusuz MA. The effect of simple local resection on pain and scoliotic curve in patients with scoliosis secondary to osteoid osteoma and osteoblastoma in the spine. Acta Orthop Traumatol Turc. 2016;50:330-8.
9. Kan P, Schmidt MH. Osteoid Osteoma and Osteoblastoma of the Spine. Neurosurgery Clinics of North America 2008;19:65-70.
10. Ozaki T, Liljenqvist U, Hillmann A, Halm H, Lindner N, Gosheger G, et al. Osteoid osteoma and osteoblastoma of the spine: experiences with 22 patients. Clin Orthop Relat Res. 2002:394-402.
11. Wang B, Han SB, Jiang L, Yuan HS, Liu C, Zhu B, et al. Percutaneous radiofrequency ablation for spinal osteoid osteoma and osteoblastoma. Eur Spine J. 2017:1884-92.
12. Pettine KA, Klassen RA. Osteoid-osteoma and osteoblastoma of the spine. J Bone Joint Surg Am. 1986;68:354-61.
13. Raskas DS, Graziano GP, Herzenberg JE, Heidelberger KP, Hensinger RN. Osteoid osteoma and osteoblastoma of the spine. J Spinal Disord. 1992;5:204-11.
14. Zileli M, Cagli S, Basdemir G, Ersahin Y. Osteoid osteomas and osteoblastomas of the spine. Neurosurg Focus. 2003;15:1-7.
15. Enneking WF. A system of staging musculoskeletal neoplasms. Clin Orthop Relat Res. 1986:9-24.
16. Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine (Phila Pa 1976). 1997;22:1036-44.
17. Bergstrand H. Uuber Eine Eigenartige, Wahrscheinlich Bisher Nicht Beschriebene Osteoblastische Krankheit in Den Langen Knochen Der Hand Und Des Fusses. Acta radiol. 1930;11:596-613.
18. Jaffe HL. Osteoid osteoma: a benign osteoblastic tumor composed of osteoid and atypical bone. Arch Surg. 1935;31:709-28.
19. Esteban Cuesta H, Martel Villagran J, Bueno Horcajadas A, Kassarjian A, Rodriguez Caravaca G. Percutaneous radiofrequency ablation in osteoid osteoma: Tips and tricks in special scenarios. Eur J Radiol. 2018;102:169-75.
20. Mandell GA, Harcke HT. Scintigraphy of spinal disorders in adolescents. Skeletal Radiology. 1993;22:393-401.
21. Vanderschueren GM, Obermann WR, Dijkstra SP, Taminiau AH, Bloem JL, Van Erkel AR. Radiofrequency ablation of spinal osteoid osteoma: clinical outcome. Spine (Phila Pa 1976). 2009;34:901-4.
22. Yu X, Wang B, Yang S, Han S, Jiang L, Liu X, et al. Percutaneous radiofrequency ablation versus open surgical resection for spinal osteoid osteoma. Spine J. 2019;19:509-15.
23. Wang GQ, Kang YJ, Lv GH, Li YW, Wang B. Osteoid osteoma leading to sciatica. Spine J. 2016;16:e315.
24. Etemadifar MR, Hadi A. Clinical Findings and Results of Surgical Resection in 19 Cases of Spinal Osteoid Osteoma. Asian Spine J. 2015;9:386-93.
25. Kneisl JS, Simon MA. Medical management compared with operative treatment for osteoid-osteoma. J Bone Joint Surg Am. 1992;74:179-85.
26. Aydinli U, Ozturk C, Ersozlu S, Filiz G. Results of surgical treatment of osteoid osteoma of the spine. Acta Orthop Belg. 2003;69:350-4.
27. Ransford A, Pozo JL, Hutton PA, Kirwan EO. The behaviour pattern of the scoliosis associated with osteoid osteoma or osteoblastoma of the spine. J Bone Joint Surg Br. 1984;66:16-20.

J Turk Spinal Surg 2020;31(1):11-7
DOI: 10.4274/jtss.galenos.galenos.2020.27

COMPARISON OF THREE DIFFERENT SURGICAL TREATMENT PROCEDURES USED IN THE TREATMENT OF LUMBAR SPINAL STENOSIS; RETROSPECTIVE CLINICAL STUDY

Ali Erhan KAYALAR[1], Orkhan MAMMADKHANLI[2], Suat CANBAY[3], Sait NADERI[1]

[1]Ümraniye Training and Research Hospital, Clinic of Neurosurgery, İstanbul, Turkey
[2]Medical Park Ankara Hospital, Clinic of Neurosurgery, Ankara, Turkey
[3]Yüksek İhtisas University Faculty of Medicine, Medical Park Ankara Hospital, Clinic of Neurosurgery, Ankara, Turkey

ABSTRACT

Objective: We aimed to compare the clinical results of three different surgical approaches (bilateral decompression via unilateral approach (BDUA), BDUA + fusion with unilateral instrumentation, total laminectomy and fusion with bilateral instrumentation) in the treatment of lumbar spinal stenosis.

Materials and Methods: The clinical and surgical aspects of 51 surgically treated patients with lumbar spinal stenosis were retrospectively reviewed.

Results: Duration of surgery, amount of bleeding, pain assessment visual analogue scale, length of stay (LOS), duration of mobilization, time required for return to work, complications and cost were analyzed. The mean postoperative low back VAS score was calculated to be 7.1 in group 1, 8.3 in group 2, and 8.6 in group 3. Significant decreases were found in the VAS scores of each group ($p<0.005$). In group 2 and group 3, delayed mobilization was the main cause of prolonged LOS.

Conclusion: In this study, comparing these three surgical procedures, we evaluated the VAS scores of the low backs and legs of the patients separately, and found no significant difference in the VAS scores of any group. Similarly, durations of surgery, blood loss during surgery, and the time required for return to work make BDUA more advantageous. Presence of severe low back pain and risk of iatrogenic instability may dictate the addition of unilateral fusion and instrumentation to surgery in selected cases.

Keywords: Spinal stenosis, laminectomy, fusion, unilateral instrumentation, decompression

INTRODUCTION

Lumbar spinal stenosis may appear in one or multiple spinal segments, and in central part or in lateral part of the spinal canal. Facet joint hypertrophy, ligamentum flavum hypertrophy, disc degeneration, unstable spine segment, or coexistence of one or more of these may have a role in pathology. Neurogenic claudication is the main symptom in cases not accompanied by significant instability[1].

Surgery is indicated for adequate spinal canal and nerve root decompression. For this purpose, surgical procedures such as total laminectomy unilateral laminotomy, bilateral laminotomies and open door laminoplasty have been performed. Fusion can be added to decompression in cases with existing preoperative instability and in cases with risk of iatrogenic instability[2,3].

Bilateral decompression via a unilateral approach (BDUA) was initially described by Young et al.[4] and then was modified by McCulloch[5]. In this technique, the risk of iatrogenic instability is reduced by preserving the facet joints.

Unilateral stabilization and contralateral decompression were considered to be effective in terms of operation time, surgical complications, and patient benefit visual analogue scale in comparison to other surgical techniques for the treatment of lumbar spinal stenosis.

There is no doubt that a fusion procedure should be performed in the presence of accompanying instability. However, in spinal stenosis cases without instability and spondylolisthesis less than grade 1, the role of spinal fusion is controversial. This is so because spinal instrumentation in degenerative spine may cause adjacent segment degeneration and disease. Therefore, procedures such as bilateral foraminotomy, BDUA, and

This study was presented in the "Unilateral Instrumentation-fusion and Bilateral Decompressive Surgery in Degenerative Lumbar Spinal Stenosis via Unilateral Approach; Advantages and Comparison to Different Approaches" XVI. World Congress of Neurosurgery, Program book, 242, as an oral presentation in İstanbul, Turkey in August 2017.
Address for Correspondence: Orkhan Mammadkhanli, Medical Park Ankara Hospital, Clinic of Neurosurgery, Ankara, Turkey
Phone: +90 538 943 88 13 **E-mail:** dr.mammadkhanli@gmail.com **Received:** 06.11.2019
Accepted: 10.01.2020 ORCID: orcid.org/0000-0003-3299-4196

endoscopic decompression, whereby adequate decompression can be ensured without creating iatrogenic instability, by using less invasive methods, has become popular[6,7]. The objective of this study is to compare the efficacy of BDUA with the efficacy of stabilization with decompression.

MATERIALS AND METHODS

The data of 51 patients operated with three different surgical procedures due to lumbar spinal stenosis were analyzed retrospectively. Informed consent was obtained from the patients.

Inclusion Criteria: Patients with spinal stenosis, who had no instability and spondylolisthesis less than grade 1 in their preoperative imaging tests; who had no concomitant pathologies such as inflammation and malignancy; and who had not undergone spinal surgery in the past, were enrolled in the study.

Exclusion Criteria: Patients with spinal stenosis, who had instability and spondylolisthesis higher than grade 1 in their preoperative imaging tests; who had pathologies such as inflammation and malignancy; and who had a history of spinal surgery, were excluded from the study.

Groups

Group 1 consisted of patients treated with BDUA; when we noticed instability of facet joints or removed more than 50% of facet joints, then we added instrumental fusion during surgery. Group 2 consisted of patients treated with BDUA plus instrumented fusion via a unilateral approach; and group 3 consisted of patients treated with total laminectomy and bilateral instrumentation as well as fusion.

Patients underwent lumbar flexion and extension radiographs in the postoperative period, in the 2nd month, 6th month, and 1 year after the surgery. We considered the patient as unstable when there were both back pain and the vertebral slippage.

Surgical Procedure

All of them were operated by posterior midline approach. It was performed unilaterally in group 1 and 2. In group 3, we used bilateral subperiosteal dissection as an approach. We used microscope (Zeiss).

Group 1: BDUA

All the surgical operations were performed under general anesthesia when the patients were placed in the prone position. Surgery was initiated from the side where the patient's complaints were dominant; and in patients with no findings regarding the sides, surgery was initiated from the side where stenosis was greater according to the lumbar computed tomography (CT) or magnetic resonance imaging (MRI) images. The bases of the spinous process as well as the upper and lower laminae were removed up to the free edge of the hypertrophic ligamentum, using a high-speed burr. The operating table was tilted to the opposite side so that the angle of the microscope faced towards to the other side. In consequence of these maneuvers, an angle of about 60° to 70° was achieved. After the removal of the opposite side and the spinous process, the ligamentum flavum was excised. In this way, decompression was performed on the both sides under a microscope, and then the operation was ended (Figure 1-2).

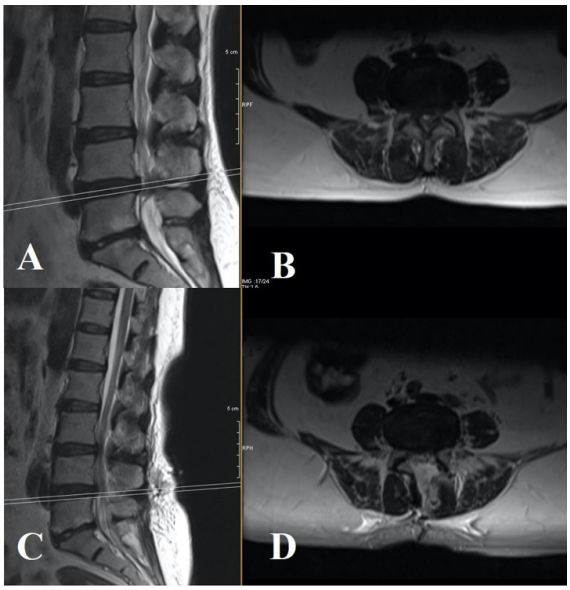


Figure 1. MR images of group 1
A. Preoperative Sagittal T2-weighted MR imaging showing the level of spinal stenosis
B. Preoperative Axial T2-weighted MR imaging showing narrowing spinal canal
C. Postoperative Sagittal T2-weighted MR imaging of patients
D. Postoperative Axial T2-weighted MR imaging showing bilateral decompression of spinal canal via a unilateral approach

MR: Magnetic resonance

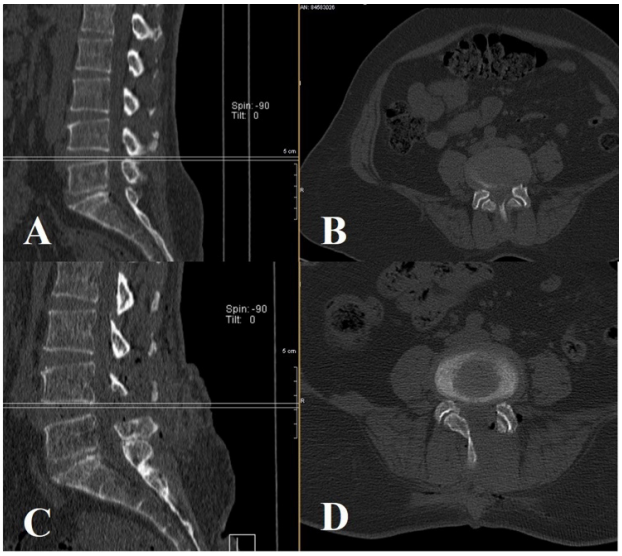


Figure 2. CT images of group 1
A. Preoperative Sagittal CT showing the level of spinal stenosis
B. Preoperative axial CT showing narrow spinal canal
C. Postoperative Sagittal CT demonstrating the level of decompression
D. Postoperative Axial CT showing bilateral decompression of spinal canal via a unilateral approach (bone window)

CT: Computed tomography

Group 2: BDUA + Fusion with Unilateral Instrumentation

In this group, transpedicular polyaxial screws were placed under fluoroscopy to each related vertebra. After that, a BDUA was performed. After BDUA, autogenous bone grafts were used for fusion. The bone grafts were placed on the lateral sides of the system and outside of the rod by decorticating the bone structures (Figure 3-4).

Group 3: Total Laminectomy and Fusion with Bilateral Instrumentation

In this group, after exposure, transpedicular polyaxial screws were placed under fluoroscopy to each vertebra on both sides. Total laminectomy was then performed on the preoperatively determined stenotic segments using a Kerrison Ronguer and high-speed drill under a microscope. After the decompression, the screws were fixed with rods. Autogenous bone grafts were used for fusion. The bone grafts were placed on the lateral sides of the system and outside of the rods by decorticating the bone structures (Figure 5-6).

RESULTS

Duration of surgery, amount of bleeding, pain assessment (VAS), length of stay (LOS), duration of mobilization, time required for return to work, complications and cost were analyzed.

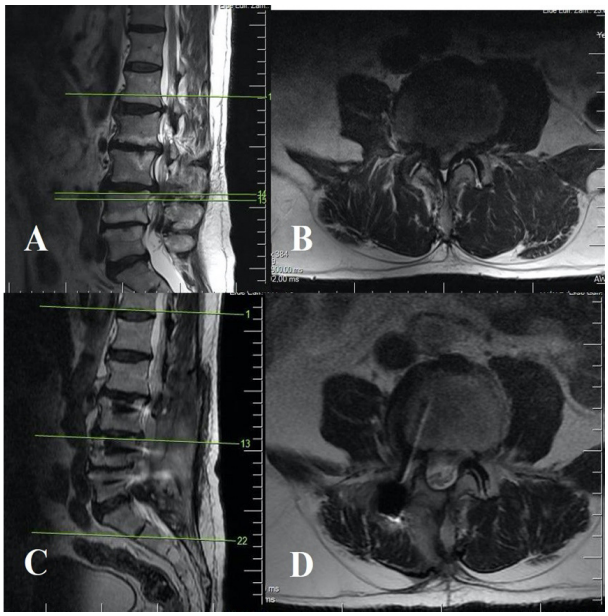


Figure 3. MR images of group 2
A. Preoperative Sagittal T2-weighted MR imaging showing the level of spinal stenosis at the level L3-4
B. Preoperative Axial T2-weighted MR imaging showing ligamentum flavum hypertrophy
C. Postoperative Sagittal T2-weighted MR imaging demonstrating laminectomy defect
D. Postoperative Axial T2-weighted MR imaging showing bilateral decompression and instrumentation via a unilateral approach
MR: Magnetic resonance

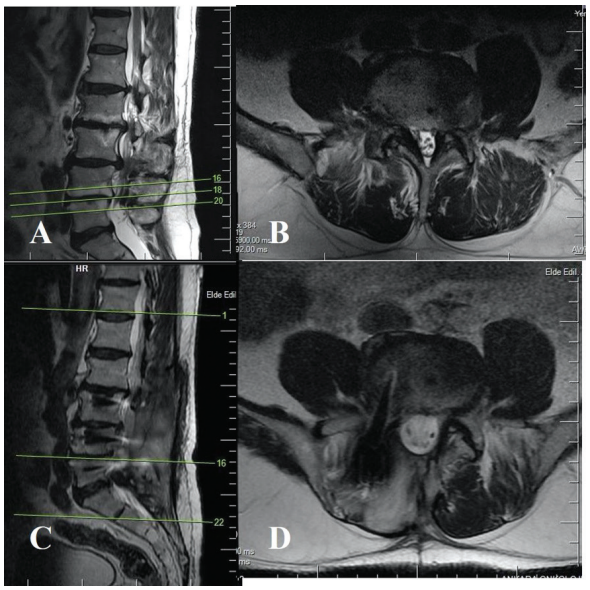


Figure 4. MR images of group 2
A. Preoperative Sagittal T2-weighted MR imaging the same patient showing the level of spinal stenosis at the level L4-5
B. Preoperative Axial T2-weighted MR imaging showing narrowing spinal canal
C. Postoperative Sagittal T2-weighted MR imaging demonstrating level of decompression
D. Postoperative Axial T2-weighted MR imaging showing bilateral decompression and instrumentation via a unilateral approach
MR: Magnetic resonance

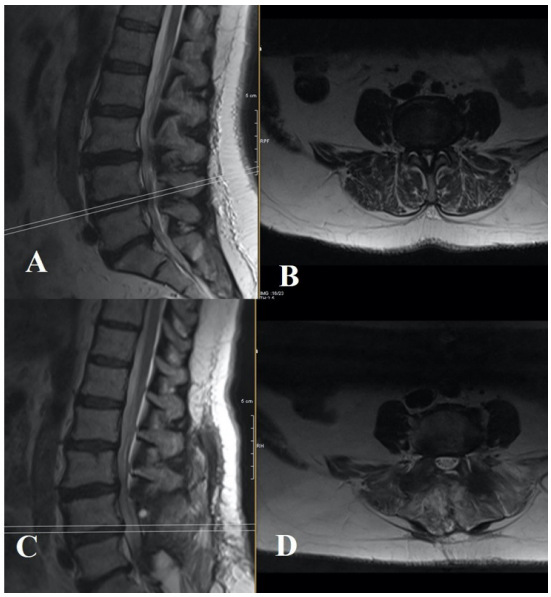


Figure 5. MR images of group 3
A. Preoperative Sagittal T2-weighted MR imaging showing the level of spinal stenosis
B. Preoperative Axial T2-weighted MR imaging showing narrowing spinal canal
C. Postoperative Sagittal T2-weighted MR imaging demonstrating laminectomy defect
D. Postoperative Axial T2-weighted MR imaging showing decompression of spinal canal
MR: Magnetic resonance

The demographic data of the patients are given in Table 1, data regarding the level of surgery are given in Table 2, and the complication rates are given in Table 3.

Duration of surgery: Duration of surgery was defined as duration from skin to skin. The mean duration was observed to be 94.7 minutes in group 1, 105.1 minutes in group 2, and 163.8 minutes in group 3. A significant difference was observed between each of these three groups in terms of duration of surgery ($p<0.005$).

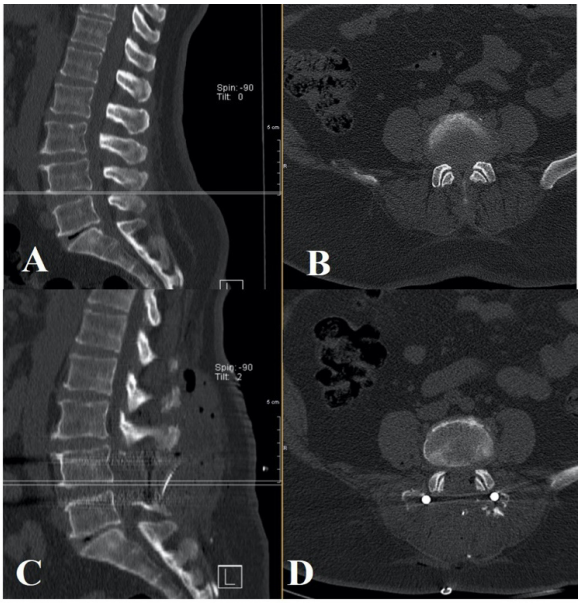


Figure 6. CT images of group 3
A. Preoperative Sagittal CT showing the level of spinal stenosis
B. Preoperative axial CT showing facet joint hypertrophy and narrowing spinal canal
C. Postoperative Sagittal CT demonstrating laminectomy defect
D. Postoperative Axial CT showing decompression of spinal canal and bilateral instrumentation materials
CT: Computed tomography

Table 1. Demographic data of patients

	Group 1	Group 2	Group 3
Number of patients	18	16	17
Female/Male	9/9	11/5	11/6
Age	63.3	65.7	55.8
Mean operation time (min)	94.7	105.1	163.8
Mean blood loss (cc)	70.4	75.2	275.5
Mean length of stay (day)	2.1	3.1	3.6
Mean follow-up period (month)	11	13	14
Mean Preoperative/ Postoperative VAS (leg)	8/2	8/2	8/3
Mean Preoperative/ Postoperative VAS (low back)	7/3	8/3	8/2

VAS: Visual anolog scale

Amount of bleeding: The amount of bleeding depended to the duration of surgery, the size of the surgical site, and the level of surgical procedure. The mean bleeding rate was 70.4 cc in group 1, 75.2 cc in group 2, and 275 cc in group 3 patients. Two patients in group 3 needed 1 unit of erythrocyte suspension (ES) replacement before surgery.

Assessment of pain: Road walking distances as well as the levels of numbness and pain in the legs after walking were assessed. Preoperative and postoperative low back pain and leg pain levels were assessed separately using the VAS. The mean preoperative Leg VAS score was calculated to be 8.3 in group 1, 8.5 in group 2, and 8.1 in group 3. The mean postoperative low back VAS score was calculated to be 7.1 in group 1, 8.3 in group 2, and 8.6 in group 3. Significant decreases were found in the VAS scores of each group ($p<0.005$) (Table 1).

Neurological condition: All of the patients have neurogenic claudication preoperatively and it was resolved postoperatively in all of them. Motor examination of 30 out of 51 patients showed 1/5 muscle strength of ankle dorsiflexion. It was improved in 2 months after operation.

Length of stay: The mean LOS in each of the three groups was calculated and assessed. The mean LOS was observed to be 2.1 days in group 1, 3.1 days in group 2, and 3.6 days in

Table 2. Number of patients based on operated levels

Level	Group 1	Group 2	Group 3
L3-4	1	1	3
L4-5	11	11	7
L3-4/4-5	4	4	4
L 3-4/4-5/5-1	2	-	-
L 2-3/3-4/4-5	-	-	3

Table 3. Complication rates

Complications	Group 1	Group 2	Group 3
Dura defect	5	2	2
Reoperation for dura repair	1	-	-
Wound site infection	-	1 (ab)	2 (ab + HBO)
Postoperative instability	2	-	-
Adjacent segment instrumentation and decompression	-	-	1
Need for microdiscectomy during follow-up	1	1	-
Instrumentation for the treatment of iatrogenic instability	1	-	-

ab: Antibiotic, HBO: Hyperbaric oxygen

group 3. Routinely antibiotherapy was stopped after the first postoperative day. The number of days of hospitalization that increased due to complications was also considered in the calculation of the days. In group 2 and group 3, delayed mobilization and postoperative routine antibiotherapy were the main causes of prolonged LOS.

Mobilization timing: In group 1 and group 2, early mobilization was performed 6 hours after the surgery, and the patients were discharged the next day. Group 3 patients were mobilized the next morning, and they were then discharged after antibiotherapy. All of the patients were mobilized with lumbosacral brace. The mobilization was unassisted. All of them received physical therapy for their abdominal and spine muscles 6 weeks after surgery.

Complications: The most common complications appeared as a screw malposition, dura defect, and surgical site infection. There were four patients in group 2 and four patients in group 3 with a screw malposition. None of them needed any operation since all of them were asymptomatic. The possibility of screw malposition increased depending on the number of screws used. The number of dural defects changed depending on the increase in the degree of stenosis of the patients, and increased depending on the number of decompressed levels. Surgical site infection increased depending on the increases in the duration of surgery, the amount of bleeding, blood replacement, and the size of the surgical site.

Group 1: Dura defect occurred in five patients, four of whom benefited from perioperative dura repair and one of whom was re-operated after 1 week for dura repair. One patient was given foraminal steroid injection due to leg pain after the 3rd month control examination. In one patient, discectomy was initially performed after the control lumber MRI performed due to pain suffered in the follow-up period; and then instrumentation was made due to the development of iatrogenic instability. Surgical operation was recommended to one of the patients due to postoperative instability, but the patient rejected it, and then physical therapy rehabilitation was recommended (There was a minimal slippage on postoperative X-ray compared to the preoperative films. Also, patient had a back pain and was considered as unstable. Pain was relieved after physical therapy).

Group 2: Two patients had perioperative dura defect and were treated during surgery. One patient was re-hospitalized due to wound site discharge and was given intravenous antibiotic therapy for a period of 10 days due to superficial wound infection. Upon the development of instability during follow-up period, physical therapy was recommended to one patient, who is currently followed up. The condition of one patient was evaluated with MRI due to the increased pain during the follow-up examinations, and then microdiscectomy was performed.

Group 3: In two patients, perioperative dura defect developed and was treated during surgery. Since a screw fracture was detected in one patient during the follow-up examination, the instrument was removed and then screw fixation was not repeated. Due to adjacent segment disease development detected during the follow-up examination of one patient, the instrument was extended to the upper level and total laminectomy was performed for the adjacent stenotic segment. Two patients were re-hospitalized due to wound site discharge and were given antibiotic therapy for a period of 10 days and 15 sessions of hyperbaric oxygen therapy. Since screw malposition was detected in the postoperative CT of one patient, he was re-operated and the screw was corrected the same day.

Cost: Considering the duration of surgery, LOS, possibility of need for blood transfusion, instrument materials used in surgery, possible complications and additional procedures to be performed to correct them, the cost-height ranking was thought to be group 3>2>1.

Length of follow-up: After their discharge, patients were invited for control examinations to be performed on the 7th day for wound examination and for the removal of the sutures, and in the 3rd and 12th months for pain assessment. The mean follow-up periods were 11, 13 and 14 months for group 1, group 2 and group 3, respectively.

DISCUSSION

The objective of surgery for lumbar spinal canal stenosis is the restoration of spinal canal width. Traditional treatment of spinal stenosis is extensive laminectomy, medial laminectomy or total laminectomy[1]. However, aggressive decompression may lead to spinal instability. Therefore, many surgeons add fusion to decompression[8,9].

Lumbar spinal fusion may be associated with pseudoarthrosis and adjacent segment disease in long-term. This makes spinal fusion procedure controversial. In this sense, the importance of minimally invasive surgical procedures for the decompression of spinal stenosis has increased. BDUA has been developed for this purpose and has taken its place as an effective option in the treatment of spinal stenosis[10,11]. We checked the existence of either loosening or pseudoarthrosis based on the lumbar flexion and extension X-ray, which were performed in the 2nd month, 6th month, and a year after surgery. None of the patients developed screw loosening and pseudoarthrosis.

In classical extensive laminectomy, supraspinous and interspinous ligament complexes may be destroyed, resulting in iatrogenic spinal instability[12]. Spondylisthesis may progress as a consequence of the removal of more than 50% of the facet joints[2]. In BDUA, a significant portion of this ligament complex and facet joints are preserved. This surgical technique reduces the risk of instability; and therefore, does not require the addition of fusion to surgery[9].

In the literature, good clinical results were reported after BDUA (87% success in a 9-month follow-up, and 82% in a one-year follow-up, 70-88% in an 18-month follow-up, 67% in a two-year follow-up, and 68% in a four-year follow-up). As the follow-up periods of studies prolong, a decrease in success draws attention[13].

Cavuşoğlu et al.[14] found the patient's satisfaction rate to be 94% and the recovery rate to be 96% during the 18-24-month follow-up periods of patients with BDUA. In their study comparing clinical and radiological results of BDUA and classical laminectomy, Yaman et al.[15] found differences in VAS scores of leg pain in the postoperative 6th and 12th months. However, low back pain VAS scores in patients with BDUA were found to be significantly lower. In their randomized clinical study comparing BDUA with decompression and involving 79 patients, Choi et al.[16] showed that BDUA was as effective as open decompression in the improvement of ODI scores. In our study, VAS was used to determine patient's satisfaction. The mean VAS change of all these three groups was calculated to be between 60 and 80%.

Park et al.[17] compared the patients that they treated with ipsilateral and contralateral canal decompression by using unilateral laminectomy. In their study, the improvement rate of VAS was 75.4% for the ipsilateral side and 73.7% for the contralateral side of each leg. No significant difference was found between the two sides when they were compared with each other.

Another advantage of BDUA is that the paravertebral muscles open unilaterally. Radiological and electromyography findings of atrophy that develops in consequence of bilateral opening and retraction of the paraspinal muscles have been shown in a large number of studies. Unilateral and more limited retraction of BDUA allows for more preservation of the paraspinal muscles[18]. Similarly, less blood loss is observed in BDUA. Krut'ko[19] found less blood loss in BDUA procedure compared to blood loss in the standard technique. One of the advantages of this procedure is that less muscle is detached, and less blood loss is observed in minimally invasive techniques as a result of more limited resections. In the study carried out by Cavuşoğlu et al.[14], transfusion of ES was required for some patients in the classical laminectomy group. However, transfusion was not performed in patients in the BDUA group. In our study, blood loss was measured in each of the three groups. The mean blood loss was 70cc in group 1 and group 2, and over 200 cc in group 3.

In the literature, durotomy during laminectomy has been reported to be in rates ranging from 5 to 15%. In their study involving 40 patients, Cavuşoğlu et al.[14] reported three durotomy complications in the classical laminectomy group, and two in the BDUA group. This rate ranges from 3 to 5% in BDUA. In the study carried out by Park et al.[17], this rate was 5.1%. Durotomy is a fearful complication for surgeons, but in the BDUA procedure and similar minimally invasive approaches, surgeons work through a smaller window; and therefore, there is no significant difference in durotomy rates compared to rates in classical laminectomy. In our study, dural tear rate was about 25% in group 1, 12,5 % in group 2, 11,7 % in group 3 (group 1–five patients, group 2–two patients, and group 3–two patients).

As another advantage, adjacent segment disease does not develop in BDUA. As is known, adjacent segment degeneration and adjacent segment disease may develop after stabilization in degenerative cases[20,21]. This condition may require surgery after some time. This means both increased complication and re-operation can increase the total cost[9,22]. In current series, adjacent segment disease was observed in group 1 and group 2. One patient in group 3 was operated due to adjacent segment disease.

Therefore, total laminectomy and bilateral decompression are losing their popularity with each passing day.

As an alternative, BDUA can be performed with intent to avoid bilateral dissection and provide stabilization in patients with low back pain due to degenerative spine disorders. With this procedure, results equivalent to those in bilateral intervention have been reported[23]. The instrumentation was compared, and unilateral stabilization was found to be advantageous in terms of the duration of surgery, cost and complication[24].

In addition, Mao et al.[25] revealed that unilateral stabilization was less rigid than bilateral stabilization, and therefore, led to less adjacent segment degeneration.

When we analyzed our case series, we found that the BDUA procedure was more successful, in many ways than the classic methods using bilateral decompression and stabilization, particularly in patients with neurogenic claudication and leg pain. When considering complication rates, LOS, and additional treatment requirements in follow-up periods, we found BDUA to be an adequate treatment procedure for appropriate indications. When we compared our patients treated with unilateral screw fixation in group 2 with other patients, BDUA appeared to be the right treatment option for patients with appropriate indications because it involved less instrument materials than those used in the classical procedure, displayed lower duration of surgery rates, shorter hospital stay, and less complication, and there was a decrease in pain symptoms at similar rates.

CONCLUSION

Lumbar spinal stenosis is among a group of diseases that we usually treat with surgery in spine surgery practice. The surgical treatment options include simple unilateral lumbar decompression, unilateral decompression plus unilateral fusion, bilateral decompression, and bilateral fusion. In this study, comparing these three surgical procedures, we evaluated the VAS scores of the low backs and legs of the patients separately, and we found no significant difference in the VAS scores of any group. Similarly, durations of surgery, blood loss during surgery, and the time required for return to work make BDUA more advantageous. The presence of severe low back pain and risk of iatrogenic instability may dictate the addition of unilateral fusion and instrumentation to surgery in selected cases.

Ethics

Ethics Committee Approval: Ethical approval have not been taken for the retrospective study.

Informed Consent: Informed consent was obtained from the patients.

Authorship Contributions

Surgical and Medical Practices: S.C., Concept: S.N., Design: O.M., Data Collection or Processing: A.E.K., Analysis or Interpretation: S.N., Literature Search: A.E.K., Writing: S.C.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Kayalar AE, Onen MR, Gerilmez A, Naderi S. A Cost-Effectiveness Analysis of Bilateral Decompression via Unilateral Approach versus Instrumented Total Laminectomy and Fusion for Lumbar Spinal Stenosis. Turk Neurosurg. 2019;29:643-50.
2. Phan K, Mobbs RJ. Minimally invasive versus open laminectomy for lumbar stenosis: a systematic review and meta-analysis. Spine (Phila Pa 1976). 2016;41:E91-E100.
3. Usman M1, Ali M, Khanzada K, Ishaq M, Naeem-ul-Haq, Aman R, et al. Unilateral approach for bilateral decompression of lumbar spinal stenosis: a minimal invasive surgery. J Coll Physicians Surg Pak. 2013;23:852-6.
4. Young S, Veerapen R, O'Laoire SA. Relief of lumbar canal stenos is using multi level subarticular fenestrations as an alternative to wide laminectomy: preliminary report. Neurosurgery. 1988;23:628-33.
5. McCulloch JA. Microsurgical Spinal Laminotomies in The Adult Spine: Principles and Practice. J.W. Frymoyer, ed. New York: RavenPress, Ltd., 1991
6. Aryanpur J, Ducker T. Multilevel lumbar laminotomies: An alternative to laminectomy in thetreatment of lumbar stenosis. Neurosurgery. 1990;26:429-32; discussion 433.
7. Chatani K. A novel surgical approach to the lumbar spine in volving hemilateral split-off of the spinous process to preserve the multifidus muscle: technical note. J Neurosurg Spine. 2016;24:694-9.
8. Johnsson KE, Willner S, Johnsson K. Postoperative instability after decompression for lumbar spinal stenosis. Spine (Phila Pa 1976). 1986;11:107-10.
9. Katz JN, Lipson SJ, Lew RA, Grobler LJ, Weinstein JN, Brick GW, et al. Lumbar laminectomy alone or with instrumented or noninstrumented arthrodesis in degenerative lumbar spinal stenosis. Patient selection, costs, and surgical outcomes. Spine (Phila Pa 1976). 1997;22:1123-31.
10. Detwiler PW, Spetzler CB, Taylor SB, Crawford NR, Porter RW, Sonntag VK. Biomechanical comparison of facet-sparing laminectomy and Christmastree laminectomy. J Neurosurg. 2003;99(2 Suppl):214-20.
11. Kleeman TJ, Hiscoe AC, Berg EE. Patient out comes after minimally destabilizing lumbar stenosis decompression: the "Port-Hole" technique. Spine (Phila Pa 1976). 2000;25:865-70.
12. Tuite GF, Stern JD, Doran SE, Papadopoulos SM, McGillicuddy JE, Oyedijo DI, et al. Outcome after laminectomy for lumbar spinal stenosis: Part I: Clinical correlations. J Neurosurg. 1994;81:699-706.
13. Thome C, Zevgaridis D, Leheta O, Bazner H, PocklerSchoniger C, Wohrle J, et al. Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy. J Neurosurg Spine. 2005;3:129-41.
14. Cavuşoğlu H, Türkmenoğlu O, Kaya RA, Tuncer C, Colak I, Sahin Y, et al. Efficacy of unilateral laminectomy for bilateral decompression in lumbar spinal stenosis. Turk Neurosurg. 2007;17:100-8.
15. Yaman O, Ozdemir N, Dagli AT, Acar E, Dalbayrak S, Temiz C. A Comparison of Bilateral Decompression via Unilateral Approach and Classic Laminectomy in Patients with Lumbar Spinal Stenosis: A retrospective Clinical Study. Turk Neurosurg. 2015;25:239-45.
16. Choi WS, Oh CH, Ji GY, Shin SC, Lee JB, Park DH, et al. Spinal canal morphology and clinical outcomes of microsurgical bilateral decompression via a unilateral approach for lumbar spinal canal stenosis. Eur Spine. J 2014;23:991-8.
17. Park WB, Hong JT, Lee SW, Sung JH, Yang SH, Kim IS. Clinical and Radiological Comparison between Ipsilateral and Contralateral Side Canal Decompression Using an Unilateral Laminotomy Approach. Korean J Spine. 2016;13:41-6.
18. Mayer TG, Vanharanta H, Gatchel RJ, Mooney V, Barnes D, Judge L, et al. Comparison of CT scan muscle measurements and isokinetic trunk strength in postoperative patients. Spine (Phila Pa 1976). 1989;14:33-6.
19. Krut'ko AV. Results of decompressive-stabilizing procedures via unilateral approach in lumbar spinal stenosis. Zh Vopr Neirokhir Im N N Burdenko. 2012;76:33-40.
20. Ha K-Y, Schendel MJ, Lewis JL, Ogilvie JW. Effect of immobilization and configuration on lumbar adjacent-segment biomechanics. J Spinal Disord. 1993;6:99-105.
21. Shono Y, Kaneda K, Abumi K, McAfee PC, Cunningham BW. Stability of posterior spinal instrumentation and its effects on adjacent motion segments in the lumbosacral spine. Spine (Phila Pa 1976). 1998;23:1550-8.
22. Kuntz KM, Snider RK, Weinstein JN, Pope MH, Katz JN. Cost-effectiveness of fusion with and without instrumentation for patients with degenerative spondylolisthesis and spinal stenosis. Spine (Phila Pa 1976). 2000;25:1132-9.
23. Kabins MB, Weinstein JN, Spratt KF, Found EM, Goel VK, Woody J, et al. Isolated L4–L5 fusions using the variable screw placement system: Unilateral versus bilateral. J Spinal Disord. 1992;5:39-49.
24. Fernández-Fairen M, Sala P, Ramírez H, Gil J. A prospective randomized study of unilateral versus bilateral instrumented posterolateral lumbar fusion in degenerative spondylolisthesis. Spine (Phila Pa 1976). 2007;32:395-401.
25. Mao L, Chen GD, Xu XM, Guo Z, Yang HL. Comparison of lumbar interbody fusion performed with unilateral or bilateral pedicle screw. Orthopedics. 2013;36:e489-93.

ORIGINAL ARTICLE
18

J Turk Spinal Surg 2020;31(1):18-23
DOI: 10.4274/jtss.galenos.2019.49

MINIMAL SUPERIOR ARTICULAR PROCESS REMOVAL OF FACET JOINT IN LATERAL INTERPEDICULAR APPROACH COULD PROVIDE A BETTER EXPOSURE IN FAR LATERAL DISC HERNIATION TREATMENT: A TECHNICAL REPORT

Halil CAN[1], Atilla KIRCELLİ[2]

[1]Biruni University Faculty of Health Sciences, Department of Neurosurgery, İstanbul, Turkey
[2]Başkent University, Department of Neurosurgery, İstanbul, Turkey

ABSTRACT

Objective: To assess the results of 28 patients who underwent lateral interpedicular surgical approach (LISA) and to compare the outcomes with the current literature.

Materials and Methods: Twenty-eight patients with far lateral lumbar disc herniation (FLLDH) undergoing LISA between 2015 and 2018 were retrospectively analyzed. Extruded or sequestered far lateral lumbar disc herniations, which cause radiculopathy, were included in this study. A visual analogue scale (VAS) and patient's subjective comment on the result of surgery with Mac Nab Classification were recorded at the pre- and post-operative follow-ups.

Results: There were 15 males and 13 females. The mean age was 50.5± 9.65 years. Two patients had L2-3 herniations, 11 had L3-4, and 15 had L4-5. The mean duration of operation was 48.8±8.7 minutes. Preoperative VAS scores (9.32±0.61) were found to decline to 0.78±0.57. The Mac Nab Classification of the postoperative 6th month results yielded 78.5% to be excellent, 14.2% to be good and 7.1% to be fair. There were no complications, including CSF leak, nerve injury or hematomas.

Conclusion: The LISA is a minimally invasive, safe and simple procedure for FLLDH surgery with short hospital stay and duration of operation and with low complication rates.

Keywords: Far lateral disc herniation, lateral interpedicular approach, superior articular process, facet joint

INTRODUCTION

A far lateral lumbar disc herniation (FLLDH) is building of the disc material into the area that is lateral to the superior and inferior pedicles[1]. A FLLDH causes exiting nerve root compression, contrary to paramedian discs, which compress the nerve root at the level below[2]. Far lateral compartment is delineated as the area lateral to the superior and inferior pedicles, where the disc is located anteriorly, leading edge of the superior articular facet medially and the facet joint posteriorly[3-5]. 7-12% of all lumbar disc herniations are found to be FLLDH[6-8]. Postacchini and Montanaro[9] defined the disc herniations lateral to the pedicle as "extreme lateral disc herniations, which is also used by Fankhauser and Trilobet [10,11] however, some authors prefer the term "extraforaminal"[9-13]. In recent studies, lateral disc herniations have been referred to as FLLDHs [2].

Macnab[14] reported two cases of extraforaminal L5-S1 disc herniations leading L5 root compression, following a failed exploration at the L4-5 level in 1971. In 1974, Abdullah et al.[15] described the extreme lateral lumbar disc herniations for the first time.

Clinical characteristics of FLLDHs differentiated from paramedian disc herniations, such as sharper radicular pain due to direct compression of the dorsal root ganglion and acute onset[16]. Compression of the exiting nerve root and dorsal root ganglion causes some clinical symptoms[1]. Compared to paramedian disc herniations, FLLDHs are more prone to be at the upper lumbar levels and to have adjacent pathologies like paramedian or foraminal disc herniations and spinal stenosis at the same level[16].

This study aims to present anatomical landmarks of the lateral interpedicular approach without opening the intertransverse fascia, as well as the route followed, and to ensure that this surgical approach becomes safer via identifying exiting root and dorsal root ganglion earlier. Accordingly, figures obtained from out fresh cadaver dissections and our clinical experiences of 28 cases were presented in this study.

Address for Correspondence: Atilla Kırcelli, Başkent University, Department of Neurosurgery, İstanbul, Turkey
E-mail: atillakircelli@gmail.com **Received:** 08.12.2019 **Accepted:** 29.01.2020 **ORCID ID:** orcid.org/0000-0003-2109-1274

MATERIAL AND METHODS

Patients and Methods

For this research, 28 patients with FLLDHs undergoing lateral interpedicular (lateral micro neurosurgical) surgical approaches (LISA) between 2015 and 2018 were retrospectively analyzed. This study was a single-center analysis and all operations were done with informed consent of the patients. This is a retrospective study performed in accordance with Helsinki Declarations and it was reported from patients' files. A detailed neurological examination was performed in each patient with FLLDHs confirmed by a neuroradiological imaging.

Inclusion criteria were defined as:

- At least one month of severe leg pain (with or without low back pain),
- A radiologically documented extruded or sequestered far lateral disc herniation with or without foraminal component,
- Positive straight-leg raising or femoral stretch test upon neurological examination,
- Having motor or/and sensory deficit.

We excluded patients with tumors, infections, bleeding disorders, and L5-S1 disc herniations due to high iliac crest.

A visual analogue scale (VAS) was performed pre- and post-operatively in order to evaluate pain. Patient's subjective opinion was categorized as excellent (no pain), good (some pain), fair (moderate pain) or poor (unchanged or worse) depending on the MacNab classification. This study was approved by The Council of Forensic Medicine (decision no: ATK 0.01.00.08/74).

Surgical Technique

In the operating room, after attaching the patient to monitoring equipment and placing an intravenous catheter, the patient was anesthetized and fixed in a prone position. C-arm fluoroscopic guidance of the lumbar level was conducted, sterile draping was applied, and a 3-5 cm midline-vertical skin incision was made. Paravertebral muscle fascia was cut along the midline and blunt dissection of the paravertebral muscles was done. In order to expose the junction of the upper and lower facets, two thin Taylor retractors were then placed, one on the facet where the herniation was located and the other on the facet above. The inferior and superior facet joints and pars interarticularis were visualized under a surgical microscope (Figure 1).

First, a minimal bone resection was made from lateral to medial, at the inferior aspect of pars interarticularis, using a Kerrison rongeur. Then, the approach proceeded to the superior of pars interarticularis and inferior aspect of pars-facet junction. Minimal bone removal of superior articular process of the facet provided better exposure of the disc space (Figure 2). Minimal bone resection to recognize the root was performed at the inferior facet joint of the upper vertebrae and very limited bone resection was done at pars-facet joint junction of the inferior vertebrae (Figure 3). Visualization of the lateral aspect of the facet joint and transverse process, as well as the intertransverse muscle and intertransverse fascia, was not needed.

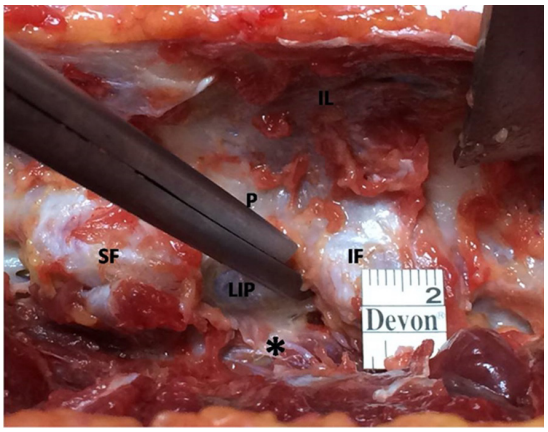


Figure 1. A picture from fresh cadaveric dissection. The inferior facet joint, superior facet joint, and pars interarticularis were exposed
SF: Superior facet joint, IF: Inferior facet joint, P: Pars interarticularis, IL: Interlaminar area, LIP: Lateral interpedicular area, *: Intertransverse muscle and fascia

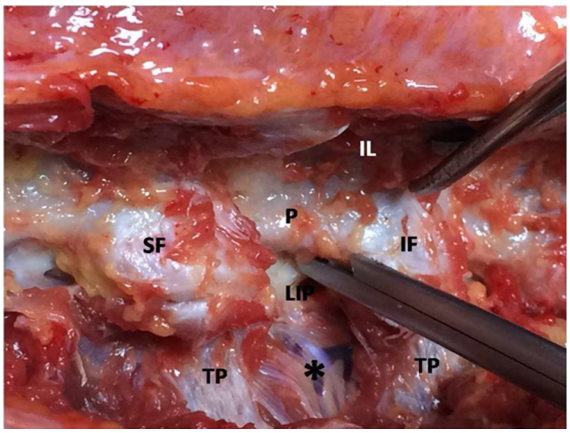


Figure 2. A picture from fresh cadaveric dissection. A minimal bone resection was performed from the lateral inferior aspect of the pars interarticularis to the medial aspect using a Kerrison rongeur
SF: Superior facet joint, IF: Inferior facet joint, TP: Transverse process, P: Pars interarticularis, IL: Interlaminar area, LIP: Lateral interpedicular area, *: Intertransverse muscle and fascia

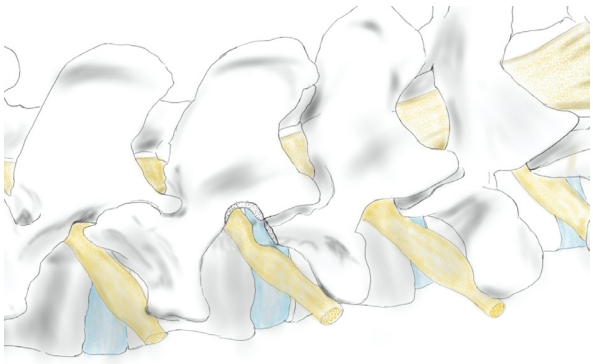


Figure 3. Pictogram, bone removal of superior articular facet and pars interarticularis

At the beginning of the surgery, exiting nerve root at the medial aspect of the upper pedicle at the same level, was exposed via limited resection of the inferior facet joint of the upper vertebrae (Figure 4).

Then, the exiting nerve root was palpated at the level where it exited, using a blunt nerve hook. Subsequently, exiting nerve root was completely exposed to the resection of pars-facet joint junction of the inferior vertebrae. Since there was no need to visualize lateral aspect of the facet joint and transverse processes, intertransverse muscle and fascia were not opened (Figure 1, 2, 4).

Veins, that were located at the medial aspect of the exiting nerve root, were coagulated with bipolar cautery. Disc fragment, sequestered or extruded, were palpated using a blunt nerve hook and removed (Figure 5).

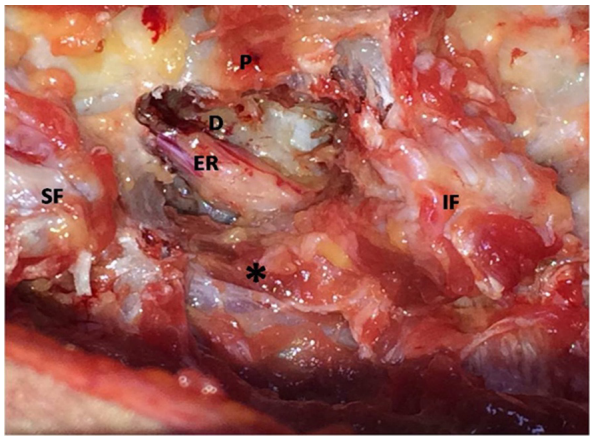


Figure 4. A picture from fresh cadaveric dissection. The nerve root exiting from the medial aspect of the upper pedicle was exposed via minimal bone resection at the superior and inferior facet joint and pars interarticularis
SF: Superior facet joint, IF: Inferior facet joint, P: Pars interarticularis, ER: Exiting nerve root, D: Intervertebral disc, *: Intertransverse muscle and fascia

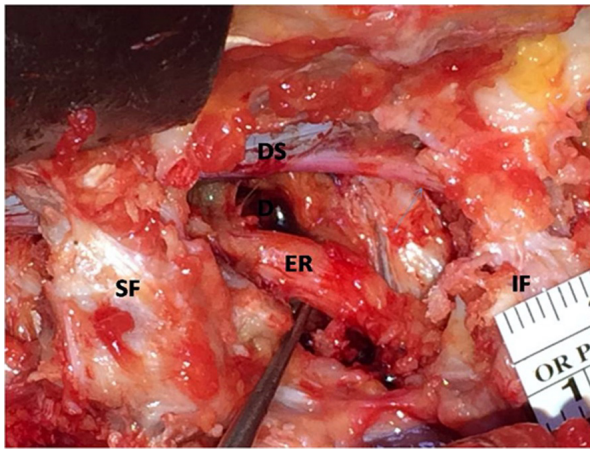


Figure 5. A picture from fresh cadaveric dissection. Pars interarticularis is completely removed
SF: Superior facet joint, IF: Inferior facet joint, blue arrow: Traversing root, ER: Exiting nerve root, D: Intervertebral disc, DS: Dural sac,*: Intertransverse muscle and fascia

Entering the disc space, bone removal was made laterally through medial aspect of pars and caudally from the superior articular process of the inferior vertebra using a Kerrison rongeur. Following the incision of the posterior longitudinal ligament, far lateral disc fragments with foraminal components were removed. A discectomy was performed and hemostasis was achieved in all patients, who were then closed up and extubated. Each patient was monitored in the unit during the early postoperative period, mobilized at the same day and discharged the following day.

All patients were assessed pre- and postoperatively for pain according to a VAS and the postoperative MacNab criteria.

Statistical Analysis

SPSS v21 for Windows (IBM Corp., Armonk, NY, USA) was used to analyze our data. Means ± standard deviations were used for normally distributed continuous variables [p>0.05 in Kolmogorov-Smirnov test or Shapiro-Wilk (n<30)] and paired T test was used to compare them. Non-normally distributed variables were defined as medians and compared using Kruskal-Wallis test. To investigate the relationship between the factors, Spearman's rank correlation coefficient was used. A p value below 0.05 was regarded as statistically significant.

RESULTS

This study included 28 retrospectively analyzed patients with FLLDHs. Out of 28 patients, two underwent surgery for FLLDHs at L2-3, 11 at L3-4 and 15 at L4-5 levels. Fifteen were male and 13 were female, with a mean age of 50.6±9.67 years. The mean duration of complaints was 5.7 weeks. Neurological examination of the patients yielded, positive femoral nerve stretch test in 82.1% and positive Laseque's sign in 10.7%. Seven point one percent of the patients had both tests positive. Overall, 67.8% had motor deficits, whereas 78.5% had sensory deficits.

Preoperative magnetic resonance imagings revealed that 46.6% of the patients had both far lateral disc herniations and foraminal fragments, while 57.6% had only far lateral disc herniation. Forty-six point four percent underwent sequestrectomy, 32.1% sequestrectomy and discectomy, and 21.4% discectomy. The mean operation surgery was 48.8±8.7 minutes.

There was no nerve root injury, cerebrospinal fluid leak, hematomas or infections at the operation site. At the 6th month follow-up assessment, VAS score was found to decline from 9.32±0.61 to 0.78± 0.57 (p<0.0001). MacNab classification evaluation showed the patient satisfaction to be excellent in 78.5%, good in 14.2%, and fair in 7.1%. A previously existing dysesthesia progressed in one patient and was managed with medical treatment. There was no segmental instability on the postoperative 6th month lumbar computed tomography scans (Figure 6).

DISCUSSION

Abdullah et al.[15] reported the clinical characteristics of FLLDHs in order to distinguish them from paramedian disc herniations for the first time in 1974. At that point, neurosurgeons were less familiar with FLLDHs since they could not be demonstrated via myelography or due to limited exploration. Following the evaluation of neuroradiological modalities, FLLDHs with or without foraminal components become more well-known[17].

FLLDHs constitute 7-12% of all disc herniations that are located in lumbar area[6-8]. Associated radicular leg pain is due to direct compression of both exiting nerve root and the dorsal root ganglion[7]. Park et al.[16] suggested that radicular leg pain was more severe in FLLDHs compared to paramediandis herniations. They also reported that this phenomenon was associated with more acute onset of symptoms before surgery (64 days vs 31 days). In our study, patients with extruded discs which were migrated superolaterally into the neural foramen were found to have shorter duration of symptoms when compared to those without migration. This was explained with the fact that migrated discs caused more direct irritation of the dorsal root ganglion.

In a study of over 200 cases of FLLDH, including cadaver dissections, Schlesinger et al.[18] suggested that craniocaudally the bone amount that had to be removed increased while working space decreased. They also reported, in the lower levels, the disc space was located more inferior than the attentive facet joint compared to upper levels. Therefore, an increased amount of bone had to be removed from the superolateral aspect of the facet joint and pars interarticulars, thus the dorsal root ganglion could be easily visualized with this exposure[18]. Similarly, in our clinical series and cadaver dissections, there was an increased amount of bone and the far lateral compartment and disc space were overlaid by an increased quantity of bone (Figure 7). In addition, there was decreased working space from L1 to L5.

Porchet et al.[17] reported that motor deficit was a more reliable finding than dysesthesia in FLLDH. However, Park et al.[16] reported that sensory dysesthesia in FLLDH was more remarkable than a motor deficit. Viswanathan et al.[13] suggested that postoperative severe burning dysesthesia in FLLDH was due to the traction of spinal nerve during dissection. Moreover, O'Hara and Marshall[19] reported that earlier visualization of posterior ramus and secure dissection of the extraforaminal area reduced the risk of postoperative sensory deficit. We also managed to reduce the risk of postoperative sensory deficit by exposing the exiting nerve root earlier (Figure 4).

There are various approaches for the surgical treatment of FLLDH: medial facetectomy, full facetectomy, intertransverse approach, percutaneous endoscopic approach, anterolateral retroperitoneal approach and lateral extraforaminal approach. Comparing lateral and medial approaches has revealed more satisfactory results with lateral approaches[4,20].

However, since the anatomical landmarks and route that is followed are not entirely known in lateral approach, medial approach is preferred more often. In a study comparing the different surgical procedures, Epstein[4] obtained better results with the lateral approach. In addition, Ryang et al.[20] reported excellent results in %95 of cases using lateral approach while 57% in medial approach. O'Hara and Marshall[19] reported good and excellent results at the postoperative 14th month follow-up in 90% of 20 patients operated using the lateral approach. In their study, Marquardt et al.[7] reported excellent outcomes in 75.9% and good outcomes in 18.4% in the long-term follow-up of patients, who were operated via minimally invasive lateral approach. In addition, Porchet et al.[21] reported good and excellent results in 73% of cases using a microsurgical far lateral approach while Weiner and Dabbah[22] reported the same outcomes in 85% of their cases. Similarly, Sasani et al.[23] obtained good and excellent results using a lateral endoscopic approach in 86.4% of their patients. In our study, using lateral interpedicular approach without exposing the intertransverse

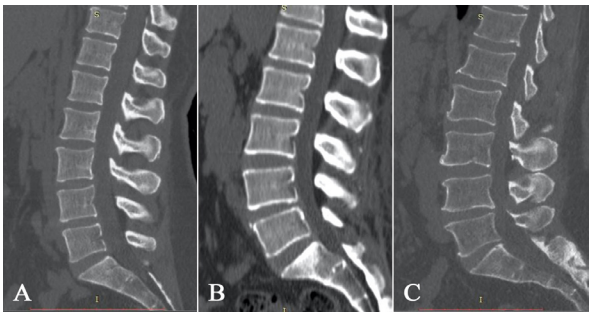


Figure 6. Postoperative 6th month sagittal computed tomography images of the patients due to far lateral lumbar disc herniation (FLLDH). Patients operated for left **(A)** L2-3, **(B)** left L4-5 and **(C)** right L3-4 FLLDH

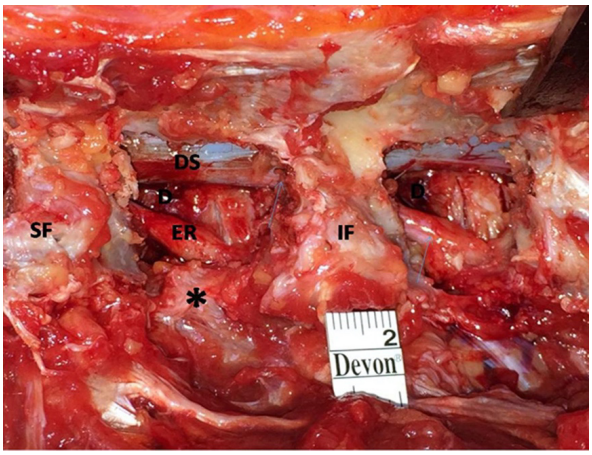


Figure 7. A picture from fresh cadaveric dissection. Pars interarticularis is completely removed for understanding of the relationship of exiting and traversing nerve roots and intervertebral disc, and inferior facet joint and pars interarticularis
SF: Superior facet joint, IF: Inferior facet joint, blue arrow: Traversing root becomes exiting root at the lower level, ER: Exiting nerve root, DS: Dural sac, *: Intertransverse muscle and fascia

fascia, we obtained excellent results in 78.5% of our cases and good results in 14.2% based on the MacNab classification.

Epsteins reported that the intertransverse fascia was exposed in the muscle splitting approach he described, while Schlesinger et al.[18] exposed the intertransverse fascia in their lateral microsurgical approach (4). O'Hara and Marshall[19] also reported that the intertransverse fascia was exposed in the new muscle splitting approach he described. Salame and Lidar[2] reported that the intertransverse fascia was opened in a minimally invasive technique using METRx tissue dilators. Also, Tessitore reported that the intertransverse muscle was opened in a microsurgical transmuscular approach, while Ryang et al.[20] reported that the intertransverse fascia was opened using a lateral transmuscular approach[5]. The intertransverse ligament was released in the paramedian approach that was used by Park et al.[16] . In the lateral interpedicular technique we used, intertransverse fascia exposure and visualization of the lateral facet and transverse process were not required. Since the nerve root was exposed at the location where it exited the medial aspect of the pedicle located superiorly, no complications of exiting root injury were observed.

It is possible to reach the foraminal and extraforaminal zones by using the lateral interpedicular technique. The herniated disc material can be reached with limited bone removal, which leads to exposure of compressed nerve root and dorsal root ganglion and by the way, does not cause instability. When compared to medial approach, which requires excessive bone removal, the risk of instability is minimal due to minimal bone resection. The lack of need for opening the intertransverse fascia and exposing the lateral aspect of the facet joint and transverse processes minimizes muscle retraction and hemorrhage at the surgical site and shortens the duration of the surgery. Studies comparing the lateral versus medial approaches reported more satisfactory results with a lateral approach[6,20]. However, since the anatomical landmarks and the route followed are not fully identified in lateral approaches, the medial approach is resorted to more often. Future experience and relevant anatomical studies on cadavers may allow the more frequent use of lateral approaches, with a better understanding of the extraforaminal zone anatomy.

Study Limitations

Some limitations existed in our study. Firstly, intertransverse ligament is not so much functionally important anatomical structure but there are many vessels beneath the ligament. The blood supply to the root has been shown to be critically dependent on the lateral radicular vessels[24,25]. Therefore, ischemic changes due to the disc fragment compression may be the cause of the acuteness of the symptoms seen in FLLDHs. So, we did not need to open the intertransverse ligament and therefore, we avoided bleeding and using bipolar cautery. Secondly, our study, consisting of only 28 patients, was relatively small. Also, the retrospective nature of this study hindered prospective analysis and randomization. In order to determine the clinical predictive value of superior articular process excision without opening intertransverse ligament, long-term follow-ups and large-scale prospective studies are required. Finally, we could achieve postoperative computed tomographies only six months after the operation; therefore, we need a longer follow-up period to evaluate the results, especially iatrogenic instability.

CONCLUSION

The LISA without exposing the intertransverse fascia enables direct access to migrated or non-migrated far lateral disc herniations and to preserve facet joint and pars interarticularis functionally. Additionally, minimal bone removal of the superior articular process of the facet provides a better exposure of disc space. It prevents excessive muscle retraction since there is no need to expose lateral aspect of the facet joint and transverse processes. Moreover, it avoids the risk of neurological damage by enabling the identification of the exiting nerve root in the early phase of the operation. Overall, the lateral interpedicular approach is a safe technique with a relatively low complication rate, associated with less tissue damage. It is a minimally invasive procedure when compared to remaining medial and lateral approaches and requires less bone removal.

Ethics

Ethics Committee Approval: This study was approved by The Council of Forensic Medicine (decision no: ATK 0.01.00.08/74).

Informed Consent: Informed consent was obtained from the patients.

Authorship Contributions

Surgical and Medical Practices: A.K., H.C., Concept: A.K., H.C., Design: A.K., H.C., Data Collection or Processing: A.K., H.C., Analysis or Interpretation: A.K., H.C., Literature Search: A.K., H.C., Writing: A.K., H.C.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Eicker SO, Rhee S, Steiger HJ, Herdmann J, Floeth FW. Transtubular microsurgical approach to treating extraforaminal lumbar disc herniations. Neurosurg Focus. 2013;35:E1.
2. Salame K, Lidar Z. Minimally invasive approach to far lateral lumbar disc herniation: technique and clinical results. Acta Neurochir (Wien). 2010;152:663-8.
3. Cervellini P, De Luca GP, Mazzetto M, Colombo F. Micro-endoscopic-discectomy (MED) for far lateral disc herniation in the lumbar spine. Technical note. Acta Neurochir Suppl. 2005;92:99-101.
4. Epstein NE. Foraminal and far lateral lumbar disc herniations: surgical alternatives and outcome measures. Spinal Cord. 2002;40:491-500.
5. Tessitore E, de Tribolet N. Far-lateral lumbar disc herniation: the microsurgical transmuscular approach. Neurosurgery. 2004;54:939-42.

6. Epstein NE. Evaluation of varied surgical approaches used in the management of 170 far-lateral lumbar disc herniations: indications and results. J Neurosurg. 1995;83:648-56.
7. Marquardt G, Bruder M, Theuss S, Setzer M, Seifert V. Ultra-long-term outcome of surgically treated far-lateral, extraforaminal lumbar disc herniations: a single-center series. Eur Spine J. 2012;21:660-5.
8. Samini F, Bahadorkhan G, Ehsaei MR, Kheradmand H. Intraforaminal and extraforaminal far lateral lumbar disc herniation (a review of 63 cases). Med J Islam Repub Iran. 2008;22:63-7.
9. Postacchini F, Montanaro A. Extreme lateral herniations of lumbar disks. Clin Orthop Relat Res. 1979;222-7.
10. Fankhauser H, De Tribolet N. Extraforaminal approach for extreme lateral lumbar disc herniation. Operative spinal surgery Churchill Livingstone, Edinburgh. 1991:145-60.
11. Fankhauser H, de Tribolet N. Extreme lateral lumbar disc herniation. Br J Neurosurg. 1987;1:111-29.
12. O'Toole JE, Eichholz KM, Fessler RG. Minimally invasive far lateral microendoscopic discectomy for extraforaminal disc herniation at the lumbosacral junction: cadaveric dissection and technical case report. Spine J. 2007;7:414-21.
13. Viswanathan R, Swamy NK, Tobler WD, Greiner AL, Keller JT, Dunsker SB. Extraforaminal lumbar disc herniations: microsurgical anatomy and surgical approach. J Neurosurg. 2002;96(2 Suppl):206-11.
14. Macnab I. Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients. J Bone Joint Surg Am. 1971;53:891-903.
15. Abdullah AF, Ditto EW 3rd, Byrd EB, Williams R. Extreme-lateral lumbar disc herniations. Clinical syndrome and special problems of diagnosis. J Neurosurg. 1974;41:229-34.
16. Park HW, Park KS, Park MS, Kim SM, Chung SY, Lee DS. The Comparisons of Surgical Outcomes and Clinical Characteristics between the Far Lateral Lumbar Disc Herniations and the Paramedian Lumbar Disc Herniations. Korean J Spine. 2013;10:155-9.
17. Porchet F, Fankhauser H, de Tribolet N. Extreme lateral lumbar disc herniation: clinical presentation in 178 patients. Acta Neurochir (Wien). 1994;127:203-9.
18. Schlesinger SM, Fankhauser H, de Tribolet N. Microsurgical anatomy and operative technique for extreme lateral lumbar disc herniations. Acta Neurochir (Wien). 1992;118:117-29.
19. O'Hara LJ, Marshall RW. Far lateral lumbar disc herniation. The key to the intertransverse approach. J Bone Joint Surg Br. 1997;79:943-7.
20. Ryang Y, Rohde I, Ince A, Oertel M, Gilsbach J, Rohde V. Lateral transmuscular or combined interlaminar/paraisthmic approach to lateral lumbar disc herniation? A comparative clinical series of 48 patients. J Neurol Neurosurg Psychiatry. 2005;76:971-6.
21. Porchet F, Chollet-Bornand A, de Tribolet N. Long-term follow up of patients surgically treated by the far-lateral approach for foraminal and extraforaminal lumbar disc herniations. J Neurosurg. 1999;90(1 Suppl):59-66.
22. Weiner BK, Dabbah M. Lateral lumbar disc herniations treated with a paraspinal approach: an independent assessment of longer-term outcomes. J Spinal Disord Tech. 2005;18:519-21.
23. Sasani M, Ozer A, Oktenoglu T, Canbulat N, Sarioglu A. Percutaneous endoscopic discectomy for far lateral lumbar disc herniations: prospective study and outcome of 66 patients. Minim Invasive Neurosurg. 2007;50:91-7.
24. Wang Q-p, Lee N-s, Zhang Y, Liu J, Zhu J-y. Intertransverse approach for extraforaminal herniations. Spine (Phila Pa 1976). 1997;22:701-5.
25. Owen JH, Naito M, Bridwell KH, Oakley DM. Relationship between duration of spinal cord ischemia and postoperative neurologic deficits in animals. Spine (Phila Pa 1976). 1990;15:618-22.

ORIGINAL ARTICLE
24

J Turk Spinal Surg 2020;31(1):24-7
DOI: 10.4274/jtss.galenos.2020.09

THE ALTERATION OF SAGITTAL LUMBOSACRAL ALIGNMENT AFTER POSTERIOR STABILIZATION-FUSION IN LUMBAR SPONDYLOLISTHESIS: CLINICAL STUDY

Aslıhan ÇEVİK[1], Recep BAŞARAN[1], Merih İŞ[2], Hakan SOMAY[2], Necat BİBER[1], Ezgi AKAR[2], Mehmet Zafer BERKMAN[2]

[1]Medical Sciences University, Sancaktepe Training and Research Hospital, Clinic of Neurosurgery, İstanbul, Turkey
[2]Medical Sciences University, Haydarpaşa Numune Training and Research Hospital, Clinic of Neurosurgery, İstanbul, Turkey

ABSTRACT

Objective: Spondylolisthesis (SL) is a condition that occurs in 2-8% of the general population. Sagittal spinopelvic alignment determines the mechanical stress in the lumbosacral junction. The aim of this study is to understand how much we can correct sagittal lumbosacral alignment to maintain sagittal balance in SL by surgical treatment and to demonstrate the effectiveness of posterior fixation in maintaining sagittal balance.

Materials and Methods: We retrospectively reviewed the cases operated with SL between January 2011 and June 2016. Wiltse classification was used to determine the type of SL. The parameters of sagittal balance (slip rate, slip angle, lumbar lordosis angle, lumbosacral kyphosis and sacral slope) were evaluated preoperatively and postoperatively.

Results: The study was carried out with 63 cases, 31.7% (n=20) male and 68.3% (n=43) female. The mean age was 57.16±12.55 years. The correction of slip rate and slip angle was found to be statistically significant ($p<0.01$).

Conclusion: The objective of our study was to investigate how the surgery influenced sagittal spino-pelvic alignment of SL and to investigate the correlation between the effectiveness and the changes of spine-pelvic sagittal parameters for patients with SL before and after operation.

Keywords: Spondylolisthesis, sagittal, balance, lumbosacral, alignment, surgery

INTRODUCTION

Spondylolisthesis (SL) is the subluxation of a vertebral body over another vertebral body in sagittal plane. SL occurs in 2-8% of the general population and affects all age groups. The common mechanism of this intervertebral instability is ligamentous weakness and laxity, pars interarticularis defect, previous surgical intervention or trauma[1,2].

The clinical stability of the spine is the ability of the spine to limit the translocation pattern when physiological load is applied[3]. On a biomechanical basis, spinopelvic morphology plays a critical role in determining the direction and magnitude of forces acting across the lumbosacral junction[4]. Normal sagittal alignment of the spine and pelvis would be helpful to maintain a stable posture and to expend a minimum of energy. SL, with the abnormal sacropelvic morphology, may disturb the normal spino-pelvic sagittal balance and result in the abnormal sacro-pelvic orientation. In SL, the instability is that the spinal column cannot limit excessive and abnormal translations[3]. The instability in lumbar SL usually progresses slowly. SL sometimes has progressive deformity[5].

Various classifications were made about the cause of SL. The universally accepted classification was proposed by Wiltse et al.[6]. The grading of SL was done by Myerding[7].

The major surgical indications are neurogenic claudication, persistent radiculopathy, severe back pain, presence of neurological symptoms, conservative treatment failure, radiological instability, progression of listhesis, Myerding grade (Gr) III and Gr IV listhesis, and spondyloptosis (Gr V)[7,8].

Sagittal sacropelvic morphology and orientation determine the lumbar spine geometry as the mechanical stress in the lumbosacral junction. For better understanding of the development of SL, several parameters have been described to define the relationship between the lumbosacral junction and the pelvis[9,10]. These parameters include pelvic inclination (PI), pelvic tilt, lumbar lordosis (LL), and sacral slope (SS).

The objective of our study was to investigate how the surgery influenced sagittal spino-pelvic alignment of SL and to investigate the correlation between the effectiveness and

Address for Correspondence: Recep Başaran, Medical Sciences University, Sancaktepe Training and Research Hospital, Clinic of Neurosurgery, Sancaktepe, Turkey
Phone: +90 506 659 72 21 **E-mail:** drrecepbasaran@gmail.com **Received:** 20.11.2019 **Accepted:** 06.02.2020
ORCID ID: orcid.org/0000-0001-5186-1116

the changes of spine-pelvic sagittal parameters for patients with SL before and after operation.

MATERIAL AND METHODS

We retrospectively reviewed the cases operated for lumbosacral SL between January 2011 and June 2016. The age, gender, level of listhesis, type and grade of SL were recorded. Wiltse classification was used to determine the type of SL[6]. Myerding classification was used to determine the percentage of slip that one vertebral body had slipped forward over the vertebral body below in SL[7]. Direct lumbosacral anteroposterior, lateral, flexion-extension functional radiographies, computerized tomography and magnetic resonance imaging examinations were evaluated before and after surgery. Pedicle screw fixation and posterolateral fusion were applied to all patients by the same surgeon. The surgical procedure was pedicle screw fixation and posterolateral fusion. Myerding slip rate (SR), slip angle (SA), LL angle, lumbosacral kyphosis (LSK), and SS measurements were performed and compared to investigate morphologic changes after surgery.

Table 1. Demographic features of the cases

		Min-Max (median)	Mean ± SD
Age (years)		15-76 (60)	57.16±12.55
Follow-up (months)		10 days-53 months	9.81±11.58
		n	**%**
Gender	Male	20	31.7
	Female	43	68.3
Meyerding classification	Grade 1	23	36.5
	Grade 2	39	61.9
	Grade 3	1	1.6

SD: Standard deviation, min: Minimum, max: Maximum, n: Sayı

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency, Odds ratio, minimum, and maximum) were used while evaluating the study data. Paired sample t-test was used for intra-group comparison of normally distributed parameters and Wilcoxon Signed Ranks test was used for intra-group comparison of non-normally distributed parameters. Significance was evaluated at $p<0.05$ level.

RESULTS

The study was carried out with 63 cases, 31.7% (n=20) male and 68.3% (n=43) female. The ages of the cases ranged from 15 to 76 years with a mean of 57.16±12.55 years. The follow-up period ranged from 3 to 53 months and the mean follow-up was 12.81±11.58 months (Table 1). According to Wiltse classification, the degenerative type was 55.6% (n=35), the isthmic type was 41.3% (n=26), the dysplastic type was 1.6% (n=1) and the iatrogenic type was 1.6% (n=1) SL. Retrolisthesis ratio was 11.1% (n=7). We found that L1-2 level was 1.6% (n=1), L2-3 level was 3.2% (n=2), L3-4 level was 16% (n=10), and L4-5 level was 50.7% (n=32) and 28.5% of the L5-S1 level (n=18). Preoperatively, considering Myerding grades SR, Gr I was found in 36.5% (n=23), GR II was found in 61.9% (n=39) and Gr III in

Table 2. Statistical results of slip rate, slip angle, lumbar lordosis, lumbosacral kyphosis and sacral slope

		Min-Max (Median)	Mean ± SD	p
Slope rate (%)	Preop	17-55 (26.2)	27.96±7.31	0.001
	Postop	0-49 (16.9)	16.52±9.72	
	Difference	-11.44±5.88		
Slope angle (°)	Preop	-2.2-30.4 (9.8)	-10.62±5.95	0.001
	Postop	0-25 (6.2)	-6.96±4.59	
	Difference	3.66±2.99		
Lumbar lordosis (°)	Preop	34-71.9 (52.1)	52.14±8.43	0.159
	Postop	37.2-68.8 (49.4)	50.96±6.97	
	Difference	-1.18±6.59		
Lumbosacral kyphosis (°)	Preop	11.7-52.7° (30.4)	30.27±10.09	0.253
	Postop	14.3-47.9°(30.1)	29.79±8.75	
	Difference	0.48±5.43		
Sacral slope (°)	Preop	24.5-57.1 (36.2)	36.93±7.58	0.036
	Postop	16.2-53.8 (35.1)	35.60±7.36	
	Difference	-1.26±4.64		

SD: Standard deviation, min: Minimum, max: Maximum, preop: Preoperative, postop: Postoperartive
Wilcoxon Signed Rank Test

1.6% (n=1). For postoperatively Myerding grades, 90.5% of the cases (n=57) were Gr I and 9.5% (n=6) were Gr II. Postoperative SR was found to be statistically significant, as low as 11.44±5.88 (p=0.001; p<0.01) (Table 2).

The preoperative SA ranged from -2.2^0 to -30.4^0, with a mean of -10.62±5.95 and a postoperative SA ranged from 0 to 25, with an average of -6.96±4.59. Postoperative SA was significantly lower than preoperative SA, 3.66±2.99 (p=0.001; p<0.01) (Table 2).

There was no statistically significant difference between the preoperative and postoperative LL measurements (p=0.159; p>0.05) (Table 2).

Preoperative LSK ranged from 11.7 to 52.7^0 with a mean of 30.27±10.090; postoperative LSK was between 14.3 and 47.9^0, with an average of 29.79±8.750. The change of LSK was not statistically significant (p>0.05) (Table 2).

Postoperative SS was found to be statistically significant, as low as 1.26±54.64 (p=0.036; p<0.05) (Table 2).

DISCUSSION

The flexion, extension, rotation and lateral bending movements performed at different levels of the spine must be done within certain intervals for a person to maintain his/her daily life activities. Pathologies that occur in the spine restrict this range of motion or cause non-physiological movements to occur. SL involves the subluxation of a vertebral body over another vertebral body in the sagittal plane[1,2]. The aim of spinal surgery is to make these pathological processes as physiological as possible.

The most common type of SL is degenerative type and it is followed by the isthmic type. Kalichman et al.[1] found degenerative type to be at the rate of 65.7% and isthmic type SL to be at the rate of 39.6% in their study. In our study, the most common type was degenerative and it is followed by isthmic SL as in literature. SL is more common in women[11]. The most common level is L4-L5[12]. Retrolisthesis is most commonly found in the L3-L4 level, which is a rare condition[11]. According to Labelle, the most important measures in evaluating SL are grade, LL, LSK, SS and SA[9].

The degree of the listhesis is based on the percentage of slip according to Myerding Classification[7]. In the literature, there is no study comparing preoperative and postoperative shifts. Our study revealed that when all the cases are evaluated, the average shift is about 11%. This suggests that the degree of listhesis can be corrected by surgery.

It is the intersection of the lower endplate of the upper vertebrae and the vertebrae passing through the upper endplate of the underlying vertebra[13]. Huang and colleagues found that the preoperative SA was -20.3±2.8^0 in HGS and -8.5±5.4^0 in LGS[4].

When we investigated the change in preoperative and postoperative SA in our study, it was seen that the change was -10.62^0 on average. It was found that the most prominent correction of SA was achieved with surgery.

LL and LSK are evaluated by lateral lumbosacral radiography. There are many factors affecting LL, such as age, gender, body mass index, and race, which make it difficult to obtain mean values. There is a strong correlation between LL and SL. In some studies, performed in the literature, the mean LL values range from 50.36 to 56.5[14,15].

In our study, preoperative LL angle was 52.14±8.43 and postoperative LL angle was 50.96±6.97. The LL angle was reduced by about 2^0 in the postoperative period. It is seen that there is no significant improvement in the LL surgically.

The physical findings of the listhesis are related to the degree of slip and LSK[16]. There is no valid consensus to assess the LSK. Boxall SA, Dubousset LSA, SDSG LSA, Dysplastic SDSG LSA, Sagittal Rotation and Kyphotic Cobb angle can be used.

In our study, the change in preoperative and postoperative LSK angle was found to be less than an increase of grade. It is not possible to correct this angle by applying surgery.

S1 is the angle between the upper endplate and the horizontal line. Normal PI and SS values range from 42±5 to 74±1^0 and 35±4 to 53± 7^0 [10,17]. Along with the development of listhesis, these values are increasing[18].

In our study, the SS mean value increased by about 1.26^0. This significant result suggests that it is possible to surgically correct the sacral SA.

CONCLUSION

SL occurs in the sagittal plane with subluxation of a vertebrae body through another vertebral body. Sagittal sacropelvic morphology and orientation determine the lumbar spine geometry as the mechanical stress in the lumbosacral junction. Lumbosacral malalignment in this region affects the development and progression of SL. It is possible to approximate the amount of SR, SA and SS to normal ranges by the surgery but this not possible for the LL and LSK.

Ethics

Ethics Committee Approval: Retrospective study.

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: A.Ç., R.B., M.İ., H.S., N.B., E.A., M.Z.B., Concept: A.Ç., M.İ., M.Z.B., Design: A.Ç., M.İ., M.Z.B., R.B., Data Collection or Processing: A.Ç., Analysis or Interpretation: A.Ç., R.B., Literature Search: A.Ç., R.B., Writing: A.Ç., R.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Kalichman L, Kim DH, Li L, Guermazi A, Berkin V, Hunter DJ. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. Spine (Phila

Pa 1976). 2009;34:199-205.
2. Simotas AC, Dorey FJ, Hansraj KK, Cammisa F Jr. Nonoperative treatment for lumbar spinal stenosis: clinical and outcome results and a 3-year survivorship analysis. Spine (Phila Pa 1976). 2000;25:197-203.
3. White AA, Panjabi MM (Eds). Clinical biomechanics of the spine. Vol. 2. 1990: Lippincott, Philadelphia 1990;pp:2.
4. Huang RP, Bohlman HH, Thompson GH, Poe-Kochert C. Predictive value of pelvic incidence in progression of spondylolisthesis. Spine (Phila Pa 1976). 2003;28:2381-5.
5. Benzel EC. Biomechanics of spine stabilization. 3rd edition. Thieme.2015.
6. Wiltse LL, Newman PH, Macnab I. Classification of Spondyloisis and Spondylolisthesis. Clin Orthop Relat Res. 1976;117:23-9.
7. Myerding H. Spondylolisthesis. Surg Gynecol Obstet. 1932;54:371-7.
8. Eismont FJ, Norton RP, Hirsch BP. Surgical management of lumbar degenerative spondylolisthesis. J Am Acad Orthop Surg. 2014;22:203-13.
9. Labelle H, Roussouly P, Berthonnaud E, Dimnet J, O'Brien M. The importance of spino-pelvic balance in L5-s1 developmental spondylolisthesis: a review of pertinent radiologic measurements. Spine (Phila Pa 1976). 2005;30(6 Suppl):27-34.
10. Labelle H, Roussouly P, Berthonnaud E, Dimnet J, O'Brien M. Spino-pelvic alignment after surgical correction for developmental spondylolisthesis. Eur Spine J. 2008;17:1170-6.
11. He L, Wang YX, Gong JS, Griffith JF, Zeng XJ, Kwok AW, et al. Prevalence and risk factors of lumbar spondylolisthesis in elderly Chinese men and women. Eur Radiol. 2014;24: 441-8.
12. Gille O, Challier V, Parent H, Cavagna R, Poignard A, Faline A, et al. Degenerative lumbar spondylolisthesis. Cohort of 670 patients, and proposal of a new classification. Orthop Traumatol Surg Res. 2014;(6 Suppl)100:311-5.
13. Taillard W. Le Spondylolisthesis Chez L'enfant et L'adolescent1 (Etude de 50 cas). Acta Orthopaedica Scandinavica. 1954;24:115-44.
14. Yang M, Yang C, Ni H, Zhao Y, Li M. The Relationship between T1 Sagittal Angle and Sagittal Balance: A Retrospective Study of 119 Healthy Volunteers. PloS One. 2016;11:e0160957.
15. Wang Z, Wang B, Yin B, Liu W, Yang F, Lv G. The relationship between spinopelvic parameters and clinical symptoms of severe isthmic spondylolisthesis: a prospective study of 64 patients. Eur Spine J. 2014;23:560-8.
16. Baldwin N, Matsunaga S, Ehni B. Spondylolisthesis: sagittal plane lumbar spine deformity correction. Spine Surgery-techniques, Complication Avoidance, and Management. Pennsylvania, PA: Elsevier Churchill Livingstone, Philadelphia 2005;pp:655-74.
17. Mac-Thiong JM, Duong L, Parent S, Hresko MT, Dimar JR, Weidenbaum M, et al. Reliability of the Spinal Deformity Study Group classification of lumbosacral spondylolisthesis. Spine (Phila Pa). 2012;37:95-102.
18. Labelle H, Roussouly P, Berthonnaud E, Transfeldt E, O'Brien M, Chopin D, et al. Spondylolisthesis, pelvic incidence, and spinopelvic balance: a correlation study. Spine (Phila Pa 1976). 2004;29:2049-54.

ORIGINAL ARTICLE
28

J Turk Spinal Surg 2020;31(1):28-31
DOI: 10.4274/jtss.galenos.2020.94

UNINTENDED DURAL INJURY IN DEGENERATIVE LUMBAR SPINAL SURGERY: A RETROSPECTIVE STUDY

Soner Çİvİ

Başkent University Faculty of Medicine, Department of Neurosurgery, Adana, Turkey

ABSTRACT

Objective: Unintended dural injury rate in all spinal surgeries is between 0.2% and 20%. This rate approaches the upper rates in degenerative lumbar surgery. Unintended dural injury occurs due to many factors and revision surgery is one of these reasons. As a result of the injury, the possibility of neurological deficits is not high, but conditions such as headache, pesudomeningocele, superficial infection, meningitis and radicular pain can occur. However, these complications can be solved today. In our study, we aimed to evaluate unintended dural injury and its results retrospectively.

Materials and Methods: Between 2011 and 2018, 376 (225 female and 151 male) patients who had undergone decompression and posterior lumbar pedicle screw fixation were included in the study. Fifty-eight patients were operated due to revision surgery. The mean patient age was 57.35 years (range: 33-79 years). Dural injuries were sutured with microsurgical technique and sealant was used. All patients were recommended bed rest between 24 and 48 hours.

Results: The number of unintended dural injuries was 26. Eleven patients with dural injury were operated for revision surgery. There was pseudomeningocele in three patients, superficial wound infection in three patients, meningitis in one patient, and transient radicular symptoms in 12 patients. Twenty-one patients had early cerebral hypotension and all responded to the medication.

Conclusion: Unintended dural injury occurring in surgeries performed due to lumbar degenerative process does not significantly affect surgical results. It is very important to properly diagnose and treat additional complications caused by unintended dural injury.

Keywords: Unintended dural injury, complications, degenerative spine surgery

INTRODUCTION

Unintended dural injury is a common complication during degenerative lumbar spinal surgery. Dural injury rate in all spinal surgeries is between 0.2% and 20%[1-4]. Unintended dural injury increases with increasing age, female sex, surgical experience, invasive surgery, revision surgery and degenerative process. In degenerative process, this rate approaches the upper limits. The average rate is 17%[4,5-9]. Cerebrospinal fluid (CSF) leakage caused by dural injury may complicate the postoperative period with headaches, nausea, vomiting, back pain, abducens nerve palsy, fistula formation, pseudomeningocele, surgical site infections, meningitis, and in rare circumstances, chronic subdural hematomas[10-15].However, these complications can be handled by developing surgical techniques. In this study, we aimed to retrospectively evaluate the causes and consequences of unintended dural injury.

MATERIALS AND METHODS

Patients

All patients who underwent spine surgery for degenerative conditions performed at our institution between 2011 and 2018 were included in the study. We excluded patients treated for tumors, infections, and deformity from this study. This retrospective study included 376 adult patients (225 female and 151 male) who had undergone decompression and posterior lumbar pedicle screw fixation.

Study Approval

The need for informed consent was waived owing to the retrospective nature of the study.

Surgical Technique

All patients in the study underwent decompression and pedicular screw fixation due to the degenerative process. Dural

This study was presented in the Spinal Complications Symposium/Turkish Neurosurgery Association-Spinal and Peripheral Nerve Surgery Group, in 2019.
Address for Correspondence: Soner Çivi, Başkent University Faculty of Medicine, Department of Neurosurgery, Adana, Turkey
E-mail: sonercivi@yahoo.com **Received:** 28.01.2020 **Accepted:** 06.02.2020
ORCID ID: orcid.org/0000-0002-1055-5152

injuries were sutured with microsurgical technique and sealant (Tisseel-Baxter Healthcare Corporation) was used. Postoperative management with bed rest was questioned in relation to the size of the dural tear. All patients were recommended 24-48 hours of bed rest.

RESULTS

The demographic characteristics of the patients enrolled in the study are shown in Table 1. Three hundred seventy-six patients were included in the study. Two hundred twenty-five (59.84) patients were female and 151 (40.16%) patients were male. The mean patient age was 57.35 years (range: 33-79 years). Fifty-eight (15.4%) patients underwent revision surgery. Twenty-six (6.91%) patients had unintended dural injury. Fifteen (3.98%) of the dural injuries were detected in patients who underwent primary surgery and 11 (2.96%) were seen in patients who underwent revision surgery. The ratio of dural injury in revision cases was 25.86% and the ratio of dural injury in primary cases was 3.45%. Three had pseudomeningocele and three had superficial wound infection. Only one patient was treated for meningitis. Radicular pain and paresthesia occurred in 12 patients who were given medical treatment. Twenty-one patients had early cerebral hypotension and all responded to medical treatment (Table 2).

DISCUSSION

Diagnostic and therapeutic methods developed in recent years have increased the surgical rates due to lumbar degenerative process. Unintended dural injury is a common complication during degenerative lumbar spine surgery (Figure 1-2). Dural injury rate is between 0.2% and 20% in all spinal surgeries[1-4,10]. In open surgery series for lumbar degenerative process, unintended dural injury rate was 8.11% (range: 2-20%). In our series, unintended dural injury was 6.91% in the whole group whereas in primary cases, this rate decreased to 3.45% and the rates were consistent with the literature. Surgical invasiveness and manipulation of dura has been reported as a general predictor of dural injury and appears to be associated with overall dural injury rates.

Dural injury incidence in a group of patients who underwent revision surgery was 25% and was not associated with the years of experience of the surgeon[16]. In our study, the ratio of dural injury in revision cases was found to be 25.86% (15/58).

Dural injury is one of the most common complications in spinal surgery. Although different methods have been described for the treatment of this complex problem, the primary treatment

Table 1. Patient demographics and findings

None of patients	376	
Male-rate	151	40.16%
Female-rate	225	59.84%
Mean age, range	57.35	33-79
Primary surgery-rate	318/376	84.6%
Revision surgery-rate	58/376	15.4%
Dural tear in patient group	26/376	6.91%
Ratio of dural damage in revision cases	15/58	25.86%
Ratio of dural damage in primary cases	11/318	3.45%

Table 2. Complications

Pseudomeningocele	3	11.53%
Superficial wound infection	3	11.53%
Radicular pain and paresthesia	12	46.15%
Early cerebral hypotension	21	80.76%
Meningitis	1	3.84%

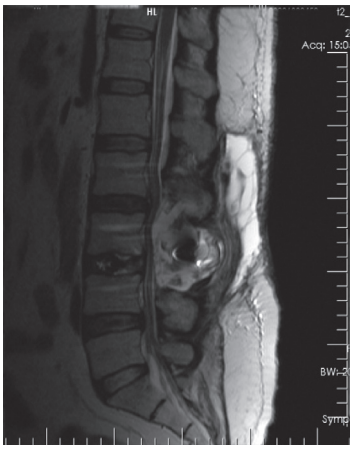


Figure 1. Dural leakage is observed in the T2 - weighted MRI - Sagittal Image
MRI: Magnetic resonance imaging

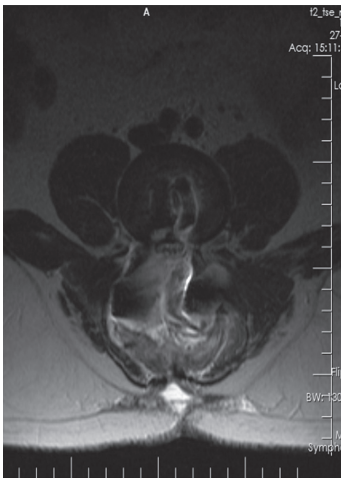


Figure 2. Dural leakage is observed in the T2 - weighted MRI - Axial Image
MRI: Magnetic resonance imaging

of dural injuries is primary repair. Closed subarachnoid drainage; laser tissue welding; grafts consisting of muscle, fat, or fascia; blood patches; fibrin-adhesive or cyanoacrylate polymer sealant; application of Gelfoam to the tear; bed rest; and avoidance of the use of wound drains are other treatment methods[17]. Due to the small number of patients in the literature, it is difficult to compare the effectiveness of treatment modalities; however, most authors advocated using a combination of these methods[17]. In our study, we applied the combination of microsurgery repair, sealant use and bed rest. Bed rest time is controversial due to comorbidities that may develop.

Rest for a long time can lead to problems such as deep vein thrombosis, pneumonia, and additional cost[18]. For this reason, we did not apply bed rest longer than 48 hours for our patients. Intracranial hypotension (IH) is a clinical syndrome in which absolute or relative hypovolemia of CSF results in various neurological symptoms[19]. An increasing number of publications in recent years shows that IH is no longer a rare syndrome. IH can occur spontaneously or iatrogenically. This group of patients is treated by anesthesiologists and neurologists as the first reason in iatrogenic cases is lumbar puncture. However, IH knowledge is essential for spine surgeons, spinal surgery and complications of degenerative spinal disorders may be secondary causes of IH[19]. In our study, we encountered headache due to early IH in 21 of 26 patients with dural injury. In patients responding to symptomatic treatment, no further complications related to IH occurred. However, it should be kept in mind that post-surgical CSF leakage may cause temporary symptoms such as headache, as well as more serious intracranial complications.

Iatrogenic pseudomeningocele is an extradural cystic formation caused by CSF leak after spinal surgery[18] . The incidence of unintended durotomy is anywhere from 0.3 to 13% and most frequently occurs as a result of lumbar laminectomy[20].

The lumbar region pseudomeningocele is more common because more lumbar surgery is performed today and the CSF pressure is higher in this area. In the study of Swanson and Fincher involving 1700 patients, the incidence of postoperative pseudomeningocele was shown to be 0.07%[20]. Hawk and Kim[20] reported pseudomeningocele rate as 0.8% in his retrospective study in 1408 patients.

In our study, the rate of patients who developed dural injury was 11.53% while this rate was 0.79% in the whole series. Our findings were consistent with the literature.

Postoperative meningitis after spinal surgery is rare but can lead to serious complications, including death. Twyman et al.[21] showed its incidence as 0.18% in its 2180 cases. Lin et al.[22] reported an incidence of postoperative meningitis as 0.10% (21 of 20,178 surgeries). Morris et al.[23] reported bacterial meningitis in two cases of dural tears with posterior instrumentation with pedicle screws. It achieved good results with timely diagnosis and treatment in both patients. This study showed that postoperative meningitis was a rare complication after spinal lumbar surgery. Be aware of fever, neck stiffness, and consciousness disturbance findings that develop after spinal surgery. Intraoperative unintended dural injury is the most important predictor. Early diagnosis and appropriate antibiotic treatment for at least two weeks can lead to a good outcome. In our study, the symptoms of meningitis were encountered in one patient and there was a dural injury in the patient. Good results were obtained with early diagnosis and appropriate treatment. The causes of superficial wound infection following dural damage were defined as CSF fistula, prolonged operation time, and need for long bed rest[24]. In our study, we encountered superficial wound infection in three patients. This complication occurred in patients with obesity and Diabetes Mellitus. It was not associated with dural injury.

Takenaka et al.[24] said that dural injury was associated with an increased risk of postoperative neurological deficits, and dural injury formation was an important risk factor for postoperative neurological deficits. McMahon et al.[25] and Williams et al.[26] showed that dural injury was associated with postoperative neurological deficits in two different large series. However, we cannot conclude a causal relationship between dural injury and neurological deficits.

However, entering the dura intraoperatively may injure neural elements, or additional procedures performed by surgeons to repair the dural injury may lead to neurological deficit[24]. In our study, temporary paresthesia and radiculopathy were detected in 12 (46.15%) of 26 patients with dural injury, but no serious neurological deficits were observed. These complaints were attributed to additional manipulations performed during repair.

Conclusion

Unintended dural injury occurring in surgeries performed due to lumbar degenerative process does not significantly affect surgical results. Dural injury is common during revisions. Additional temporary complications may occur. However, good or excellent results can be obtained when appropriate treatment methods are applied.

Ethics

Ethics Committee Approval: Retrospective study.

Informed Consent: Retrospective study.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Papavero L, Engler N, Kothe R. Incidental durotomy in spine surgery: first aid in ten steps. Eur Spine J. 2015;24:2077-84.
2. Ghobrial GM, Theofanis T, Darden BV, Arnold P, Fehlings MG, Harrop JS. Unintended durotomy in lumbar degenerative spinal surgery: a 10-year systematic review of the literature. Neurosurg Focus. 2015;39:E8.
3. Stromqvist F, Jonsson B, Stromqvist B. Dural lesions in lumbar disc herniation surgery: incidence, risk factors, and outcome. Eur Spine J. 2010;19:439-42.
4. Khan MH, Rihn J, Steele G, Davis R, Donaldson WF 3rd, Kang JD, et al. Postoperative management protocol for incidental dural tears during

degenerative lumbar spine surgery: a review of 3,183 consecutive degenerative lumbar cases. Spine (Phila Pa 1976). 2006;31:2609-13.

5. Stolke D, Sollman W, Seifert V. Intra- and postoperative complications in lumbar disc surgery. Spine (Phila Pa 1976). 1989;14:56-9.
6. O'Connor D, Maskery N, Griffiths WE. Pseudomeningocele nerve root entrapment after lumbar discectomy. Spine (Phila Pa 1976). 1998;23:1501-2.
7. Koo J, Adamson R, Wagner Jr FC, Hrdy DB. A new cause of chronic meningitis: infected lumbar pseudomeningocele. Am J Med. 1989;86:103-4.
8. Eismont FJ, Wiesel SW, Rothman RH. Treatment of dural tears associated with spinal surgery. J Bone Joint Surg Am. 1981;63:1132-6.
9. Radcliff KE, Sidhu GD, Kepler CK, Gruskay J, Anderson DG, Hilibrand A, et al. Complications of Flat Bed Rest After İncidental Durotomy. Clin Spine Surg. 2016;29:281-4.
10. Cammisa FP Jr, Girardi FP, Sangani PK, Parvataneni HK, Cadag S, Sandhu HS. Incidental durotomy in spine surgery. Spine (Phila Pa 1976). 2000;25:2663-7.
11. Hodges SD, Humphreys SC, Eck JC, Covington LA. Management of incidental durotomy without mandatory bed rest. A retrospective review of 20 cases. Spine (Phila Pa 1976). 1999;24:2062-4.
12. Kalevski SK, Peev NA, Haritonov DG. Incidental Dural Tears in lumbar decompressive surgery: Incidence, causes, treatment, results. Asian J Neurosurg. 2010;5:54-59.
13. Bosacco SJ, Gardner MJ, Guille JT. Evaluation and treatment of dural tears in lumbar spine surgery: a review. Clin Orthop Relat Res. 2001;389:238-47.
14. Guerin P, El Fegoun AB, Obeid I, Gille O, Lelong L, Luc S, et al. Incidental durotomy during spine surgery: incidence, management and complications. A retrospective review. Injury. 2012;43:397-401.
15. Saxler G, Kramer J, Barden B, Kurt A, Pförtner J, Bernsmann K. The long-term clinical sequelae of incidental durotomy in lumbar disc surgery. Spine (Phila Pa 1976). 2005;30:2298-302.
16. Smorgick Y, Baker KC, Herkowitz H, Montgomery D, Badve SA, Bachison C, et al. Predisposing factors for dural tear in patients undergoing lumbar spine surgery. J Neurosurg Spine. 2015;22:483-6.
17. Wang JC, Bohlman HH, Riew KD. Dural tears secondary to operations on the lumbar spine. Management and results after a two-year-minimum follow-up of eighty-eight patients. J Bone Joint Surg Am. 1998;80:1728-32.
18. Oitment C, Aref M, Almenawar S, Reddy K. Spinal Dural Repair: A Canadian Questionnaire. Global Spine J. 2018;8:359-64.
19. Inamasu J, Guiot BH. Intracranial hypotension with spinal pathology. Spine J. 2006;6:591-9.
20. Hawk MW, Kim KD. Review of spinal pseudomeningoceles and cerebrospinal fluid fistulas. Neurosurg Focus. 2000;9:e5.
21. Twyman RS, Robertson P, Thomas MG. Meningitis complicating spinal surgery. Spine (Phila Pa 1976). 1996;21:763-5.
22. Lin TY, Chen WJ, Hsieh MK, Lu ML, Tsai TT, Lai PL, et al. Postoperative meningitis after spinal surgery: a review of 21 cases from 20,178 patients. BMC Infect Dis. 2014;23;14:220.
23. Morris BJ, Fletcher N, Davis RA, Mencio GA. Bacterial meningitis aftertraumatic thoracic fracture-dislocation: two case reports and review of the literature. J Orthop Trauma. 2010;24:e49-53.
24. Takenaka S, Makino T, Sakai Y, Kashii M, Iwasaki M, Yoshikawa H, et al. Dural tear is associated with an increased rate of other perioperative complications in primary lumbar spine surgery for degenerative diseases. Medicine (Baltimore). 2019;98:e13970.
25. McMahon P, Dididze M, Levi AD. Incidental durotomy after spinal surgery: a prospective study in an academic institution. J Neurosurg Spine 2012;17(1):30-6.
26. Williams BJ1, Sansur CA, Smith JS, Berven SH, Broadstone PA, Choma TJ, et al. Incidence of unintended durotomy in spine surgery based on 108,478 cases. Neurosurgery. 2011;68:117-23.

ORIGINAL ARTICLE
32

J Turk Spinal Surg 2020;31(1):32-5
DOI: 10.4274/jtss.galenos.2020.41

RECURRENT LARYNGEAL NERVE PALSY AFTER CERVICAL SPINE SURGERY CAN BE PREVENTED

Hüseyin DOĞU[1], Halil CAN[2]

[1]Atlas University, Department of Neurosurgery, İstanbul, Turkey
[2]Biruni University, Department of Neurosurgery, İstanbul, Turkey

ABSTRACT

Objective: To prevent postoperative laryngeal nerve palsy in patients undergoing anterior cervical spine surgery (ACSS).

Materials and Methods: A retrospective study was conducted with data from 643 patients who underwent ACSS between 2006 and 2019. Of these patients, 125 who underwent only ACSS served as group I; the other 518, who underwent retractor loosening and displacement along with ACSS, served as group II. The two groups were compared, and paralyzed patients were compared with the general community. In the 518 patients in group II, the Cloward retractor was loosened every 15 minutes, which resulted in a slight change in its position. This protocol was unlike the standard procedure. The retractor was left loose during copy scopy.

Results: The majority (58%) of the patients were female, and average age was 47 years (range: 24 to 75 years). The mean duration of surgery was 152 minutes in group I and 162 minutes in group II. Transient laryngeal nerve palsy developed postoperatively in three patients (2.4%) of group I but no patients in group II. No significant difference was observed in terms of surgical level, duration of surgery, age, gender, or comorbid conditions.

Conclusion: Retractor loosening and displacement for every 15 minutes during ACSS helps prevent postoperative recurrent laryngeal nerve palsy.

Keywords: Recurrent laryngeal nerve palsy, cervical spine, spine surgery

INTRODUCTION

Anterior cervical spine surgery (ACSS) is the intervention most commonly preferred for the management of cervical spine disease; the surgical techniques are well documented. R. A. Robinson and G. W. Smith, Albert Dereymaeker and Joseph C. Mulier, and Ralph B. Cloward in 1950s were the first to describe the surgical techniques for ACSS; since then, the techniques have undergone several modifications and become widely used. ACSS enables efficient management of spinal disorders such as cervical stenosis, cervical myelopathy, and cervical radiculopathy. It provides easy access to the vertebrae and produces highly satisfactory surgical outcomes in the majority of cases[1], and it remains the "gold standard" for the management of various spinal disorders. Anterior cervical discectomy and fusion, in particular, has high success rates and low complication rates.

Despite the advantages of ACSS, postoperative complications occur. The most common complication after ACSS is recurrent laryngeal nerve palsy (RLNP), followed by vocal fold paralysis or vocal cord paralysis[2]. RLNP results from ischemia caused by surgical pressure, neuropraxia caused by overstretching, and edema that results from perioperative trauma[3]. We evaluated the efficacy of retractor loosening and displacement during surgery in preventing postoperative RLNP.

MATERIALS AND METHODS

Data from 643 patients who underwent ACSS between 2006 and 2019 were studied retrospectively. Of these patients, 125, who served as group I, underwent standard ACSS; the other 518, who served as group II, underwent ACSS and retractor loosening and displacement every 15 minutes; that is, the retractor was repositioned slightly during ACSS. A member of the surgery team was assigned to remind the retractor to be repositioned. He or she used the stopwatch while making the timing. This procedure was repeated every 15 minutes, and the retractor was left loose during scopy shots. Finally, low cutoff pressure was not applied in both group I and group II. All operations were performed at the same hospital and by the same surgeon. The surgical outcomes measured were operation time, postoperative RLNP development, and characteristic of patients with RLNP in groups I and II.

Address for Correspondence: Hüseyin Doğu, Atlas University, Department of Neurosurgery, İstanbul, Turkey
Phone: +90 542 651 41 36 **E-mail:** huseyindogu@gmail.com **Received:** 28.11.2019 **Accepted:** 06.02.2020 **ORCID ID:** orcid.org/0000-0002-7754-4984

RESULTS

Of the total of 643 patients, 367 (57%) were female and 276 (43%) were male (Table 1). The average age of the patients with injury was 47.2 years, and mean duration of surgery in those patients was 148.79 minutes (Table 1). Of the 125 patients in group I, 76 (60.8%) were female and 49 (39.2%) were male. Of the 518 patients in group II, 291 (56.2%) were female and 227 (43.8%) were male (Table 1). There was no difference between these groups in average age (47 years), but the mean duration of surgery was significantly longer for group II (152.24±83.01 minutes), p=0.023 (Table 2).

Of all 643 patients, three (2.4%) patients had RLNP; all three were from group I (Table 3). The patients with RLNP were given non-steriodal anti-inflammatory drugs and low dose corticosteroid as medical treatment. They were trained to prevent aspiration. All of the patients with RLNP recovered within 2 months without the need for a second surgery.

There were no significant differences in mean age and mean duration of surgery between group I and the total patient population (Table 4). The majority of patients [416 (64.7%)] underwent one-level surgery; of these patients, 72 (57.6%) were in group I and 344 (66.4%) were in group II. (Table 5). The observed chi-square value was 4.477 and p=0.107, which indicated no association between the number of surgical levels and patient groups.

Groups were evaluated statistically in terms of gender (Table 1). The observed chi-square value was 0.878 and p=0.349, which indicated no association between gender and groups.

DISCUSSION

Cervical spinal disorders not only affect patients' health but also increase the economic burden on the individuals, families, and most of society. Most cervical diseases can be managed non-surgically, but early surgical intervention is recommended in cases of neurological impairment to improve its functional outcome[4,5]. Although the anterior approach of cervical surgery is most preferred by surgeons because of its high rates of clinical success, RLNP continues to be the major postoperative complication of ACSS that results from surgical pressure[3].

Table 1. Associations between gender and groups.

	Group		
Gender	**Group I (n=125)**	**Group II (n=518)**	**Total**
Male	49 (39.2%)	227 (43.8%)	276 (42.9%)
Female	76 (60.8%)	291 (56.2%)	367 (57.1%)
Total	125 (100.0%)	518 (100.0%)	643 (100.0%)

n: Number
Chi-square value: 0.878, 0.349>p>0.05

Table 2. Difference in mean age and duration of surgery between groups I and II

Measure	Group I (n=125)	Group II (n=518)	t	p
	Mean ± standard deviation			
Age (years)	47.02±10.11	47.30±10.66	-0.258	0.797
Duration of surgery (minutes)	134.50±52.54	152.24±83.01	-2.281	0.023*

*p<0.05

Table 3. Percentage of patients with paralysis in groups I and II

Measure	Total	Group I	Group II
Cases	643	125	518
Paralysis	3	3 (2.4%)	0

Table 4. Comparison of mean age and duration of surgery between patients with paralysis and total patient population

Measure	Mean ± standard deviation		p
	Patients with paralysis (n=3)	Total patient population (n=643)	
Age (in years)	56.33±18.58	47.24±10.55	0.138
Duration of surgery (minutes)	74.00±15.10	148.79±78.31	0.099

Table 5. Number of surgical levels by group

Number of levels	Group		Total
	Group I	Group II	
1	72 (57.6%)	344 (66.4%)	416 (64.7%)
2	43 (34.4%)	130 (25.1%)	173 (26.9%)
3	10 (8.0%)	44 (8.5%)	54 (8.4%)
Total	125 (100.0%)	518 (100.0%)	643 (100.0%)

Chi-square value: 4.477; 0.107>p>0.05

In a retrospective review, Kriskovich et al.[2] tested "whether controlling for endotracheal tube/laryngeal wall interactions by cervical retraction system [would] reduce symptomatic or asymptomatic RLNP or permanent paralysis." They found that during surgery, the retractor "moved the larynx against the shaft of the endotracheal tube," thereby compressing the "vulnerable intralaryngeal segment of the laryngeal nerve." They therefore recommended continuous monitoring of endotracheal tube cuff pressure and intermittent or temporary release after retractor placement to allow repositioning of the endotracheal tube within the larynx and to prevent further injury to the laryngeal nerve. Similar findings were reported by Cheung and Luk[3] and Matgé[6], who recommended the use and temporary release of a sharp-toothed retractor to prevent anteromedial and anterolateral displacement, which could otherwise compress and damage the trachea and carotid artery, respectively. In our study, similar to both studies, our finding is that intermittent retractor relaxation decreases RLNP. Unlike other studies, we standardized retractor relaxation within a certain time interval and did not release cuff.

The literature indicates that the left-sided approach, followed by low endotracheal cuff pressure and intermittent release of retractors tension during ACSS when not required, helps reduce the incidence of postoperative RLNP. However, there are sparse data on how often retractor tension can be reduced and on whether repositioning of retractors intraoperatively can help reduce RLNP. Hence, this retrospective, observational study of 643 patients who underwent ACSS was proposed, in which the majority of patients underwent retractor loosening and displacement during ACSS. The surgical outcome measured was based on success rate, duration of operation procedure, postoperative RLNP occurrence, and characteristic of patients with RLNP.

Single- or multiple-level discectomy is performed in ACSS[7], and as the number of levels increases, radiographic non-fusion increases, as do complication rates[8-10]. However, in this study, no statistical association was observed between multiple-level surgery and the occurrence of RLNP; all three patients with postoperative RLNP underwent only one-level surgery.

The ratio of male and female patients with RLNP in this study was 2:1; their mean age was 56.33 years. The mean duration of surgery in all three cases did not exceed the general average; these patients had not undergone neck surgery previously, and none had preoperative hoarseness. There were no etiological factors or diseases that could cause RLNP in patients. However, the surgical approach was right-sided at C5-6 and C6-7, which is a major risk factor for postoperative RLNP[11,12]. There is a claim that the left-sided intervention is safer. In our series, left-sided surgery was performed in five cases. However, since the number is low, it is not included in the series.

Study Limitations

This study has all the limitations of a retrospective study, and so a multicenter, matched case-control prospective study with a larger cohort is necessary to validate the findings. Another limitation of our study is that the pressure applied to the retractor and endotracheal cuff pressure are not measured. It must be determined how much retractor and cuff pressure causes RLNP formation. In patients who develop RLNP, the etiological factors that may cause such as the anatomical structure of the neck should be investigated.

CONCLUSION

Laryngeal nerve palsy is one of the most common postoperative surgical complications of ACSS. It must be addressed immediately to prevent permanent vocal cord paralysis and associated lifelong disability. This study showed that loosening and displacement of the Cloward retractor every 15 minutes during ACSS helped prevent RLNP and improved the clinical success rate. Hence, a large multicenter, matched case-control study to confirm these findings is warranted.

Ethics

Ethics Committee Approval: Retrospective study.
Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: H.D., Concept: H.D., Design: H.D., Data Collection or Processing: H.D., H.C., Analysis or Interpretation: H.D., H.C., Literature Search: H.D., H.C., Writing: H.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The author declared that this study received no financial support.

REFERENCES

1. Tasiou A, Giannis T, Brotis AG, Siasios I, Georgiadis I, Gatos H et al. Anterior cervical spine surgery-associated complications in a retrospective case-control study. J Spine Surg. 2017;3:444-59.
2. Kriskovich MD, Apfelbaum RI, Haller JR. Vocal fold paralysis after anterior cervical spine surgery: incidence, mechanism, and prevention of injury. Laryngoscope. 2000;110:1467-73.
3. Cheung JPY, Luk KD-K. Complications of Anterior and Posterior Cervical Spine Surgery. Asian Spine J. 2016;10:385-400.
4. Garg R, Rath GP, Bithal PK, Prabhakar H, Marda MK. Effects of retractor application on cuff pressure and vocal cord function in patients undergoing anterior cervical discectomy and fusion. Indian J Anaesth. 2010;54:292-5.
5. O'Dowd JK. Basic principles of management for cervical spine trauma. Eur Spine J. 2010;19(Suppl 1):18-22.
6. Matgé G. Approaches to Cervical Spine. In: Sindou M. (eds) Practical Handbook of Neurosurgery. Springer, Vienna 2009; pp:1141-1160.
7. Mayfield Clinic & Spine Institute. Anterior cervical discectomy and Fusion [online] 2013. http://www.mayfieldclinic.com/PE-ACDF.htm#.Vc8aTvlcjVJ. (Accessed February 10 2020).
8. Kreitz TM, Hollern DA, Padegimas EM, Schroeder GD, Kepler CK, Vaccaro AR et al. Clinical Outcomes After Four-Level Anterior Cervical Discectomy and Fusion. Global Spine J. 2018;8:776-83.
9. Morgan JP, Asfora WT. Extreme multi-level anterior cervical discectomy and fusion. S D Med. 2013;66:273-7.
10. Bum-Suk Yu, Farid Yudoyono, Seong Yi, Yoon Ha, Keung Nyun Kim, Do Heum Yoon et al. Analysis of Surgical Results According to the Number of Fused Levels in Anterior Cervical Discectomy and Fusion: A retrospective study. The Nerve. 2017;3:32-37.
11. Gokaslan ZL, Bydon M, De la Garza-Ramos R, Smith ZA, Hsu WK, Qureshi SA et al. Recurrent Laryngeal Nerve Palsy After Cervical Spine Surgery: A Multicenter AOSpine Clinical Research Network Study. Global Spine J. 2017;7(1 Suppl):53S-57S.
12. Nikandish R, Zareizadeh A, Motazedian S, Zeraatian S, Zakeri H, Ghaffarpasand F. Bilateral Vocal Cord Paralysis after Anterior Cervical Discectomy Following Cervical Spine Injury: A Case Report. Bull Emerg Trauma. 2013;1:43-5.

ORIGINAL ARTICLE
36

J Turk Spinal Surg 2020;31(1):36-40
DOI: 10.4274/jtss.galenos.2020.62

INCIDENCE AND MORTALITY OF OSTEOPOROTIC SACRAL INSUFFICIENCY FRACTURES: A RETROSPECTIVE SINGLE-CENTRE STUDY

Bahtiyar HABERAL[1], Ekin KAYA ŞİMŞEK[2], Mahmut IŞIK[1]

[1]Başkent University, Department of Orthopedics and Traumatology, Ankara, Turkey
[2]Beypazarı State Hospital, Clinic of Orthopedics and Traumatology, Ankara, Turkey

ABSTRACT

Objective: The incidence of osteoporosis increases with the ageing of the world population. In recent years, sacral insufficiency fractures (SIF) have become more prevalent due to the increase in life expectancy of the elderly population. The aim of this study was to investigate the incidence and the mortality rates of SIF in elderly patients with osteoporosis.

Materials and Methods: The records of patients admitted to our hospital between January 2011 and May 2018 were examined. Medical records, radiological images and reports of 245 patients over 65 years of age who had undergone pelvic computed tomography (CT) or magnetic resonance imaging (MRI) for any reason were retrospectively reviewed. Twenty-six patients (three male, 23 female) over 65 years of age who were proven to have osteoporosis with bone mineral densitometry (BMD) values at the time of diagnosis were included in the study.

Results: The mean age at the time of diagnosis was 80,5. MRI was used for diagnosis in 20 patients and CT in six patients. The mean value of BMD was found to be-3.62. The most common type of fracture was B1. Surgery was performed in four patients and conservative treatment in 22 patients.

Conclusion: Increased risk of fractures due to osteoporosis also increases the risk of SIF. In our study, the incidence of fractures of sacral insufficiency was found to be 12.44% and 5-year mortality was 26.9%.

Keywords: Osteoporosis, sacral insufficiency fractures, mortality

INTRODUCTION

The incidence of osteoporosis increases with the lengthening of the average lifetime of the world population. Uncoupling of osteoclast-osteoblast activity leads to a decrease in the bone mass and the deterioration of bone microstructure. All of these changes in the structure of the bone, which are seen both in the senile osteoporosis and post-menopausal osteoporosis, cause an increase in the fracture risk even during the regular activity and these fractures are defined as insufficiency fractures. The fracture risks directly related to the degree of bone loss. The most common fractures are seen in the vertebral body, hip and wrist, respectively. In recent years, sacral insufficiency fractures (SIF) have become more prevalent due to the increase in the life expectancy of the elderly population[1-3].

SIF were firstly described by Lourie in 1982. Although osteopenia, rheumatoid arthritis, corticosteroid use, radiotherapy, renal osteodystrophy, osteomalacia, Paget's disease, hyperparathyroidism, joint arthroplasties and lumbosacral fusion are risk factors for SIF, osteoporosis is the most common risk factor[4]. SIF presents itself with non-specific symptoms like low dorsal pain, buttock and hip pain, which resemble symptoms of various pathologies. These pathologies include lumbar spinal canal stenosis, vertebral fractures and metastatic disease. On the other hand, it is difficult to visualize sacrum with X-rays. Also, sacrum was not considered as a reason of symptoms at the first step of evaluation. Therefore, the diagnosis of the SIF is difficult and often delayed. In non-displaced SIF, the first line of treatment is conservative treatment. This treatment consists of analgesics and mobilization that is regulated according to the degree of the patient's pain. However, if the patient complains about long-standing pain or the fracture is displaced, surgical stabilization should be considered. Because the patients suffering from the SIF could easily deteriorate with surgical trauma, the least possible invasive treatment is recommended[5].

Although the exact incidence of SIF is still unknown, it is reported as between 1% and 1.8% in various studies[1,5]. Studies have shown that almost all osteoporotic fractures, especially osteoporotic vertebrae and hip fractures, are associated with

Address for Correspondence: Bahtiyar HABERAL, Başkent University, Department of Orthopedics and Traumatology, Ankara, Turkey
Phone: +90 312 203 68 68 / 1350 **E-mail:** bahtiyarhaberal@hotmail.com **Received:** 30.12.2019 **Accepted:** 27.01.2020
ORCID ID: orcid.org/0000-0002-1668-6997

increased mortality risk. However, in the literature, there are very few studies on the mortality rates of the patients with the SIF. One of the studies reported mortality within the three years after the occurrence of sacral insufficiency fracture as 25.5%[6]. The aim of this study is to investigate the incidence and mortality rates of SIF in elderly patients with osteoporosis.

MATERIALS AND METHODS

After obtaining approval from the Başkent University Medical and Health Sciences Research Review Board (no: KA 19/444, date: 02.01.2020), the recordings of patients referred to our hospital between January 2011 and May 2018 were examined. Medical records, radiological images and reports of 245 patients who were over 65 years of age and underwent pelvic computed tomography (CT) or magnetic resonance imaging (MRI) for any reason were retrospectively reviewed.

Thirty-two of the 62 patients with the diagnosis of sacrum fracture were excluded from the study for the following reasons: high-energy sacrum fractures (14 patients), patients with other SIF risk factors (renal osteodystrophy, 10 patients; pathological fractures, eight patients). Bone mineral density (BMD) values of four of the remaining 30 patients could not be reached and they were excluded from the study. As a result, 26 patients (three male, 23 female) over 65 years of age who were proven to have osteoporosis with BMD values at the time of the diagnosis were included in the study.

Patients' demographics and radiological features were examined. Besides, the fractures of the patients were classified according to the classification systems previously described by Bakker et al.[7] in the literature (Table 1).

Statistical Analysis

The incidence was calculated according to the obtained data and statistically compared with the findings in the literature. Mortality data were obtained from the "Ministry of Health, Death Notification System". Mean values and standard deviations were calculated and statistical analyses were done by using SPSS (Statistical Package for the Social Sciences) for Windows v24.0.

RESULTS

Data of 26 patients (three male, 23 female) with SIF, who met the study criteria, were examined. The demographic data of each patient are shown in Table 2. The mean age at the time of diagnosis was 80.5±9.02 years [mean ± standard deviation (SD)] and the age distribution of the patients is shown in Graphic 1.

MRI was used for the diagnosis of 20 patients (76.9%) and CT was used in six patients (23.1%) (Figure 1). When the results of bone mineral densitometry (BMD) that was measured by dual-energy X-ray absorptiometry method were evaluated, the mean value was found to be -3.62 ±0.46 (mean ± SD). According to the classification system of Bakker et al.[7] of SIFs, the most common fracture type was B1. Numerical and percentage distribution of fracture types are shown in Graphic 2.

The treatment of patients with SIF was examined. Four of the patients had a surgical operation and 22 of them received conservative treatment. Iliosacral screw fixation was performed in patients who underwent surgical treatment. After the patients were placed in the supine position, screws were bilaterally placed percutaneously using secure corridors of the S1 and S2 vertebrae under scope control. In retrospective mortality screening, it was revealed that seven of 26 patients (26.9%) died during the follow-up period after the diagnosis. The 3-month mortality rate after fracture diagnosis was 7.7%, the 1-year mortality rate was 11.5%, the 2-year mortality rate was 19.2%, and the 5-year mortality rate was 26.9%. According to the results, the incidence of osteoporotic SIF was calculated as 12.44% in the study population.

Table 1. Classification of sacral insufficiency fractures according to Bakker et al.[7]

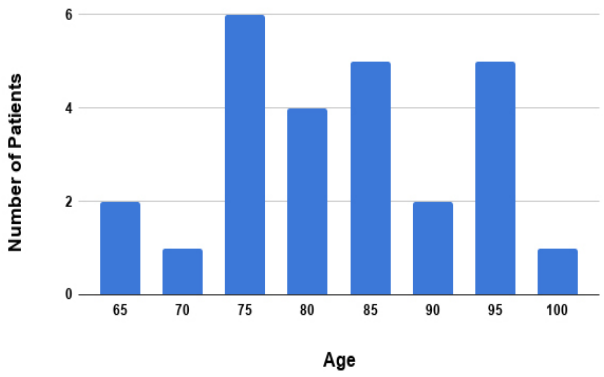
Type A: Fractures of the sacral ala	
A1	Bone bruise (MRI) without a visible fracture line in the CT-Scan
A2	Deformation of the anterior cortical bone without a cortical disruption
A3	Anterolateral rim fracture of the ala with up to 1 cm distance in the direction of the medial sacroiliac joint
Type B: Fractures of the sacral ala	
B1	Fracture parallel to the sacroiliac joint
B2	Fracture involving the sacroiliac joint
B3	Fracture with an involvement of the neural foramina or the spinal canal
Type C: Corpus fractures	
C1	Fracture moves from anterior cortex dorsally or into the sacroiliac joint
C2	Fracture with an unilateral involvement of the neural foramina or the spinal canal
C3	Unstable and represents bilaterally sagittal fractures combined with a transverse lesion.

MRI: Magnetic resonance imaging, CT: Computed tomography

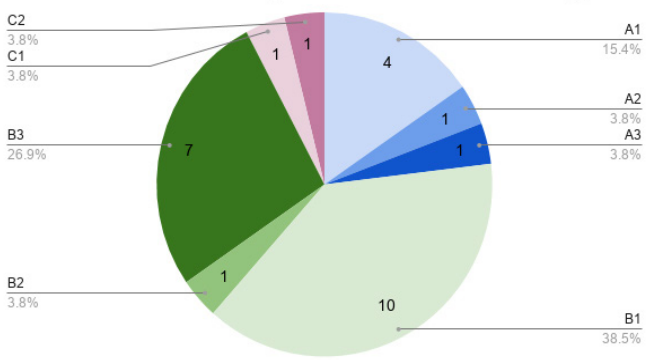
Table 2. The demographic data of each patient

Case	Age (year)	Gender	Imaging modality	BMD L1-L4 t-score	Fracture type	Treatment
1	81	F	MRI	-3.1	B1	C
2	65	F	MRI	-3.5	B3	C
3	65	F	MRI	-3.7	B1	C
4	91	F	MRI	-4.0	A3	C
5	75	F	MRI	-3.6	C1	C
6	76	F	MRI	-3.5	B1	C
7	82	F	MRI	-3.3	B2	C
8	89	M	CT	-4.3	A1	C
9	92	M	CT	-3.6	B3	C
10	95	F	CT	-3.0	A2	C
11	73	M	CT	-3.2	C2	C
12	75	F	MRI	-3.6	B1	C
13	96	F	MRI	-4.8	B1	C
14	81	F	MRI	-4.1	B1	C
15	86	F	MRI	-4.3	B3	C
16	93	F	CT	-3.2	B3	C
17	76	F	MRI	-3.5	B1	C
18	92	F	MRI	-4.0	B3	C
19	73	F	MRI	-3.0	A1	C
20	77	F	MRI	-3.2	B3	C
21	72	F	CT	-3.8	A1	C
22	81	F	MRI	-3.2	A1	C
23	74	F	MRI	-3.1	B1	S
24	85	F	MRI	-4.1	B1	S
25	70	F	MRI	-3.6	B3	S
26	80	F	MRI	-3.9	B1	S

M: Male, F: Female, CT: Computed tomography, MRI: Magnetic resonance imaging, BMD: Bone mineral density, C: Conservative, S: Surgical



Graphic 1. Distribution of patient numbers by age



Graphic 2. Numerical and percentage distribution of fracture types

DISCUSSION

The number of patients with osteoporosis increases and osteoporosis is more common in the elderly and female population. In the systematic review performed by Yoder et al.[4], risk factors causing SIF were investigated and these fractures were shown to be highly associated with old age, female gender and osteoporosis. In the literature; it has been suggested that the greater pelvic deflection angle of women causes biomechanical disadvantage and therefore, SIF are more common in the female population than in the male population. As consistent with other studies in the literature, our study also found a higher rate of SIF in women over 65 years of age.

It has been shown in many studies that plain radiographs are inadequate to detect SIF[1,4,8]. Tamaki et al.[1] found that the diagnosis of SIF was delayed on average 29.3 days after the referral to the emergency department and they suggested that this delay was caused by the use of plain radiographic examination. SIF are often located in the sagittal plane and parallel to the sacroiliac joint; therefore, scintigraphy also gives non-specific results. CT can only detect the changes that appear weeks after the fracture. Bone edema after a fracture occurs within hours and can be detected by MRI[8]. Therefore, MRI seems to be the most effective method for early diagnosis and also the most valuable diagnostic method in patients with vague low back pain that are suspected to have SIFs.

In the study of Na et al.[9], 15 patients with osteoporotic pelvic insufficiency fractures were examined. It was reported that only four of the patients had sacral and nine had both sacral and pubic fractures. In this study, the mean BMD value was found to be -3.9. In our study, the mean BMD value was found to be -3.6 in accordance with these data. Wagner et al.[2] examined patients with osteoporosis-related SIF and calculated the bone mass of different parts of the sacrum by using special software with CT. According to this study, the bone mass of the sacrum body is generally decreased. However, the greatest loss of bone mass was shown to be in the alar regions. According to Bakker et al.'s[7] sacral insufficiency fracture classification, type B fractures are located in the alar region. The fracture line extends along with the sagittal plane and parallel to the sacroiliac joint. In addition, they reported the most frequent fracture as type B fractures in their study. Also, in our study, the most common fracture type was type B fractures. When all these data were examined together, it was found that the data of our study were consistent with the literature.

Conservative treatment is the first-line treatment for sacrum insufficiency fractures[5]. In the study performed by Park et al.[6], only 21 (6.5%) of 325 patients with sacral insufficiency were treated with surgery. In our study, this rate was 15.38% (4/26). The higher rate of surgical treatment may be due to the variability in the severity of osteoporosis and persistent symptoms associated with it.

In the literature, there are few studies reporting the mortality of SIF. In the study performed by Park et al.[6], 3-month, 6-month, 1-year, 2-year, and 3-year mortality after SIF were evaluated and were found as 5.8%, 9.8%, 17.5%, 23.7% and 25.5, respectively. In our study, mortality rates were found to be 7.7%, 7.7%, 11.5%, 19.2%, and 23%, respectively. In addition, 5-year mortality was %26.9 in our study. When both studies were evaluated together, it can be said that the obtained mortality data were proportionally similar.

The true incidence of SIF is unknown. The first study was done in 1993 by Weber et al.[10] In this study, the incidence was reported as 1.8% for the whole study group (n=20). While all patients were included in the calculation, only 12 patients with osteoporosis were included in the study. In the study performed by Tamaki et al.[1] in 2017, they investigated the sacral CT images of the patients who were referred to the emergency department and the incidence was calculated as 4.4%. On the other hand, there are no data available for BMD in both studies. In our hospital, the incidence of osteoporosis-associated sacral insufficiency fracture is 12.44%. Our study includes patients with osteoporosis-related SIF, which have been diagnosed by BMD values. Developing imaging technologies may have led to a higher incidence rate in our study.

Study Limitations

The present study has some limitations. Firstly, this is a single-centered and retrospective study; so, the sample of the study was lower compared to other studies. Secondly, other factors affecting insufficiency fractures were not included in the evaluation. Finally, the treatment of osteoporosis and their possible effect of the treatment were not considered in the study.

CONCLUSION

Symptoms of SIF are non-specific and similar to the symptoms of some other pathologies. Due to the difficulty in the visualization of the fracture, the diagnosis of the SIF cannot be made on time. Increased risk of fractures due to osteoporosis also increases the risk of SIF. In our study, the incidence of fractures of sacral insufficiency was found to be 12.44% and 5-year mortality was 26.9%. Therefore, if plain radiographs are negative in osteoporotic elderly patients with low back, hip and thigh pain, SIF should always be kept in mind. Further studies would increase our awareness and knowledge about these fractures.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from the Başkent University Medical and Health Sciences Research Review Board (no: KA 19/444, date: 02.01.2020).

Informed Consent: No informed consent was obtained because of the retrospective study design.

Authorship Contributions

Concept: B.H., E.K.Ş., Design: B.H., Data Collection or Processing: E.K.Ş., M.I., Analysis or Interpretation: B.H., Literature Search: M.I., Writing: B.H., E.K.Ş., M.I.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Tamaki Y, Nagamachi A, Inoue K, Takeuchi M, Sugiura K, Omichi Y, et al. Incidence and clinical features of sacral insufficiency fracture in the emergency department. Am J Emerg Med. 2017;35:1314-6.
2. Wagner D, Hofmann A, Kamer L, Sawaguchi T, Richards RG, Noser H, et al. Fragility fractures of the sacrum occur in elderly patients with severe loss of sacral bone mass. Arch Orthop Trauma Surg. 2018;138:971-7.
3. Wagner D, Ossendorf C, Gruszka D, Hofmann A, Rommens PM. Fragility fractures of the sacrum: how to identify and when to treat surgically? Eur J Trauma Emerg Surg. 2015;41:349-62.
4. Yoder K, Bartsokas J, Averell K, McBride E, Long C, Cook C. Risk factors associated with sacral stress fractures: a systematic review. J Man Manip Ther. 2015;23:84-92.
5. Rommens PM, Wagner D, Hofmann A. Fragility Fractures of the Pelvis. JBJS Rev. 2017;5. pii: 01874474-201703000-00004.
6. Park JW, Park SM, Lee HJ, Lee CK, Chang BS, Kim H. Mortality following benign sacral insufficiency fracture and associated risk factors. Arch Osteoporos 2017;12:100.
7. Bakker G, Hattingen J, Stuetzer H, Isenberg J. Sacral Insufficiency Fractures : How to Classify? J Korean Neurosurg Soc. 2018;61:258-66.
8. Bencardino JT, Kassarjian A, Palmer WE. Magnetic resonance imaging of the hip: sports-related injuries. Top Magn Reson Imaging. 2003;14:145-60.
9. Na WC, Lee SH, Jung S, Jang HW, Jo S. Pelvic Insufficiency Fracture in Severe Osteoporosis Patient. Hip Pelvis. 2017;29:120-6.
10. Weber M, Hasler P, Gerber H. Insufficiency fractures of the sacrum. Twenty cases and review of the literature. Spine (Phila Pa 1976). 1993;18:2507-12.

J Turk Spinal Surg 2020;31(1):41-6
DOI: 10.4274/jtss.galenos.2020.42

GIANT CELL TUMOR OF THE SACRUM AND CURRENT TREATMENT STRATEGIES

Ali ÖNER, Yunus Emre AKMAN

Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Clinic of Orthopedics and Traumatology, İstanbul, Turkey

ABSTRACT

Objective: Giant cell tumor (GCT) is a benign local aggressive tumor seen mostly in the third and fourth decades. Sacrum is the most commonly affected spinal region, followed by thoracic, cervical and lumbar regions. Aim of this study is to evaluate the results of surgical treatment in sacral GCT and review the treatment options of GCT in this uncommon location.

Materials and Methods: Between 2002 and 2018, online hospital database search was conducted for a diagnosis of sacrum and GCT. Patient records were evaluated for recurrence and called for last follow-up.

Results: There were four patients (one male, three female) operated due to sacral GCT, included in the study. Mean follow-up was 49 (25 to 82) months. High speed burr, electrocauterization and phenol were used as adjuvant treatment in all cases. Cementing was used in two patients.

Conclusion: En bloc resection is the most effective treatment method with the lowest recurrence rate, yet it has the highest morbidity. In addition to intralesional curettage, high speed burr, electrocauterization, phenol and cement as adjuvant therapies can be used in the treatment of GCTs to decrease local recurrence in sacral cases while protecting neural tissues.

Keywords: Giant cell tumor, sacrum, phenol, cement, electrocauterization, high speed burr

INTRODUCTION

Giant cell tumor (GCT) is a progressive, destructive tumor of unknown origin. It is seen mostly in the third to fourth decades with a slightly higher prevalence in females. Progressive pain and swelling are the most frequent presenting symptoms in extremity GCTs; however, spinal GCTs present with back pain, accompanying radiculopathy, and sometimes with rectal, bladder or sexual dysfunction. GCT constitutes approximately 16.2% of all primary tumors of the spine[1,2]. Sacrum is the most commonly affected spinal location, followed by the thoracic, cervical and lumbar mobile spinal regions, and it is the 4th most frequently seen anatomic location after distal femur, proximal tibia, and distal radius. GCT of the sacrum is usually centered in the S1-S2 region, which may involve nerve roots, and extent into ilium through sacroiliac joint.

GCT is revealed as an eccentric radiolucent expansile mass in the epiphysis of the long bones on X-ray. A faint, narrow zone of transition may accompany. Cortical destruction, periosteal reaction, and bone loss are not uncommon aggressive features. Even though GCT is a benign tumor, lung metastasis may develop occasionally. Therefore, all newly diagnosed patients should obtain chest imaging. Computerized tomography (CT) is the best radiologic entity to visualize the cortical rim, remaining subchondral bone and lack of internal matrix. A soft tissue component with high cellularity and hemosiderin substance that leads to low to intermediate T1 and low T2 signal on magnetic resonance imaging (MRI) may be present[3,4]. Tumor is vascular and therefore, signal enhancement is present on MRI. An elevated level of ATP-dependent proton pumps in the giant cells generates enhanced fluoro deoxy glucose uptake on positron emission tomography[5,6].

Since GCT in sacrum is a rare entity, most information is from GCTs of all skeletal bones, or small case series of sacral GCTs[7-12]. Although a recurrence rate of 17.2-50% is present in spinal GCTs[13], surgery is the mainstay of the treatment. En bloc resection of GCT has the lowest recurrence rate with a better prognosis compared to intralesional surgical procedures[14,15], yet en bloc resection is either extremely difficult or it is associated with increased morbidity and complication rates of approximately 50-100% due to the adjacent structures of GCT[16,17].

Address for Correspondence: Ali Öner, Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Clinic of Orthopedics and Traumatology, İstanbul, Turkey
E-mail: mail@alioner.com.tr **Received:** 03.12.2019 **Accepted:** 11.02.2020
ORCID ID: orcid.org/0000-0002-0438-8335

The aim of this study is to evaluate the results of surgical treatment in GCT of the sacrum and to review the treatment strategies in this rarely-seen anatomic location.

MATERIALS AND METHODS

After obtaining local ethics committee approval from Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Medical Specialty Board Ethics Committee (date: 23,12.2019, no: 376) a retrospective review of the patients who were operated due to GCT between 2002 and 2018 was performed. Four patients who were operated due to GCT of the sacrum were included in the study.

All patients were evaluated by a multidisciplinary orthopedic-oncology team before the treatment procedure. Tumor location and extension were described in Table 1 with patient demographics. All patients were operated with a posterior approach only; however, one patient was re-operated with an anterior–posterior combined procedure due to recurrence, and another patient was re-operated due to inadequate tumor removal and cementing. The follow-up was carried out every three months during the first two years, then annually. Control image studies of the pelvis and chest were conducted during follow-up period.

RESULTS

Four patients [one male, three female, mean age: 35.8 (30 to 44) years] were treated due to GCT of the sacrum. The mean follow-up was 49 (25 to 82) months. Pain was the main symptom in all patients. There were no urinary or fecal incontinence symptoms in any patients pre- and post-operatively. First patient was treated with total excision of S4–Coccyx region. Two patients were treated with intralesional curettage, adjuvant therapy followed by cementation with polymethylmethacrylate (PMMA). The last patient was treated with intralesional curettage and bone grafting in the first surgery, recurrence was detected after 50 months, then the combined approach with a multidisciplinary surgical team was performed for anterior–posterior resection, and posterior lumbar–iliac reconstruction.

DISCUSSION

GCT is a rare, benign but locally aggressive tumor, which can progress and cause pathologic fractures. Pathologic fracture may be present in up to 30% of patients[14,15,18]. Various treatment options such as surgery, radiotherapy (RT), embolization, cryotherapy, and chemical adjuvants are used for GCT of the spine. Surgical treatment generally includes intralesional curettage, adjuvant therapy as possible and grafting/cementing with or without internal fixation[4,19].

The purpose of the treatment is to remove the tumor and to prevent its recurrence, as spinal structures protected, and neurologic impairment prevented. Although total en bloc resection is the best surgical treatment method, it is not always possible in spinal GCTs because of injury potential to adjacent main neurovascular structures, such as medulla spinalis, aorta, vena cava, ductus thoracicus, and vertebral artery. Blunt dissection is used to protect these important structures, which may lead to excessive bleeding, contamination during removal of tumor cells, and spinal instability may develop secondary to spinal osteotomies for tumor resection. Boriani et al.[14,15], reported good results with en bloc resection to decrease local recurrence compared to other spinal GCT procedures, such as piecemeal resection, RT, and embolization alone. One of our patients, whose lesion was located in S4-S5 region, was treated with en bloc resection, there was no recurrence during the last follow-up (Figure 1).

Intralesional curettage and bone grafting was described previously by Puthoor and Iype[20], and Blackley et al.[21] with a recurrence rate of 14% and 12%, respectively. In our study, intralesional curettage and bone grafting was performed in primary surgery in the patient with recurrence, and the patient was symptom-free in the first 2 years postoperatively, and the patient was lost to follow-up after the 3rd year. Intralesional

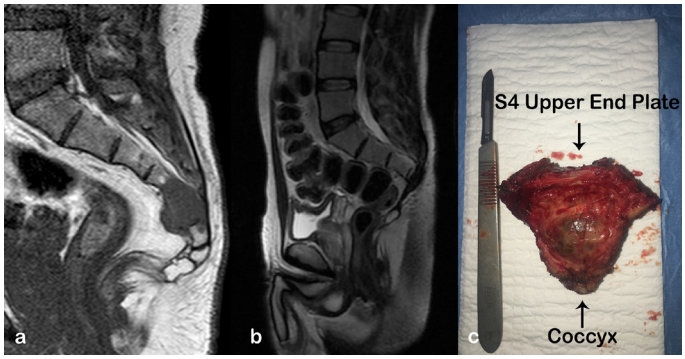


Figure 1. Male patient, 44-year-old. En bloc resection at upper end plate of S4 was performed. **a.** Preoperative sagittal view of GCT at S4 and S5. **b.** Postoperative sagittal view. c. Pathology specimen
GCT: Giant cell tumor

Table 1. Patient demographics, tumor locations

Patient no	Gender	Age (Year)	Follow-up (months)	Tumor Location
1	Male	44	25	S4 and S5 corpus
2	Female	32	43	Ala of Right S1
3	Female	30	46	Ala of right S1 and posterior ilium
4	Female	37	82	Ala of left S1 and posterior ilium

curettage + bone grafting alone has some controversies compared to curettage + cementing and also adding adjuvant therapies. In the systematic review of Zuo et al.[22] published in 2013, local recurrence rate was higher in curettage + bone grafting than in curettage + cementing patients. Also, curettage + grafting + adjuvant treatment was found with a higher recurrence rate than curettage + cementing + adjuvant patients in the same systematic review. In the systematic review of Vaishya et al.[23], an overall recurrence rate of 20.4% in six studies and 42% in one study were reported. Even though grafting was used in one of our patients, we have been preferring cementing over grafting in GCTs in our clinic, respecting the literature and our clinical experience.

The patient re-applied with pain localized in the sacral region in the postoperative 5th year. A large recurrent mass was detected, biopsy confirmed recurrent GCT, and therefore anterior-posterior partial sacral and iliac resection was performed with iliolumbar reconstruction.

In patients undergoing intralesional procedures, adjuvant therapy modalities such as cryotherapy, burr, cauterization, cementation, and phenol were described to decrease the recurrence rates. In long bones, cryosurgery was introduced in 1964, which had a recurrence rate less than 10%, but there were some major complications, such as fractures, delayed bone and wound healing, and osteoarthritis[24-26]. Because of risks to the neurologic structures, we do not use cryotherapy in spinal cases. Curettage using high-speed burr as an adjuvant therapy in addition to autologous bone grafting and allograft packing was used by Blackley et al.[21], with a recurrence rate of 12%. The combination of high-speed burr with a thermal (cauterization or cryotherapy) or chemical adjuvant modality decreased the recurrence rate[21,26,27]. Despite the limited use of high-speed burr in spinal cases, we have been using on the walls of sacrum distant from nerve roots. The use of phenol as an adjuvant therapy has controversies in literature. Phenol has been used as local adjuvant therapy for extremity GCTs, with comparable results with cryotherapy[13,28]. In the report of Klenke et al.[29], recurrence was not decreased in patients treated with phenol as an adjuvant therapy to intralesional curettage and bone grafting. We believe that tumor removal with thorough curettage is more important than using phenol alone. However, intralesional curettage, adjuvant therapy and cementing with PMMA have lower recurrence rates than curettage and bone grafting[29,30]. We have been using phenol as adjuvant therapy in sacral GCTs, by using a small gauge saturated with phenol. Two patients were treated with curettage, adjuvant therapy (high speed burr, cauterization and phenol application) and cementing and there were no recurrences in these patients (Figure 2). PMMA has a small zone of cytotoxic effect due to exothermic reaction which results in less complications compared to cryotherapy[24,26]. In addition, since PMMA is durable in compressive forces, filling the curettage void with PMMA supports the bone and prevents fractures. In our clinic, after intralesional curettage, we fill the cavity with the contrast medium, and use fluoroscopy to compare the extension of curettage borders with preoperative CT images, which helps total removal of tumor tissue (Figure 3). After adequate removal of tumor tissue, we use blunt tip of osteotomes to protect neural structures from thermal complications of cementing and apply PMMA (Figure 4). Intralesional curettage with high-speed burr, cauterization and phenol application as possible and cementation is the primary choice in GCTs without soft tissue components with intact bone structure in long bones, pelvis and sacrum, yet it may be impossible to perform curettage with high-speed burr and to use of PMMA in other regions of the spine.

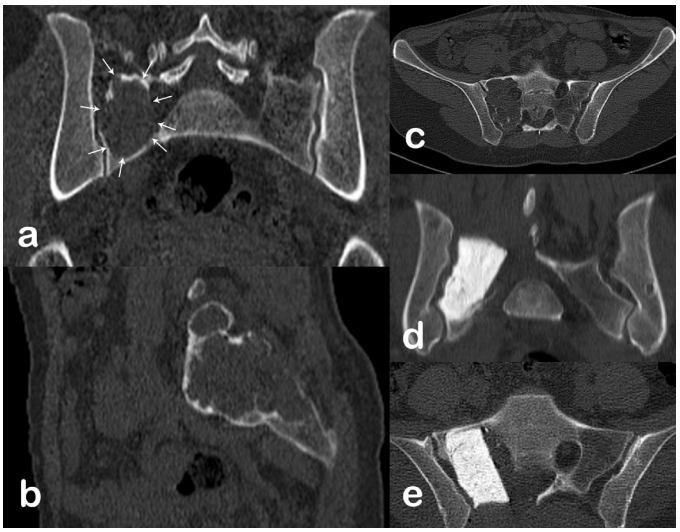


Figure 2. Female, 32-year-old. **a.** Preoperative axial view, CT of GCT at right S1 & S2. **b.** Preoperative sagittal view, CT. **c.** Preoperative coronal view, CT. **d.** Cement as adjuvant therapy seen on postoperative axial view. **e.** Cement is seen on postoperative coronal view

CT: Computed tomography, GCT: Giant cell tumor

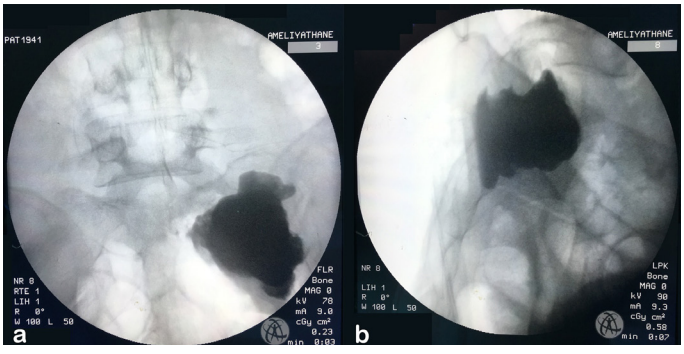


Figure 3. After removal of tumor, void is filled with contrast and fluoroscopy is used to control the borders of curettage borders. If it is insufficient, re-curettage is performed. **a.** AP view **b.** Lateral view

AP: Anteroposterior

Cauterization is used as necrotizing adjuvant therapy in extremities[10], yet we are not aware of any reports in literature for its use in spinal GCTs. Also, high-speed burr is frequently used to remove remaining tumor from the walls in extremities, yet its use is limited in the spine[15]. Phenol is used in GCTs of extremities as adjuvant therapy, yet its use is not suggested in spinal cases due to risks to the medulla spinalis and nerve roots[15]. Among patients with intralesional curettage in extremity GCTs, phenol as adjuvant therapy has a higher recurrence rate in grafting than cementing patients[30]. However, we used high-speed burr, electrocautery, and phenol safely in the present study, and we believe they can be used with neural tissue protective precaution safely, such as using a small sponge saturated with phenol for the application of phenol on the walls (Figure 5).

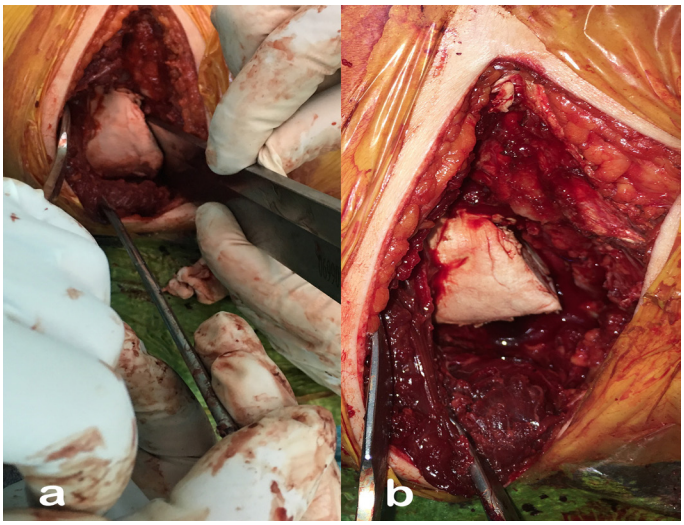


Figure 4. High-viscosity cement can be safely used by using blunt tip of osteotomes to protect neural structures. a. During application and setting cement. b. Posterior view after removal of osteotomes

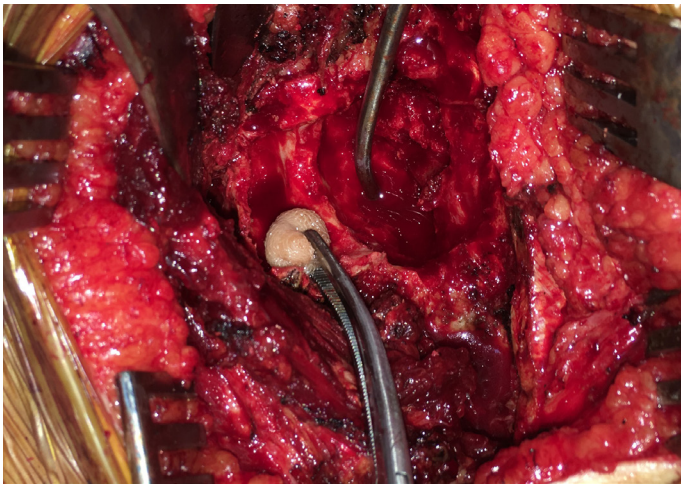


Figure 5. By saturating a small sponge with phenol, walls can be treated with it safely

There was no case treated with preoperative embolization or RT in our series. However, preoperative embolization followed by resection is an option in large GCTs[7,31,32]. RT is suggested to decrease postoperative recurrence in GCT. However, there is still debate on the development of myelopathy and sarcoma secondary to RT[19,33].

Lung metastasis has been reported in 3% of the cases[4]. However, as high as 15.6% rate of lung metastasis has also been reported[30]. Lung metastasis in GCT usually represents as benign with long survival time and without malignant histologic cases, yet it may become progressive in certain cases, with a mortal course[15,30,34,35]. Metastatic spots are usually not painful, and they are either observed or marginally excised via thoracotomy[10,11,33]. Chest radiograms should be studied for metastasis evaluation during follow-up. There was no case with lung metastasis in our series. Imatinib (Novartis, East Hanover, NJ, USA) is the choice of drug for the treatment of lung metastasis; however, chemotherapy with Adriamycin and Cisplatin may be preferred[36]. Lately, Denosumab, a monoclonal antibody to RANKL, has been approved by the Food and Drug Administration in adjuvant therapy for primary tumor site[8,37-41], and it has also been used in the adjuvant treatment of lung metastasis[42]. There was no patient treated with Denosumab in this study population. We had no experience with Denosumab previously, hence it was not used in the patient with recurrence. However, we have been using Denosumab treatment in large GCTs of long bones recently, which has promising results in surgical treatment of the large tumors in our clinical experience, similar to recent literature.

Study Limitations

The limitations of our study are the retrospective design, small sample size, and the application of different treatment techniques in our series. Since sacral GCTs are rare tumors, it is difficult to design a prospective design in a single center. Prospectively randomized designed multi-center studies with larger patients' groups are required.

CONCLUSION

Careful curettage of all tumor outweighs the adjuvant therapy, and cementing has better local recurrence rates than grafting. Thus, intralesional curettage and filling void with PMMA is the primary option in patients without soft tissue component in sacral GCTs. Patients need to be monitored with radiographs and CT for lesion recurrence and pulmonary metastases. Refractory, recurrent, and particularly aggressive lesions may undergo en bloc excision, yet for the areas that are inaccessible and difficult to treat such as the skull base, and for large lesions with soft tissue component of the spine, pelvis, and sacrum in adults and adolescents, there are limited options. In those patients, embolization, RT, or Denosumab treatment may be

used as standalone therapy or as adjuvant therapy in addition to surgical treatment.

Ethics

Ethics Committee Approval: Ethical approval is obtained from Metin Sabancı Baltalimanı Osteopathic Training and Research Hospital, Medical Specialty board Ethics Committee (date: 23.12.2019 no: 376).

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: A.Ö., Y.E.A., Concept: A.Ö., Design: A.Ö., Y.E.A., Data Collection or Processing: A.Ö., Analysis or Interpretation: A.Ö., Y.E.A., Literature Search: A.Ö., Writing: A.Ö., Y.E.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Orguc S, Arkun R. Primary Tumors of the Spine. Semin Musculoskelet Radiol. 2014;18:280-99.
2. Dang L, Liu X, Dang G, Jiang L, Wei F, Yu M, et al. Primary tumors of the spine: a review of clinical features in 438 patients. J Neurooncol. 2015;121:513-20.
3. Murphey MD, Nomikos GC, Flemming DJ, Gannon FH, Temple HT, Kransdorf MJ. From the archives of AFIP. Imaging of giant cell tumor and giant cell reparative granuloma of bone: radiologic-pathologic correlation. RadioGraphics. 2001;21:1283-309.
4. Parman LM, Murphey MD. Alphabet Soup: Cystic Lesions of Bone. Semin Musculoskelet Radiol. 2000;4:0089-0102.
5. Skubitz KM, Cheng EY, Clohisy DR, Thompson RC, Skubitz APN. Gene expression in giant cell tumors. J Lab Clin Med. 2004;144:193-200.
6. Morgan T, Atkins GJ, Trivett MK, Johnson SA, Kansara M, Schlicht SL, et al. Molecular profiling of giant cell tumor of bone and the osteoclastic localization of ligand for receptor activator of nuclear factor kappaB. Am J Pathol. 2005;167:117-28.
7. Martin C, McCarthy EF. Giant cell tumor of the sacrum and spine: series of 23 cases and a review of the literature. Iowa Orthop J. 2010;30:69-75.
8. Gong LH, Liu WF, Ding Y, Zhang W, Yang YK, Yu F, et al. Clinical, radiologic and pathologic features of giant cell tumor of bone treated with denosumab. Zhonghua Bing Li Xue Za Zhi. 2018;8;47:449-54.
9. Kim SC, Cho W, Chang U-K, Youn SM. Clinical Outcome of Treatment for Patients with Giant Cell Tumor in Spine. J Korean Neurosurg Soc. 2015;58:248-53.
10. Domovitov SV, Chandhanayingyong C, Boland PJ, McKeown DG, Healey JH. Conservative surgery in the treatment of giant cell tumor of the sacrum: 35 years' experience. J Neurosurg Spine. 2016;24:228-40.
11. Jamshidi K, Bagherifard A, Mirzaei A, Bahrabadi M. Giant Cell Tumor of the sacrum: Series of 19 patients and Review of the Literature. Arch Bone Jt Surg. 2017;5:443-50.
12. Hussain S, Makhdoomi R, Khursheed N, Aiman A, Bhat N. Giant Cell Tumor of Sacrum: a Report of Two Cases (Internet). J Turk Spinal Surg. 2015;26:47-50.
13. Dürr HR, Maier M, Jansson V, Baur A, Refior HJ. Phenol as an adjuvant for local control in the treatment of giant cell tumour of the bone. Eur J Surg Oncol. 1999;25:610-8.
14. Campanacci M, Baldini N, Boriani S, Sudanese A. Giant-cell tumor of bone. J Bone Joint Surg Am. 1987;69:106-14.
15. Boriani S, Bandiera S, Casadei R, Boriani L, Donthineni R, Gasbarrini A, et al. Giant cell tumor of the mobile spine: a review of 49 cases. Spine (Phila Pa 1976). 2012;37:E37-45.
16. Turcotte RE, Sim FH, Unni KK. Giant cell tumor of the sacrum. Clin Orthop Relat Res. 1993:215-21.
17. Sar C, Eralp L. Surgical treatment of primary tumors of the sacrum. Arch Orthop Trauma Surg. 2002;122:148-55.
18. Enneking WF, Spanier SS, Goodman MA. A system for the surgical staging of musculoskeletal sarcoma. 1980. Clin Orthop Relat Res. 2003:4-18.
19. Miszczyk L, Wydmański J, Spindel J. Efficacy of radiotherapy for giant cell tumor of bone: given either postoperatively or as sole treatment. Int J Radiat Oncol Biol Phys. 2001;49:1239-42.
20. Puthoor D, Iype W. Giant cell tumor: Curettage and bone grafting. Indian J Orthop. 2007;41:121-23.
21. Blackley HR, Wunder JS, Davis AM, White LM, Kandel R, Bell RS. Treatment of giant-cell tumors of long bones with curettage and bone-grafting. J Bone Joint Surg Am. 1999;81:811-20.
22. Zuo D, Zheng L, Sun W, Fu D, Hua Y, Cai Z. Contemporary adjuvant polymethyl methacrylate cementation optimally limits recurrence in primary giant cell tumor of bone patients compared to bone grafting: a systematic review and meta-analysis. World J Surg Oncol. 2013;16;11:156.
23. Vaishya R, Pokhrel A, Agarwal AK, Vijay V. Current status of bone cementing and bone grafting for giant cell tumour of bone: A systemic review (Internet). Ann R Coll Surg Engl. 2019;101:79-85.
24. Marcove RC, Weis LD, Vaghaiwalla MR, Pearson R, Huvos AG. Cryosurgery in the treatment of giant cell tumors of bone. A report of 52 consecutive cases. Cancer. 1978;41:957-69.
25. Jacobs PA, Clemency RE. The closed cryosurgical treatment of giant cell tumor. Clin Orthop Relat Res. 1985:149-58.
26. Malawer MM, Bickels J, Meller I, Buch RG, Henshaw RM, Kollender Y. Cryosurgery in the treatment of giant cell tumor: A long term followup study. Clin Orthop Relat Res. 1999:176-88.
27. O'Donnell RJ, Springfield DS, Motwani HK, Ready JE, Gebhardt MC, Mankin HJ. Recurrence of giant-cell tumors of the long bones after curettage and packing with cement. J Bone Joint Surg Am. 1994;76:1827-33.
28. Capanna R, Sudanese A, Baldini N, Campanacci M. Phenol as an adjuvant in the control of local recurrence of benign neoplasms of bone treated by curettage. Ital J Orthop Traumatol. 1985;11:381-8.
29. Klenke FM, Wenger DE, Inwards CY, Rose PS, Sim FH. Giant cell tumor of bone: risk factors for recurrence. Clin Orthop Relat Res. 2011;469:591-9.
30. Klenke FM, Wenger DE, Inwards CY, Rose PS, Sim FH. Recurrent giant cell tumor of long bones: analysis of surgical management. Clin Orthop Relat Res. 2011;469:1181-7.
31. He S, Xu W, Sun Z, Liu W, Liu Y, Wei H, et al. Selective Arterial Embolization for the Treatment of Sacral and Pelvic Giant Cell Tumor: A Systematic Review. Orthop Surg. 2017;9:139-44.
32. Wu Z, Yang X, Xiao J, Feng D, Huang Q, Zheng W, et al. Aneurysmal bone cyst secondary to giant cell tumor of the mobile spine: a report of 11 cases. Spine (Phila Pa 1976). 2011;36:E1385-90.
33. Feigenberg SJ, Marcus Jr RB, Zlotecki RA, Scarborough MT, Berrey BH, Enneking WF. Radiation therapy for giant cell tumors of bone. Clin Orthop Relat Res. 2003;411:207-16.
34. Yin H, Cheng M, Li B, Li B, Wang P, Meng T, et al. Treatment and outcome of malignant giant cell tumor in the spine. J Neurooncol 2015;124(2):275-81.
35. van der Heijden L, van de Sande MAJ, van der Geest ICM, Schreuder HWB, van Royen BJ, Jutte PC, et al. Giant cell tumors of the sacrum-a nationwide study on midterm results in 26 patients after intralesional excision. Eur Spine J. 2014;23(9):1949-62.

36. William Makis, Z. Alabed, Ayoub Nahal, Javier A. Novales-Diaz, Marc Hickeson Giant Cell Tumor Pulmonary Metastases Mimic Primary Malignant Pulmonary Nodules on 18F-FDG PET/CT. Nucl Med Mol Imaging. 2012;46:134-37.
37. Lin P, Lin N, Teng W, Wang SD, Pan WB, Huang X, et al. Recurrence of Giant Cell Tumor of the Spine after Resection: A Report of 10 Cases. Orthop Surg. 2018;10:107-14.
38. de Carvalho Cavalcante RA, Silva Marques RA, Santos VG dos, Sabino E, Fraga AC, Zaccariotti VA, et al. Spondylectomy for Giant Cell Tumor After Denosumab Therapy. Spine (Phila Pa 1976). 2016;41:E178-82.
39. Inoue G, Imura T, Miyagi M, Saito W, Tazawa R, Nakazawa T, et al. Total en bloc spondylectomy of the eleventh thoracic vertebra following denosumab therapy for the treatment of a giant cell tumor. Oncol Lett. 2017;14:4005-10.
40. Fraile NM, Toloi D, Kurimori CO, Matutino AR, Codima A, Camargo VP, et al. Successful Intravascular Correction of Intratumoral Pseudoaneurysm by Erosion of the Aorta in a Patient with Thoracic Giant Cell Tumor of Bone Responding to Denosumab. Case Rep Oncol Med. 2015:626741.
41. Kajiwara D, Kamoda H, Yonemoto T, Iwata S, Ishii T, Tsukanishi T, et al. Denosumab for Treatment of a Recurrent Cervical Giant-Cell Tumor. Asian Spine J. 2016;10:553-57.
42. Watanabe Y, Kaya M, Sasaki M, Emori M, Murahashi Y, Mizushima E, et al. Experience using denosumab for lung metastases of giant cell tumor of bone. Eur Orthop Traumatol. 2015;6:239-41.

J Turk Spinal Surg 2020;31(1):47-50
DOI: 10.4274/jtss.galenos.2020.48

CASE REPORT
47

GIANT CELL TUMOR OF THE THORACAL SPINE: CASE REPORT

Hümeyra Kullukçu ALBAYRAK[1], Ahmet Gürhan GÜRÇAY[2], Atilla KAZANCI[2], Mehmet Özgür ÖZATEŞ[1], Oktay GÜRCAN[1]

[1]Ankara City Hospital, Clinic of Neurosurgery, Ankara, Turkey
[2]Yıldırım Beyazıt University Faculty of Medicine, Department of Neurosurgery, Ankara, Turkey

ABSTRACT

Giant cell tumor is one of the benign tumors of bone that typically originate from the meta-epiphysial ends of long bones. It constitutes approximately 5% to 10% of all bone tumors in adults. These rarely seen tumors in the spine often present with nonspecific localized pain due to bone involvement. Diagnosis is made by demonstrating osteolytic bone lesion by direct X-ray and computed tomography. Surgical excision, radiotherapy and immunotherapy are the main treatment modalities. Herein we report a young female patient presented to our clinic with back pain and hypoesthesia in her legs. Lytic bone lesion in the second thoracic vertebra was radiologically demonstrated. After subtotal excision, histopathological examination revealed giant cell tumor of the bone. Diagnosis and treatment approaches in our case were discussed by reviewing the literature.

Keywords: Giant cell tumor, primary bone tumor, thoracic spine

INTRODUCTION

Giant cell tumor (GCT) is one of the benign tumors of bone that typically originate from the meta-epiphysial ends of long bones such as the distal femur, proximal tibia, and distal radius[1]. Generally, it is seen slightly more in women who have completed skeletal maturation in the third and fourth decades[2]. GCT is rarely seen in the spine. Spine location is mostly in the spine body rather than in the posterior elements[3]. In contrast to GCT seen in the extremities, those with spine localization are seen in younger patients[4]. In this case report, a 28-year-old female patient who was operated on and diagnosed as GCT was discussed by reviewing the literature.

CASE REPORT

A 28-year-old female patient was admitted to our clinic with the complaints of back pain localized to upper thoracic spine and hypoesthesia in the legs. These complaints had been present for 1 year and increased in the last 3 months. She had a diagnosis of lumbar discopathy and underwent various medical/physical therapies. However, her complaints increased and thoracal magnetic resonance imaging (MRI) revealed a mass lesion in the thoracic two vertebra on contrast-enhanced series. On admission, the right extensor hallucus longus and foot dorsal flexion was at 4/5 strength, and under T5 level, there was hypoesthesia. Also, there was bilateral Babinski pathological reflex and impaired tandem gait. Thoracic computed tomography (CT) and MRI showed a lytic lesion in the thoracic two vertebral corpus extending to the surrounding tissue (Figures 1-2). With the diagnosis of T2 vertebrae mass, patient underwent operation. Subtotal excision was performed macroscopically with malignant tumor bone excision after C7-T4 posterior instrumentation via posterior approach. Arthrodesis was achieved by T2 corpectomy + cage fusion implementation (Figure 3). As a result of histopathological examination, due to the presence of a plurality of multinuclear giant cells between oval round nuclei, open chromatinous, nucleolated mononuclear cells and foamy histiocytes in some

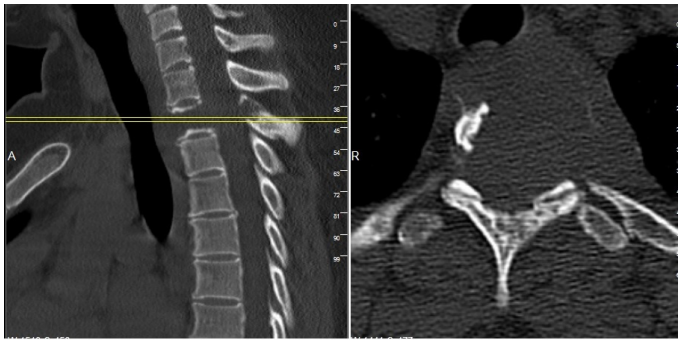


Figure 1. Preoperative CT results
CT: Computed tomography

Address for Correspondence: Hümeyra Kullukçu Albayrak, Ankara City Hospital, Clinic of Neurosurgery, Ankara, Turkey
Phone: +90 532 678 87 73 **E-mail:** humeyrakullukcu@hotmail.com **Received:** 05.12.2019 **Accepted:** 01.02.2020
ORCID ID: orcid.org/0000-003-0675-8288

areas, occasional bleeding areas, hemosiderin pigment and bone spicules, and also the presence of reactive osteoid formation as small foci within the tumor, the tumor was evaluated as a giant cell tumor of bone in the intermediate group (Figure 4). Postoperative thoracic CT and MRI examinations revealed subtotal excision of the tumor. The patient was discharged with a thoracic corset on the 7th postoperative day without any additional deficit. Denosumab/Filgrastim + Lenogastrim treatment was started after the patient was evaluated by the oncology department after discharge. There is no regression or progression for the residual mass, it is stable. There is no new lesion in the 4-year follow-up (Figure 5,6).

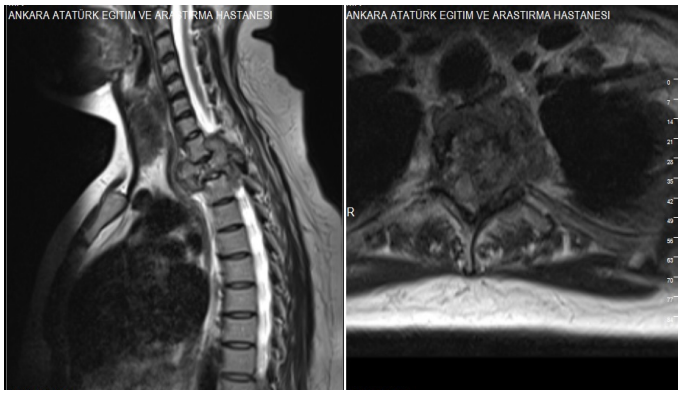


Figure 2. Preoperative MR results
MR: Magnetic resonance

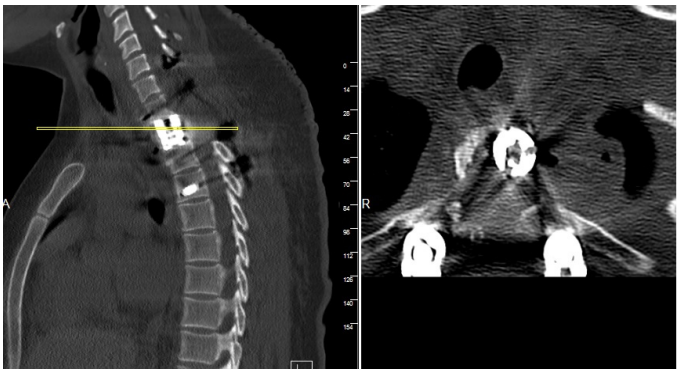


Figure 3. Postoperative 1st day CT results
CT: Computed tomography

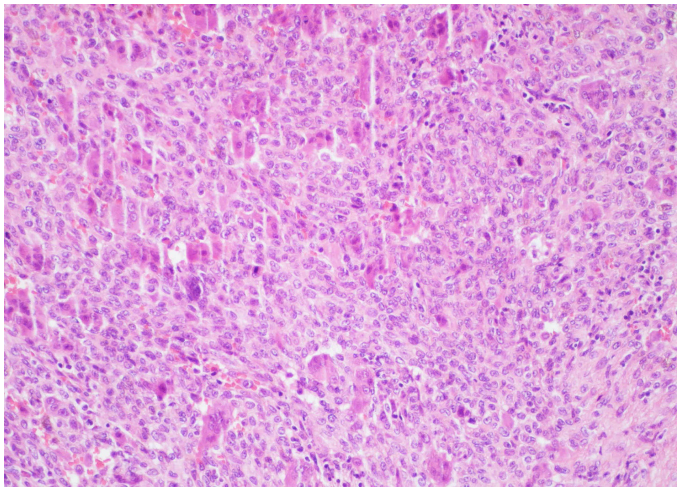


Figure 4. Patology results

DISCUSSION

GCT is one of the benign tumors of bone, which usually originates from the metaepiphysial ends of long bones and constitutes approximately 5% to 10% of all bone tumors in adults[1]. It is mostly seen in females who have completed skeletal maturation in the third and fourth decades of life[2]. Spine location is mostly in the spine body rather than the posterior elements. GCT is generally located in corpus against the posterior elements in the spine[3]. In our 28-year-old female case, the mass was located in the thoracic two vertebra corpus in accordance with the literature.

Patients commonly present with back pain. Since the first symptom is usually back pain, it may cause misinterpretations and delay in diagnosis[2,3]. With the growth of tumor size, localized pain may present with swelling and compression of spinal cord or nerve roots on the affected side and present with neurological deficits[5,6]. Similarly, our patient received medical and physical therapy with the complaint of back pain and with

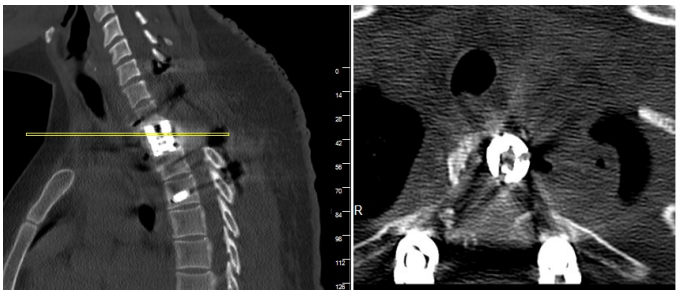


Figure 5. Postoperative 4th year CT
CT: Computed tomography

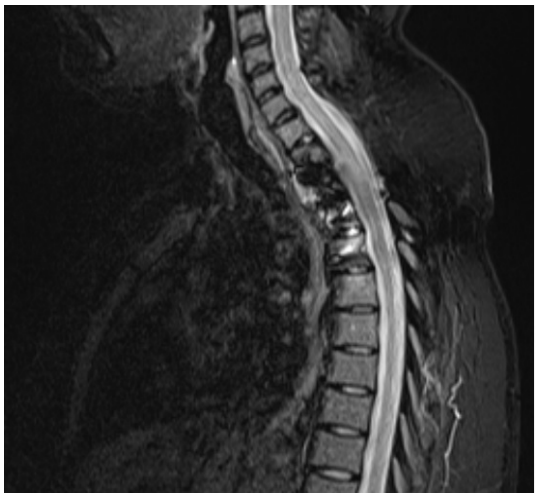


Figure 6. Postoperative 4th year MR
MR: Magnetic resonance

the diagnosis of lumbar disc disease for about 1 year in various centers. After weakness of the lower extremity and sensory deficits, the patient was diagnosed with thoracic mass.

The most common localization of GCT in the spine is the sacrum and these localized tumors are diagnosed late due to nonspecific symptoms and show a more aggressive course[7]. Depending on the location of the tumor in the sacrum, they may present with weakness in the gastrocnemius muscle in the upper sacral location, loss of bladder and bowel control in the lower sacral location, and perineal numbness and sexual dysfunction[8]. In our case, thoracic spine involvement, which is a rare localization, was present.

It is usually seen as a destructive, osteolytic lesion in radiologic imaging. Generally, they can be distinguished from other bone tumors by their radiological appearance. In our patient, as seen on thoracic CT, there was a well-circumscribed lytic lesion in the T2 vertebra corpus (Figure 1). CT and MRI provide detailed information about bone involvement, surrounding soft tissue and bone marrow[3]; bleeding, cysts and necrosis areas may vary due to variable signal intensities. Similarly, in our case, MRI of the tumor showed heterogeneous iso- or hypointense on T1-weighted sequences and heterogeneous hyperintense on T2-weighted sequences (Figure 2). It should be noted that GCT can occur in two separate vertebrae. For this purpose, the whole spine should be investigated preoperatively by bone scintigraphy or CT[9]. In our case, preoperative scintigraphy and spinal CT were performed and no second focus was detected.

The treatment of GCT is more complex due to limited surgical access to the spine, differences in vascular structures, and proximity to the spinal cord and nerve roots, as opposed to tumors in other regions. Radical excision of GCT is accepted as the best treatment option[10]. Although lower margin recurrence rates are seen in wide marginal resection or en-bloc resection of the tumor, this can often lead to serious neurological impairment[11]. Neoadjuvant treatments (neoadjuvant chemotherapy, selective arterial embolization) can be used before the surgery. Selective arterial embolization (SEE) reduces the amount of intraoperative bleeding when applied 24 hours before the surgery. There are also studies reporting a reduction in recurrence rates. SEE may act as a neoadjuvant therapy rather than a stand-alone treatment, as it alone does not provide local control. Chemotherapeutic agents are used in preoperative (Neo-adjuvant Immunotherapy) and postoperative (Adjuvant Immunotherapy) treatments. As Bisphosphonates and Denosumab are involved in the apoptosis of tumor cells and they inhibit the growth of GCT cells by inhibiting osteoclast differentiation, the use of these drugs before and after surgery is recommended[12,13]. The dimensions of surgical excision and adjuvant treatments [Radiotheraphy (RT) and immunotherapy] depend on many factors such as tumor location and patient comorbidity. Whether RT is given is controversial. The efficacy of RT and the frequency of sarcomatous conversion are two major concerns about the frequency of this therapy. RT may be an alternative treatment in cases where complete excision is not possible or there is excessive morbidity. Other adjuvant therapies such as freezing, argon beam coagulation, radioactive particles and cementation may be useful, but there is no clear study of these methods. In our case, Denosumab/Filgrastim + Lenogastrim treatment was initiated by Oncology Department after discharge. RT was not applied because of the possibility of sarcomatous transformation.

Although GCT is generally accepted as benign, they may display malignant aggressive behavior such as local invasion and lung metastasis less frequently[14]. Since these tumors have local aggressive ability, local recurrence rate is quite high if adequate excision is not performed[10]. The local recurrence rate varies between 10% and 40% depending on surgical intervention and treatment[15]. The recurrence rate is higher in patients under 30 years of age[16]. Thorax CT was performed in our patient for possible preoperative lung metastasis exclusion and no signs of metastasis were detected. There was no recurrence in the 4-year follow-up of our patient who underwent total excision and immunotherapy after surgery (Figures 5,6).

CONCLUSION

The giant cell tumor of the bone, which presents with nonspecific back and low back pain and rarely with spine involvement in long bones especially in middle-aged women, should be considered in the differential diagnosis. Although it is generally accepted as benign, the combination of neo-adjuvant treatments (SEE, Immunotherapy), radical excision and postoperative relapse reduction (RT, Bisphosphonates, Denosumab) is the most appropriate treatment because of high local recurrence rates after inadequate surgery.

Ethics

Informed Consent: Informed consent form was obtained from the patients.

Authorship Contributions

Concept: H.K.A., A.G.G., O.G., Design: H.K.A., A.K., M.Ö.Ö., Data Collection or Processing: H.K.A.,Analysis or Interpretation: H.K.A., A.G.G., O.G., A.K., Literature Search: H.K.A., O.G., A.K., M.Ö.Ö., Writing: H.K.A., A.K., O.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Larsson SE, Lorentzon R, Boquist L. Giant-cell tumor of bone. A demographic, clinical and histopathological study of all cases recorded in the Swedish Cancer Registry fort he years 1958 through 1968. J Bone Joint Surg Am. 1975;57:167-73.
2. Balke M, Henrichs MP, Gosheger G, Ahrens H, Streitbuerger A, Koehler M, et al. Giant cell tumors of the axial skeleton. Sarcoma. 2012;410973.
3. Kim HM, Lee JE, Jung SS, Chon J, Yoon DH, Park YK, et al. Spinal Cord Injury due to the Giant Cell Tumor of the second Thoracic Vertebra: A case Report. Ann Rehabil Med. 2013;37:269-73.

4. Dahlin DC. Giant-cell tumor of vertebrae above the sacrum: a review of 31 cases. Cancer. 1977;39:1350-6.
5. Kumar R, Guinto FC, Madewell JE, David R, Shirkhoda A. Expansile bone lesions of the vertebra. Radiographics. 1998;8:749-69.
6. Sanjay BK, Frassica FJ, Frassica DA, Unni KK, Mcleod RA, Sim FH. Treatment of gaint-cell tumor of the pelvis. J Bone Joint Surg Am. 1993;75:1466-75.
7. Althausen PL, Schneider PD, Bold RJ, Gupta MC, Goodnight JE, Khatri VP. Multimodality management of a giant cell tumor arising in the proximal sacrum: case report. Spine (Phila Pa 1976). 2002;27:E361-5.
8. Dahlin DC. Caldwell Lecture. Giant cell tumor of bone: highlights of 407 cases. AJR Am J Roentgenol. 1985;144:955-60.
9. Kos CB, Taconis WK, Fidler MW, ten Velden JJ. Multifocal giant cell tumors in the spine. A case report. Spine (Phila Pa 1976). 1997;22:821-2.
10. Junming M, Cheng Y, Dong C, Jianru X, Xinghai Y, Quan H, et al. Giant cell tumor of the servical spine: a series of 22 cases and outcomes. Spine (Phila Pa 1976). 2008;33:280-8.
11. Martin C, McCarthy EF. Giant cell tumor of the sacrum and spine: series of 23 cases and a review of the literatüre. Iowa Orthop J. 2010;30:69-75.
12. Cheng YY, Huang L, Lee KM, Xu JK, Zheng MH, Kumta SM. Bisphosphonates induce apoptosis of stromal tumor cells in giant cell tumor of bone. Calcif Tissue Int. 2004;75:71-7.
13. Li G, Fu D, Chen K, Ma X, Sun M, Sun W, et al. Surgical strategy fort he management of sacral giant cell tumors: a 32-case series. Spine J. 2012;12:484-91.
14. Lausten GS, Jensen PK, Schiodt T, Lund B. Local recurrences in giant cell tumor of bone. Longterm follow up of 31 cases. Int Orthop. 1996;20:172-6.
15. Kathiresan AS, Johnson JN, Hood BJ, Montoya SP, Vanni S, Gonzalez-Quintero VH. Giant cell bone tumor of the thoracic spine presenting in late pregnancy. Obstet Gynecol. 2011;118:428-31.
16. Bertoni F, Present D, Enneking WF. Giant-cell tumor of bone with pulmonary metastases. J Bone Joint Surg Am. 1985;67:890-900.

J Turk Spinal Surg 2020;31(1):51-4
DOI: 10.4274/jtss.galenos..2020.69

CASE REPORT
51

DISTAL MIGRATION OF THE RODS OF A CONSTRAINED POLYAXIAL PEDICLE SCREW SYSTEM

Selim AYHAN[1], Tiro MMOPELWA[2], Prashant ADHIKARI[2], Vugar NABI[2], Emre ACAROĞLU[3]

[1]Acıbadem Ankara Hospital ARTES Spine Center, Clinic of Neurological Surgery, Ankara, Turkey
[2]Acıbadem Ankara Hospital ARTES Spine Center, Clinic of Orthopaedics and Traumatology, Ankara, Turkey
[3]Ankara Spine Center, Department of Orthopaedics and Traumatology, Ankara, Turkey

ABSTRACT

Spinal instrumentation and surgical techniques have exponentially improved over the years, and today's spinal surgeon is well equipped to rigidly fix the spine with minimum adverse effects. Complications may emerge during or after the surgical operations. Infection, hematoma and neurological deficits are early noticed findings. Instrumentation problems i.e. screw and/or rod failures present in long-term after surgery. Caudal rod migration out of the spinal column is a rare entity. We report here three case incidents (in two patients) of lumbar degenerative disorders requiring spinal instrumentation that represented with caudal rod migration, all associated with one particular implant made.

Keywords: Implant failure, lumbar spine, migration, pedicle screw instrumentation, spinal stenosis

INTRODUCTION

Spinal instrumentation and surgical techniques have exponentially improved over the years and today's spinal surgeon is well equipped to rigidly fix the spine with minimum adverse effects. But, especially for adult spinal deformity surgery, up to one third of patients experience some form of radiographic and/or implant-related complications, ranging from rod or screw breakage to implant prominence[1]. Distant rod migration after spine instrumentation is not a common complication but could potentially result in high morbidity or even fatal outcomes if unrecognized. There are plenty of case reports in the literature about this type of complication following spinal instrumentation. These reports range from cephalic to caudal rod migrations, which in some instances lead to near catastrophes[2-5]. There are cases of rod migrating from cervical spine fixation to the occipital fossa, into the brain matter and those of rod migrating from lumbar spine fixation down to the knee[3,5,6]. Interestingly, none of all these published reports describe any propensity of this type of complication happening with any particular implant brand, make or metal type. We report here three case incidents (in two patients) of lumbar spinal instrumentation that represented with caudal rod migration, all associated with one particular implant make.

CASE REPORTS

Case 1

A 69-year-old male patient presented to our spine clinic with bilateral buttock and lower extremity pain associated with neurogenic claudication. He had no other comorbidities of significance; his body mass index (BMI) value was 34.2. His left extremity pain was worse than the right side. Motor strength was within normal limits and there were no bowel or bladder symptoms. Radiographs and magnetic resonance imaging of the lumbar spine revealed degenerative changes and a flat back with multi-level spinal stenosis. After failure of conservative treatment, he was scheduled for spinal decompression and instrumented fusion. His surgery consisted of posterior decompression through multiple laminectomies as well as facet osteotomies to restore his lordosis and posterior instrumented fusion (using local iliac crest bone) from T12 to sacrum using a constrained polyaxial pedicle screw system with a 6.0 mm rod diameter (Xia Titanium Spinal System, Stryker Spine, Allendale, NJ, USA) (Figure 1a, b) . Two 6.0 mm titanium rods and multi-level titanium polyaxial screws were used. Early post-operative period was uneventful, and the patient was discharged home four days after surgery. At three months during patient's routine

Address for Correspondence: Emre Acaroğlu, Ankara Spine Center, Clinic of Orthopaedics and Traumatology, Ankara, Turkey
E-mail: acaroglue@gmail.com **Received:** 06.01.2020 **Accepted:** 15.01.2020
ORCID ID: orcid.org/0000-0002-8163-2944

follow-up, lumbar-sacral radiographs revealed a broken left rod now lodged at the gluteal area due to caudal migration (Figure 1c, d). On further questioning, the patient reported some mild aching pain over his left buttock area especially with sitting, but denied any recent strenuous activity. There was no evidence of fusion yet at the instrumented levels. He subsequently underwent a revision surgery of his broken left rod with an additional bypass rod at the left side (Figure 1e, f). Intra-operatively, all the screw caps on the left side were loose. They appeared to be well centered but had backed off by one or two turns allowing the rod to slide down. The screws on the right side were tight. There was no evidence of infection or metallosis. Swabs for cultures were taken and all came back negative for infection.

Case 2

Twelve months after his second operation, "Case 1" presented to his local medical facility again complaining of left gluteal swelling and redness. According to accompanying notes, there was no evidence for local infection or gluteal abscess. Radiographs taken revealed a left sided distal domino failure and had caudally migrated and lodged at his left gluteal area (Figure 2a, b). Similarly, there was no history of recent trauma or strenuous activity. A third operation was subsequently performed for rod and screws exchange with another spinal instrumentation system (CD Horizon Engage 6.35 Spinal System, Medtronic, Minneapolis, MN USA) (Figure 2c, d). Intra-operative findings were strikingly similar to his previous surgery. Right rod was intact, screw caps on the left sided were well centered but had backed off one or two turns. There was no evidence of infection or metallosis. He had further follow-up of 14 months with no residual symptoms at the time of the writing of this report.

Case 3

A 72-year-old male, who had a background history of L1-3 decompression and instrumented fusion for degenerative spinal stenosis performed at another institution 5 years before presenting to our center, was admitted. He had further comorbidities of diabetes mellitus for 32 years, fungal osteomyelitis of the maxilla (treated) and a BMI of 34.6. He presented with the recurrence of low back symptoms and was diagnosed as having further multi-level degenerative spinal stenosis and sagittal imbalance. Similar to the first patient, decompression as well as long instrumented fusion (using local iliac crest bone) from T9 to ileum with partial restoration of lumbar lordosis was performed. Two 6.0 mm titanium rods and multi-level titanium polyaxial screws of the same instrumentation system as case 1 were used for fixation (Xia Titanium Spinal System, Stryker Spine, Allendale, NJ, USA). His immediate post-operative period was unremarkable. Twelve months later, the patient presented back to our institution complaining of left gluteal pain and swelling. He denied any recent strenuous activity. Further evaluation and radiographs revealed a loose left rod that had migrated caudally to the gluteal area similar to the first patient (Figure 3a, b). The left rod was revised and intra-operative findings revealed loose caps on the left side (seven in total). The caps were well centered but had backed off. There were no signs of infection or metallosis noted and culture swabs were negative. His further follow-

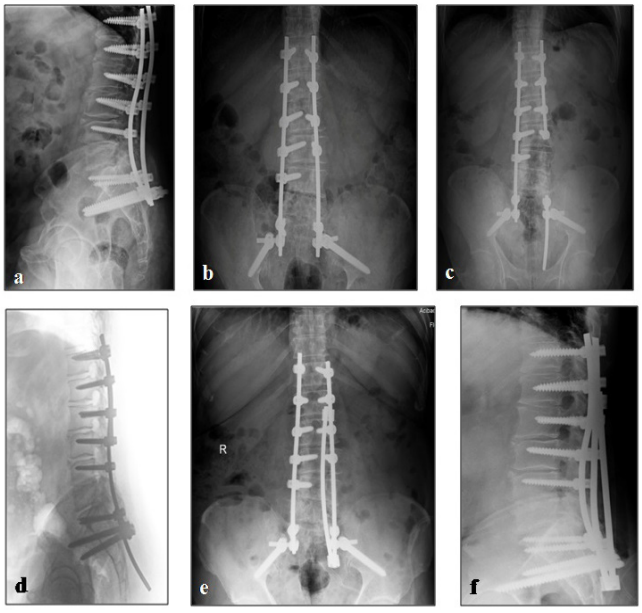


Figure 1. Early post-operative X-ray, AP **(a)** and lateral view **(b)**, a repeat X-ray at three months AP **(c)** and lateral **(d)** views showing a caudally migrated left rod. X-rays after revision surgery, AP **(e)** and lateral **(f)** views

AP: Anteroposterior

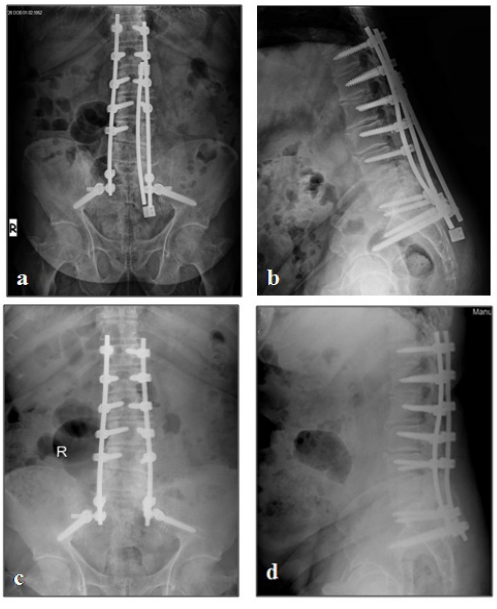


Figure 2. One year after post revision surgery showing caudally migrated domino AP (**a**) and Lateral **(b)** X-rays views. Rod and screws exchange with another spinal instrumentation system AP **(c)** and Lateral **(d)** X-rays views

AP: Anteroposterior

up of two years now is uneventful with regard to any further instrumentation problems.

DISCUSSION

This is a report of two patients who had undergone surgery consisting of decompression and instrumented fusion for lumbar spinal stenosis. These patients experienced rod loosening and migration secondary to the loosening of the screw caps with or without associated rod breakage at a total of three instances. Such a complication associated with very similar patients and a single instrumentation system has not been reported previously.

The case reports of spine rod migrations are mainly of either Harrington rods or of Luque rod instrumentation system, both unconstrained systems in regard to the anchor-rod interface[7]. In all these cases described, there was a significant time lapse between the index surgery and discovery of a migrated rod. The three incidents presented here are those of loss of rod fixation and subsequent migration involving one particular implant and all happening within a short span of time from the index surgery. Davne and Myers[8] described 5.6% of nut loosening in their series of 486 patients and they attributed this as technical problems, this problem was resolved after the introduction of integral-nut screw system. Leute et al.[9] reported a case of set screw fracture with cage dislocation after an open TLIF procedure, they acknowledged this as malpositioning of set screws or flaws in their production. In another case by Bayri et al.[7], a patient, who had underwent spinal instrumentation surgery for spondylolisthesis 6 years ago, was detected to have migration of rod into retroperitoneal region, the reason for movement of the rod in this case was due to unbalanced motion at the instrumented level without any fusion.

This type of implant failure may be secondary to several reasons: technique related, implant design defects, patient related factors and material failure with or without a non-rigid fixation (pseudoarthrosis). Poor technique in the form of insufficient tightening of the nut into the screw head, or improper coupling between nut and screw head can cause loosening and consequent dislodgment of the rod[10]. In our setting, the same team highly experienced in spinal instrumentation operated the two patients in a similar fashion to all other cases. A total of 68 patients were operated with such spinal instrumentation system (Xia Titanium Spinal System, Stryker Spine, Allendale, NJ, USA) upon having had this confusing complication. Screw nuts were tightened in accordance with the recommendations of the manufacturer (a torque wrench screw driver was used with the recommended level of torque application). Hence, surgical technique is highly unlikely to be a factor because this phenomenon has not been experienced when using different implant systems. In addition, there were no signs of eccentric coupling between the nut and screw head intra-operatively at the index surgeries or at the times of revision.

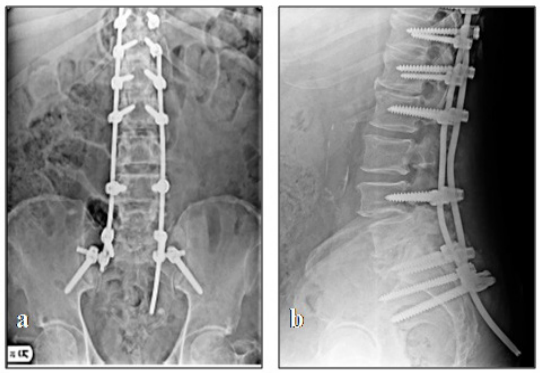


Figure 3. Post-operative X-rays AP **(a)** and Lateral **(b)** subsequent sequential failure of fixation with rod migration.
AP: Anteroposterior

Although it has been reported that these rods can get loose and migrate leaving behind a tight and properly placed pedicle screw caps without evidence of loosening[7], in our cases, the screw caps were loose and backed-off by one or two turns. It is unclear why the caps got loose although after experience with the first case, additional time was spent ensuring that the torque applied to the caps was of sufficient amount as prescribed by the manufacturer. As a second thought, one risk factor that might have been important in regard to manufacturing may be the torque wrench/driver. It is quite plausible that the torque settings of this tool might have been less than accurate resulting in less than ideal tightening of the screw caps. The fact that these failures were noted back to back within a limited time frame (2 years before the writing of this report) may be suggestive of such a manufacturing error (of the caps or the torque wrench) in a certain party of implants/instruments.

Metal corrosion and shredding leading to implant loosening are also important aspects to consider especially the interactions between titanium pedicle screw and a different metal such as Cobalt-Chromium (CoCr). This interface is under significant frictional load and can sustain crevice corrosion, metallosis with subsequent loosening[11]. In both of our patients described above, we used titanium screws on a titanium rod and there was no evidence of metallosis or corrosive loosening intra-operatively. The magnitude of stress on pedicle screws under impact or dynamic loads depends on the mechanical properties of the rod. Titanium rods are less stiff compared to CoCr rods and essentially concentrate less stress on the pedicle screws; therefore, biomechanically titanium on titanium is expected to have less stress concentration[4]. Other factor to consider is bacteria- induced metal corrosion leading to rod loosening. Propionibacterium acnes have been linked to late infections and implant corrosion and metallosis[12]. In the two patients described above, there was no evidence of infection from intra-operative cultures.

Of factors that might have been related to the specific patients, our patients were fairly similar in terms of gender and body composure. BMIs at the range of obesity might have been a contributing factor in this type of failure but most

probably not as a single decisive factor. Another potential contributing (patient related) factor may be pseudoarthrosis. It is quite plausible that at least one of our patients (case 1) had developed pseudoarthrosis as he had to have another revision surgery for further implant failure. Pseudoarthrosis is expected to impact significant stress on the screw-rod junction in spinal implants but there are no studies in literature directly linking pseudoarthrosis to rod migration. In addition, implant related problems in association with the development of pseudoarthrosis per se would be more likely to result in later (one year and on) failures with a different pattern (rod and/or screw breakage or screw loosening).

It is important to note that rod breakage with subsequent migration can have devastating consequences. Lark et al. [13] have described a case of migrated rod presenting with acute sensory changes in lower extremities with imaging showing rod failure, resulting in the penetration of the rectal wall. Al-Binali et al.[2] have reported on a child who presented with a migrated lumbar spinal instrumentation causing massive acute lower gastrointestinal bleeding due to internal iliac artery injury and bowel perforation. This clearly shows that spinal surgeons must have high index of suspicion for any patient presenting with unusual symptoms, on a background history of spinal instrumentation either anterior or posterior.

In summary, we could not identify the reasons for rod loosening and disengagement twice in one patient and another patient, all happening with the same instrumentation system and within a relatively short period of time. Also, the object of interest was that the loss of fixation happened at multiple fixation points rose suspicion of a potential inherent biomechanical weakness with this particular instrumentation system.

To conclude, implant/hardware related problems are rare complications in spine surgery; however, this should be kept in mind and this may lead to a potentially catastrophic condition. Although rare and can happen with any spinal instrumentation system, here, it appears to be higher propensity of disengagement and loosening with previously approved and tested Stryker system (Xia Titanium Spinal System, Stryker Spine, Allendale, NJ, USA). This potential biomechanical problem needs to be further investigated.

Ethics

Informed Consent: Informed consent was obtained from the patients.

Authorship Contributions

Surgical and Medical Practices: T.M., V.N.N., S.A., E.A., Concept: T.M., P.A., V.N.N., S.A., E.A., Design: T.M., S.A., E.A., Data Collection or Processing: T.M., P.A., V.N.N., S.A., E.A., Analysis or Interpretation: T.M., V.N.N., S.A., E.A., Literature Search: T.M., P.A., V.N.N., S.A., E.A., Writing: T.M., P.A., V.N.N., S.A., E.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Soroceanu A, Diebo BG, Burton D, Smith JS, Deviren V, Shaffrey C, et al; International Spine Study Group. Radiographical and Implant-Related Complications in Adult Spinal Deformity Surgery: Incidence, Patient Risk Factors, and Impact on Health-Related Quality of Life. Spine (Phila Pa 1976). 2015;40:1414-21.
2. Al-Binali AM, Sigalet D, Goldstein S, Al-Garni A, Robertson M. Acute lower gastrointestinal bleeding as a late complication of spinal instrumentation. J Pediatr Surg. 2001;36:498-500.
3. Dhatt S, Kumar S, Arora N, Dhillon M, Tripathy SK. Migration of anterior spinal rod from the dorsolumbar spine to the knee: an unusual complication of spinal instrumentation. Spine (Phila Pa 1976). 2010;35:E270-2.
4. Doulgeris J. Biomechanical comparison of titanium and cobalt chromium pedicle screw rods in an unstable cadaveric lumbar spine. : Mechanical Engineering, University of South Florida; 2013.
5. Wood KE, Fitch RD, Burton DC, Keiger CJ. Anterior scoliosis rod migration to the lower extremity. Spine J. 2009;9:e9-12.
6. Yablon IG, Cowan S, Mortara R. The migration of a Harrington rod after cervical fusion. Spine (Phila Pa 1976). 1993;18:356-8.
7. Bayri Y, Eksi MS, Dogrul R, Koc DY, Konya D. Migration of rod into retroperitoneal region: a case report and review of the literature. Korean J Spine. 2014;11:241-4.
8. Davne SH, Myers DL. Complications of lumbar spinal fusion with transpedicular instrumentation. Spine (Phila Pa 1976). 1992;17(6 Suppl):S184-9.
9. Leute PJ, Hammad A, Hoffmann I, Hoppe S, Klinger HM, Lakemeier S. Set screw fracture with cage dislocation after two-level transforaminal lumbar interbody fusion (TLIF): a case report. J Med Case Rep. 2015;9:22.
10. Agrawal A. Pedicle screw nut loosening: potentially avoidable causes of spine instrumentation failure. Asian Spine J. 2014;8:224-6.
11. Yamaguchi K, Konishi H, Hara S, Motomura Y. Biocompatibility studies of titanium-based alloy pedicle screw and rod system: histological aspects. Spine J. 2001;1:260-8.
12. Beguiristain J, del Rio J, Duart J, Barroso J, Silva A, Villas C. Corrosion and late infection causing delayed paraparesis after spinal instrumentation. Journal of pediatric orthopedics. J Pediatr Orthop B. 2006;15:320-3.
13. Lark RK, Caputo AM, Brown CR, Michael KW, Thacker JK, Richardson WJ. Distant Harrington rod migration 35 years after implantation. J Clin Neurosci. 2013;20:1452-3.

J Turk Spinal Surg 2020;31(1):55-9
DOI: 10.4274/jtss.galenos.2020.91

CASE REPORT
55

PRIMARY SPINAL CORD GLIOBLASTOMA IN YOUNG POPULATION; REPORT OF TWO CASES

Mehmet Ozan DURMAZ[1], Adem DOĞAN[1], Mehmet Can EZGÜ[1], Mehmet İlker ÖZER[2], Soner YAŞAR[1], Alparslan KIRIK[1]

[1]Gülhane Training and Research Hospital, Clinic of Neurosurgery, Ankara, Turkey
[2]Republic of Turkey Ministry of Health, Dr. Yasar Eryılmaz State Hospital, Clinic of Neurosurgery, Ağrı, Turkey

ABSTRACT

Primary spinal glioblastoma is a very rare disease of spinal cord with high morbidity and mortality. In this study, we presented two patients surgically treated for primary spinal glioblastoma.

The first case was a 21-year-old male who has a lesion at T9-T10 spinal level in Magnetic resonance imaging (MRI) in which subtotal resection was performed.

The second case was a 22-year-old male patient who has a lesion in the spinal canal between the level of C3 andT1 in MRI. The lesion was resected subtotally.

The pathological diagnosis was reported as glioblastoma in both cases. Primary spinal glioblastoma is a very rare disease. Because of its clinically and radiologically malignant behavior of prognosis, this disease must be kept in mind in differential diagnosis of cervical-thoracal spinal cord pathologies and early diagnosis and treatment should be started as soon as possible.

Keywords: Primer spinal cord tumor, glioblastoma, young patient

INTRODUCTION

Glioblastoma is the most common and most aggressive primary malignant brain tumor in adults. On the other hand, glioblastoma with primary spinal involvement is very rare[(1)]. Spinal glioblastomas have an incidence of 1-5% in all glioblastoma cases and 1.5% of all spinal tumors[(2)]. More than 60% of cases are in the cervical or cervicothoracic region[(3)]. The purpose of this case report is to provide basic information about this rare disease to present and discuss in the context of the literature.

CASE REPORTS

Case 1

First case was a 21-year-old male who was referred to our clinic with a complaint of weakness and sensory loss in the lower extremity that started 1 month ago. Urinary incontinence occurred three days after his first admission to hospital. Neurological examination revealed paraplegia and hypoesthesia below T10 level. Deep tendon reflexes were hypoactive.

As a result of the cranial and spinal Magnetic resonance imaging studies, intramedullary mass was found at T9- T10 level (Figure 1A). Bilateral tibial Sensorimotor Evoked Potential (SEP) cortical response could not be obtained. The patient was operated and the mass was subtotally resected. Postoperative neurological findings were same after surgery.

Postoperative histopathological examination showed an infiltrative tumor of the medulla spinalis. The tumor was found to be formed by atypical glial cells with large hyperchromatic nuclei. Highly mitosis and geographic necrosis areas were detected in pathologic specimen. Neoplastic cells were marked with glial fibrillary acidic protein (GFAP). Glioblastoma was diagnosed with these morphologic and immunohistochemical findings (Figure 1B).

Following postoperative wound healing, chemotherapy and radiotherapy were applied to the patient. After chemoradiotherapy, the patient was admitted to a rehabilitation program for motor weakness. Control MRI was performed 3 months after surgery. Local recurrence or distant metastasis was not detected following chemoradiotherapy. Neurological findings were not different from those in early postoperative period in follow up.

Address for Correspondence: Adem Doğan, Gülhane Training and Research Hospital, Clinic of Neurosurgery, Ankara, Turkey
E-mail: drademdogan@yahoo.com **Received:** 23.01.2020 **Accepted:** 06.02.2020
ORCID ID: orcid.org/0000-0003-0933-6072

Local recurrence and distant metastasis were not detected in the spinal MRI at the sixth month of surgery. At the ninth month of surgery, new lesions were observed on the anterior horn of right lateral ventricle and T7-8 vertebrae in the control MRI, in addition any surgical treatment was required for these lesions (Figure 1C,D). Surgical treatment was not considered for cranial lesion because the patient's neurological status did not show any deterioration in neurological examination after ninth months of surgery. For the spinal recurrence, it was thought that a second operation would not provide an additional benefit to the patient's outcome. The patient was directed to radiation oncology clinic for radiotherapy. He received radiotherapy for the cranial lesion and was discharged afterwards. It is known that the patient died about 16 months after being diagnosed.

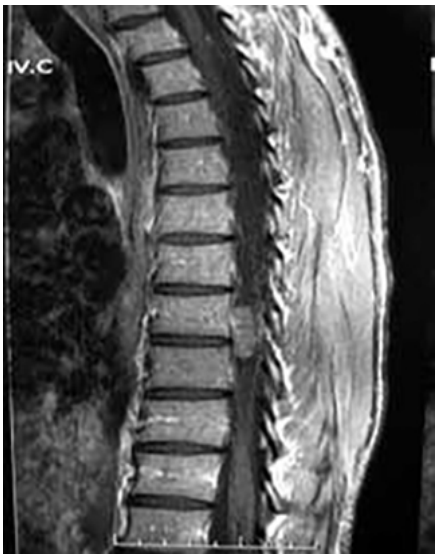


Figure 1A. Preoperative thoracolumbar T1 sagittal contrast MR image
MR: Magnetic resonance

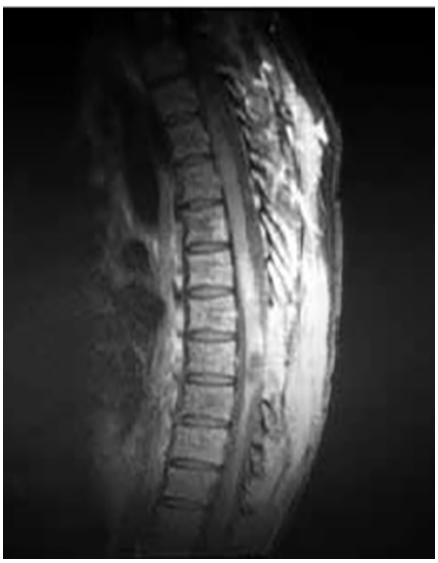


Figure 1C. Postoperative 9th month thoracolumbar T2 sagittal contrast MR image
MR: Magnetic resonance

Case 2

Second case was a 22-year-old male patient, referred to our clinic with the complaints of right sided numbness and weakness in extremities for 2 months. There was not any obvious pathology found on systemic examination. Right sided 1/5 hemiparesis was observed. Babinski's reflex was positive on the right side. Deep tendon reflexes were hyperactive in the lower limbs.

An intramedullary expansile mass was revealed on the spinal cord with an extending of C3 to T1 vertebrae spinal levels. In MRI, the size of the tumor was measured as 14x18x65 mm (Figure 2A). The lesion was thought to be compatible with

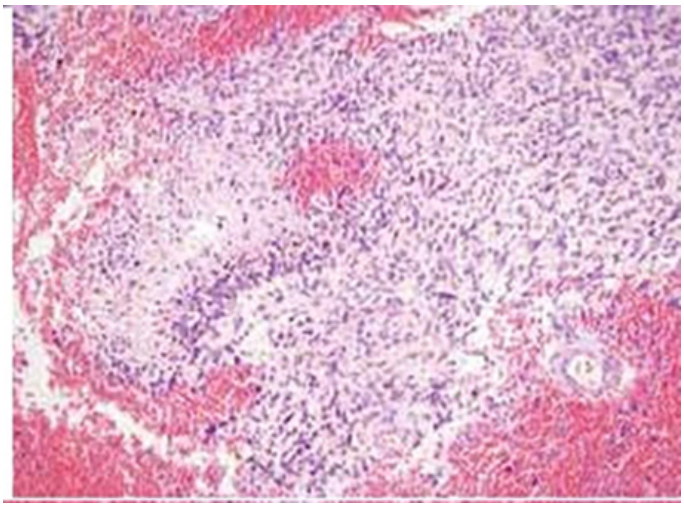


Figure 1B. Palizadic alignment around the necrotic area histological appearance of the tumor (x200, HE), HE: Hematoxylin and eosin

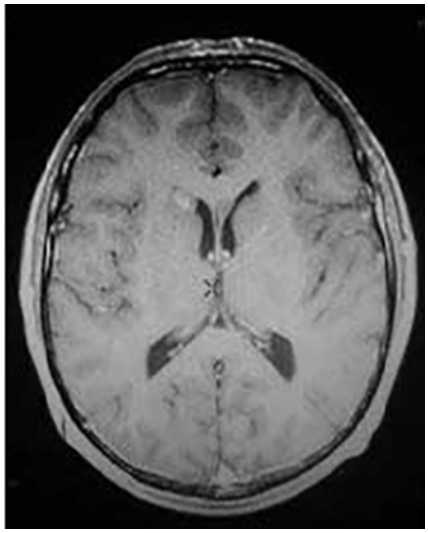


Figure 1D. Postoperative 9th month cranial T1 axial contrast MR image
MR: Magnetic resonance

ependymomas or astrocytomas due to mild degree of contrast enhancement. An edematous appearance was observed at the inferior contour of the lesion. The patient had additional thoracolumbar and brain MRI scans and no other involvements were detected.

The extension of right tibial nerve latency was detected in SEP. Soft-grained mass was subtotally resected with C4-6 total laminectomy. In the post-operative early neurologic examination, lower extremities and right upper extremity were plegic, left upper extremity was 4/5 paretic, patient was anesthetic under C4 level, and lower extremity reflexes were hyperactive. The patient was operated in the presence of neuromonitoring. Bilateral lower extremity response was not obtained in motor evoked potential during surgery.

Histopathological examination revealed that the tumor was composed of atypical glial cells with hyperchromatic nucleus, pleomorphic and high mitotic activity on a fibrillary site. Necrosis foci and microvascular proliferation areas were present around the tumor, which was palindically dyed (Figure 2B). Immunohistochemical examination revealed that the tumor was diffusely and strongly labeled with GFAP, and the cells showed nuclear positivity with P53. Ki-67 proliferation index was 70-75% (Figure 2C). Significant immunoreactivity was not detected with neuron-specific enolase, synaptophysin, chromogranin and monofilament. Tumor was reported as gliblastoma (WHO grade IV)

In the postoperative first week, the right median nerve response was not obtained in control SEP, whereas the right tibial nerve response latency was long. Left median and tibial nerve responses were normal. He underwent physiotherapy 1 month after surgery and tetraparesis recovered partially (Figure 2D). The patient was directed to the radiation oncology clinic for further treatment. After radiotherapy, adjuvant chemotherapy (temozolomide) was given to the patient. The patient was

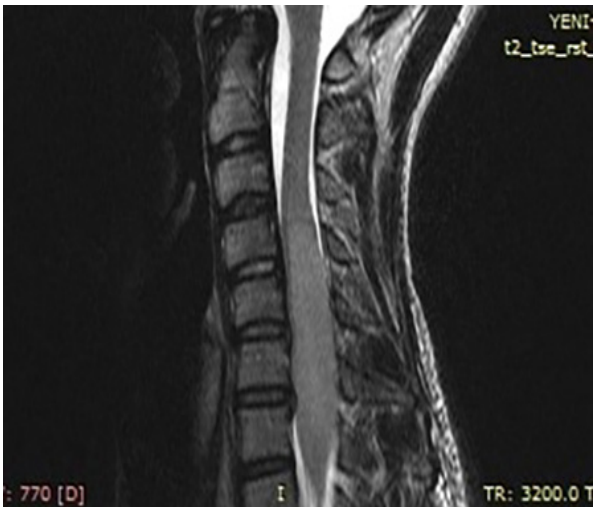


Figure 2A. Preoperative thoracolumbar T2 sagittal contrast MR image
MR: Magnetic resonance

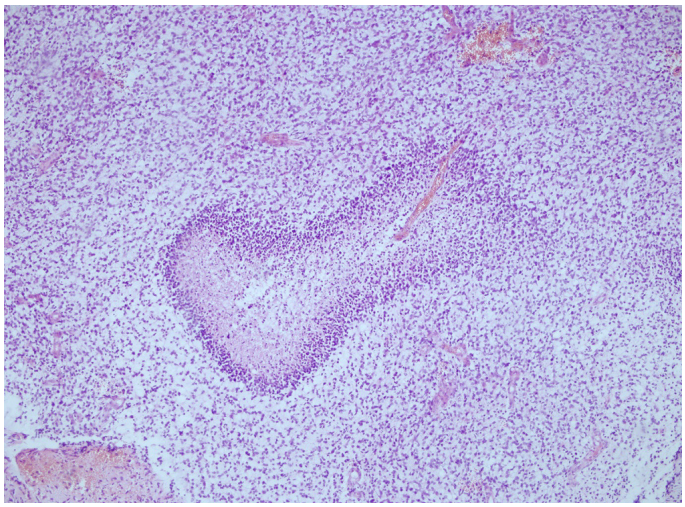


Figure 2B. Tumor necrosis area (H&E, x40)
H&E: Hematoxylin and eosin stain

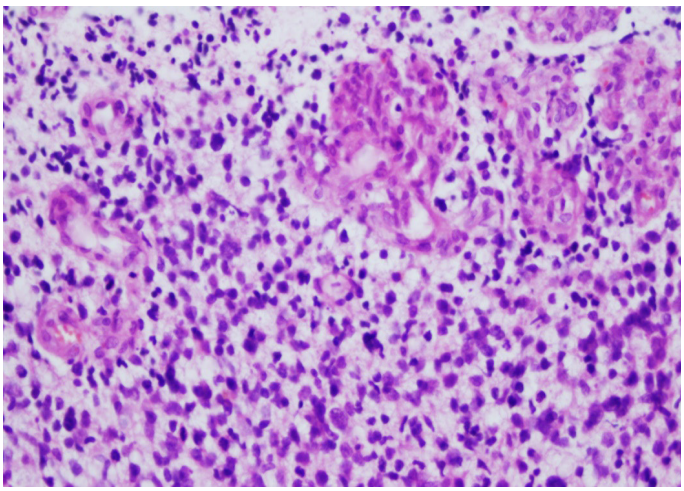


Figure 2C. Microvascular proliferation area in tumor (H&E, x100)
H&E: Hematoxylin and eosin stain

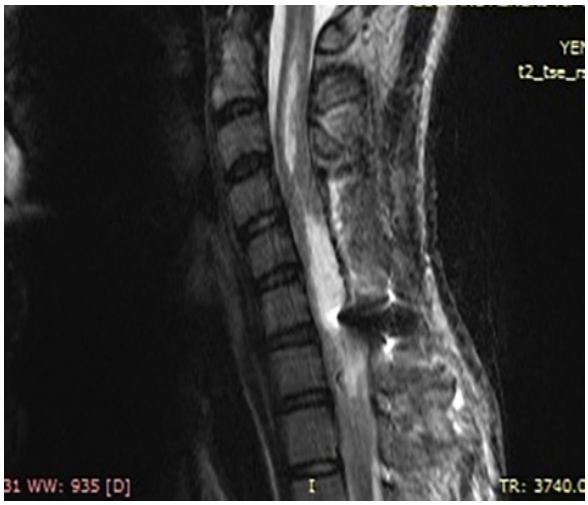


Figure 2D. Postoperative first month thoracolumbar T2 sagittal contrast MR image
MR: Magnetic resonance

transferred to a physical therapy center after radiotherapy. After about two months of physical therapy, the patient was discharged. It was learned that the patient died about 5.5 months after diagnosis.

DISCUSSION

Glioblastoma (GBM) is the most common primary malignant brain tumor in adults. In spite of that, spinal intramedullary astrocytomas constitute approximately 1% of all central nervous system tumors and 6-8% of all spinal cord tumors. Glioblastoma accounts for 7.5% of all intramedullary gliomas and only 1.5% of all spinal tumors[4]. It has been reported in the literature that spinal glioblastomas usually occur in the second and third decades, frequently in the cervical region followed by the cervicothoracic region[5,6]. Similarly, our cases were in the second decade and the settlement was at the cervical and thoracic spinal levels. Shen et al.[6] showed a review of the literature, and to date, a total number of 165 primary spinal GBM cases have been reported since 1938.

Although spinal glioblastomas are seen as primaries, spinal extension of cerebral primer tumors may also occur. Glioblastoma is rarely seen in the differential diagnosis of spinal cord masses, but should be considered in diagnosis. After diagnosis, all spinal column and brain should be scanned with MRI. Primary development or metastasis of the tumor should be discriminated and the treatment algorithm should be determined accordingly[6].

It may be difficult to diagnose early because the initial symptoms of the disease are not apparent. Neurological deterioration occurs rapidly. Diagnosis can be made by the presence of various deficits such as motor and sensory loss, hyperactive reflexes, sexual dysfunction, bladder and bowel function disorders in the clinic progress of disease[4]. The most common finding is motor weakness seen in 87% of spinal glioma cases. The 5-year survival rates are in these patients with a poor rate of 0% to 33%. Right after the diagnosis, the survival rates range from 6 to 16 months[7].

Today, MRI is the ideal imaging method for diagnosis[8,9]. In MRI, the mass is usually seen as iso-hypointense with spinal cord on T1-weighted images and hyperintense on T2-weighted images. Cystic areas within the tumoral tissue are frequently seen. Irregular homogeneous contrast retention and expansions of the spinal cord by neoplasm are other common findings.

Leptomeningeal involvement is seen in 23-27% of autopsy series of cerebral glioblastoma cases[10,11]. These metastases are generally thought to originate from neoplastic cells carried by the cerebrospinal fluid[2,12].

The aim of the surgery of high grade glial tumors is primarily maximal resection of the tumor. Recurrence of the disease is common even if total resection is performed by surgery. In high grade glial tumors, recurrences frequently develop around the origin of the lesion. In 58% of high grade glioma cases, tumor spread is seen throughout the subarachnoidal space[13].

Spinal glioblastoma treatment includes surgical resection and adjuvant radiotherapy. The application of radiotherapy and chemotherapy is important because it contributes to the enhancement of disease control[14].

To increase free survival rates in these tumors, simultaneous use of temozolamide (75 mg / m^2, adjuvant temozolamide 200 mg / m^2 daily for 6 months, followed by 28 days) was emphasized in the study of Stupp et al. in 2005[15,16].

Both of our cases underwent simultaneous radiotherapy after surgery and adjuvant chemotherapy was applied afterwards. Spinal cord primary glioblastoma is still a malignant neoplasm with high mortality and morbidity despite surgical treatment and other adjuvant therapies. It is very important to initiate appropriate treatment by making correct diagnosis in the shortest possible time in glioblastoma, if the mean survival rate of 15 months is considered in this pathology[4]. Today, glioblastoma, which has started to differ in terms of settlement location and frequency, is at the top of the list of increasingly frequent differential diagnoses among primary spinal cord pathologies.

Ethics

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: M.O.D., A.D., M.C.E., M.İ.Ö., S.Y., A.K., Concept: M.O.D., M.C.E., Design: M.O.D., M.C.E., S.Y., Data Collection or Processing: M.O.D., M.C.E., S.Y., Analysis or Interpretation: A.D., M.O.D., M.İ.Ö., M.C.E., A.K., Literature Search: A.D., M.O.D., M.C.E., A.K., Writing: A.D., M.O.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Scarrow AM, Rajedran P, Welch WC, Glioblastoma multiform of the conus medullaris. Clin Neural Neurosurg. 2000; 102:166-7.
2. Andrews AA, Enriques L, Renaudin J, Tomiyasu U. Spinal intramedullary glioblastoma with intracranial seeding. Report of a case. Arch Neurol. 1978;35:244-5.
3. Cooper PR. Outcome after operative treatment of intramedullary spinal cord tumors in adults: intermediate and long-term results in 51 patients. Neurosurgery. 1989;25:855-9.
4. Ciapetta P, Salvati M, Capoccia G, Artico M, Raco A, Fortuna A. Spinal glioblastomas: report of seven cases and review of the literature. Neurosurgery. 1991;28:302-6.
5. Caroli E, Salvati M, Ferranate L. Spinal glioblastoma with brain relapse in child: Clinical considerations. Spinal Cord. 2005;43:565-68.
6. Shen CX, Wu JF, Zhao W, Cai ZW, Cai RZ, Chen CM. Primary spinal glioblastoma multiforme, A case report and review of the literature. Medicine (Baltimore). 2017;96:e6634.
7. Takara E, Ide M, Yamamato M, Imanaga H, Jimbo M, Imai M. A case of the intracranial and spinal dissemination of primary spinal glioma. No Shinkei Geka. 1985;13:301-5.
8. Acıkgöz B, Kalaycı M, Sanser G. Intramedullary spinal cord tumors. Turkey Clinics, J Surg Med Sci. 2007;3:150-6.

9. Koeller KK, Rosenblum RS, Morrison AL. Neoplasms of the spinal cord and filum terminale: radiologic-pathologic correlation. Radiographics. 2000;20:1721-49.
10. Onda K, Tanaka R, Takahashi H, Takeda N, Ikuta F. Cerebral glioblastoma with cerebrospinal fluid dissemination: a clinicopathological study of 14 cases examined by complete autopsy. Neurosurgery. 1989;25:533-40.
11. YungWA, Horten BC, Shapiro WR. Meningeal glimatosis: a review of 12 cases. Ann Neurol. 1980;8:605-8.
12. O'Connell JE. The subaarachnoid dissemination of spinal tumors. J Neurol Neurosurg Psychiatry. 1946;9:55-62.
13. Gunderson LL, Tepper JE. Spinal Cord Tumors. Chapter 30. In: Siker M.L, Bovi J., Alexander B (Eds.). Clinical Radiation Oncology, Philadelphia 2015; pp:532-3.
14. Nakamura M, Ishii K, Watanabe K, et al. Surgical treatment of intramedullary spinal cord tumors: prognosis and complications. Spinal Cord. 2008;46:282-6.
15. Kim WH, Yoon SH, Kim CY, et al. Temozolamide for malignant primary spinal cord glioma: An experience of six cases and a literature review.J Neurooncol. 2011;101:247-54.
16. Bernadine RD. Tumors of the Central Nervous System, Adult gliomas. Jiade J. LUi Luther W. BRADY. Radiation oncology: An Evidence-Based approach 2008;pp:487.

REVIEW ARTICLE
60

J Turk Spinal Surg 2020;31(1):60-3
DOI: 10.4274/jtss.galenos.2020.31

CURRENT CONCEPTS ON SPINAL TUBERCULOSIS

Anıl Murat ÖZTÜRK[1], Can YENER[1], Meltem TAŞBAKAN IŞIKGÖZ[2]

[1]Ege University Faculty of Medicine, Department of Orthopedics and Traumatology, İzmir, Turkey
[2]Ege University Faculty of Medicine, Department of Clinical Microbiology and Infectious Diseases, İzmir, Turkey

ABSTRACT

Spinal tuberculosis (TB) is seen in 2% of TB patients and 50% of skeletal involvement of TB. Low back pain, fever, weight loss, and night sweats are the most common symptoms. However, the gold standard for its diagnosis is the growth of *Mycobacterium tuberculosis* in culture taken from tissue samples. Magnetic resonance imaging is the preferred imaging modality in the diagnosis of spinal TB. Typical findings include lesions in the vertebral endplates, anterior involvement of the vertebral body, and subligamentous spread. The aim of the treatment is to confirm the diagnosis, to clear the lesion from bacteria, and to eliminate spinal deformity and spinal cord pressure. Drug therapy is recommended for 9-12 months. There is controversy in the literature regarding the need for additional surgical intervention in the treatment of spinal TB. Many authors have suggested surgery in the presence of progressive neurological deficit, instability, progressive kyphosis above the 50 degrees or disease unresponsive to drug therapy. Surgical approach in spinal TB surgery is still being discussed. The location of the lesion, instability, patient-related factors, and severity of deformity should be considered when deciding on the approach.

Keywords: Spinal, tuberculosis, Pott disease, treatment, surgery

INTRODUCTION

Spinal tuberculosis (TB) is seen in 2% of TB patients and 50% of skeletal involvement of TB[1]. Approximately 90% of the patients are affected by the lower thoracic and upper lumbar vertebrae[2]. Spinal TB can lead to the destruction of the vertebral body, posterior elements and pars interarticularis, which can lead to deformity, spondylolisthesis, and even paraplegia[3]. Although clinical examination, patient history and radiography are usually sufficient for diagnosis, early computer tomography and magnetic resonance imaging (MRI) are useful[4,5]. Usually, only anti-TB drugs are used in the treatment but surgery may be necessary if signs of spinal compression and neurological deficits, instability, advanced kyphosis deformity or drug resistance occur[6]. Debridement, grafting and internal fixation are the main objectives of surgery. Surgical timing, amount of debridement and surgical approach are still controversial[7]. The purpose of this review is to provide information about the current approaches in the diagnosis and treatment of spinal TB.

Diagnosis

Diagnosis is difficult in the initial stages, delay in diagnosis may lead to serious spinal cord injuries[8]. Predisposing factors include malnutrition, alcoholism, diabetes, and human immunodeficiency virus (HIV) infection[9]. Symptoms are usually insidious, there may be complaints that have been going on for years before diagnosis[1]. Low back pain, fever, weight loss, and night sweats are the most common symptoms[10]. The diagnosis usually can be made on the basis of predisposing factors, history of TB disease, clinical findings and imaging methods[1]. However, the gold standard in diagnosis is positive *Mycobacterium tuberculosis* tissue culture[11]. Because of this, in the case of clinical suspicion, tissue culture should be performed. In addition, performing polymerase chain reaction in samples taken with biopsy, erythrocyte sedimentation rate (ESR), immunological hematological tests and skin test are helpful in diagnosis[12]. Radiography is preferred as the initial imaging method and the "bird's nest" appearance can be seen, evocative of an aortic aneurysmal phenomenon reflected from aortic pulsations[8]. Computed tomography (CT) can provide information on the extent of vertebral involvement. Abscess and intra-canal compression can be seen in the CT taken with intrathecal contrast[13]. The preferred imaging method for spinal cord TB is MRI. Typical findings include lesions in the vertebral end plates, anterior involvement in the vertebral body, subligamentous spreading, paraspinal cold (without signs of severe acute inflammation) abscesses and calcifications, vertebral bodies, vertebral body destruction and collapse but the disc is usually protected[8]. MRI findings can also be used in treatment follow-up, but pain reduction and neurological recovery are more important in follow-up treatment[14]. Javed et al.[15] compared the clinical and laboratory findings of patients

Address for Correspondence: Anıl Murat Öztürk, Ege University Faculty of Medicine, Department of Orthopedics and Traumatology, İzmir, Turkey
E-mail: amuratozturk@yahoo.com **Received:** 23.01.2020 **Accepted:** 01.02.2020 **ORCID ID:** orcid.org/0000-0001-8674-8877

with spinal epidural tumors and patients with spinal TB. They reported pain, fever, progressive lower extremity weakness, high ESR, epidural and paravertebral contrast involvement, spinal deformity and adjacent level involvement in MRI as possible diagnostic criteria for the spinal tuberculosis. In distinguishing pyogenic spinal infections, laboratory findings and imaging methods are useful. It has been reported that positron emission tomography, the use of which has increased in recent years, can be used in diagnosis and follow-up in pott disease[16].

Interferon gamma release tests used in the diagnosis of latent tuberculosis infection are not reliable in the diagnosis of spinal TB[17]. More clinical trials investigating different antigens are needed in this regard. In addition, although the low sensitivity of nucleic acid amplification methods prevents excluding the diagnosis, it is useful to confirm the diagnosis[18].

Biopsy can be attempted from the suspicious lesion by interventional diagnostic methods or endoscopic methods, but false negative results may be seen in these diagnostic methods[14]. Therefore, in the presence of clinical symptoms, the negative interventional diagnostic methods should not prevent open biopsy from being made[19].

Classification

Based on the clinicopathological correlation, anterior spinal tuberculosis is divided into five stages[20] (Table 1). The stages of anterior spinal tuberculosis differ from their degree of paraplegia. Stages of anterior spinal tuberculosis show bone involvement and degree of deformity while paraplegia degrees indicate the severity of spinal cord compression. Several classifications have been developed for paraplegia grading due to spinal tuberculosis. These were developed to determine the degree of pressure in the spinal cord and to evaluate the severity of the disease in making the surgical decision[21,22]. The most common of these is the classification developed by Kumar[22] based on the patient's weakness complaints, walking ability and neurological examination findings (Table 2). There are also classifications that define the paraplegia that occurs within 2 years from the onset of the disease as early onset and the result of active disease, the paraplegia that occurs after 2 years as late onset and the result of sequelae of the disease[23]. In both anterior and posterior spinal tuberculosis, motor nerves are affected before the sensory nerves[23,24]. Sensory and autonomic loss of function are added as compression increases.

Table 1. Stages of tuberculosis of spine[17]

Stage	Description	Clinicoradiological features	Usual duration
I	Stage of implantation, incipient stage or predestructive stage	Dull back pain with muscle spasm in the back. Straightening of the spine or loss of curve	<3 months
II	Stage of early destruction	Diminished disk space, paradiskal erosion, kyphosis <10° (K1)	2-4 months
III	Stage of advanced destruction and collapse	Two or more vertebral involvement with collapse. Kyphosis 11°-60° (K2) or gibbus >60° (K3)	3-9 months
IV	Stage of neurological involvement	Stage III or IV with four grades of paraplegia	Variable
V	Stage of residual deformity and aftermath	Kyphosis K1, K2, K3, disease active locally grumbling, reactivated or healed	>3-5 years

Table 2. Classification of paraplegia in tuberculosis of spine[19]

Grade of paraplegia	Complaints/symptoms		Examination/neurological deficit		
	Weakness	Walking	Motor	Sensory	Autonomic
1.	Negligible or weakness appearing after exercise	Able to walk without support	Extensor plantar ± brisk ankle jerks, muscle power grade IV to V	Nil	Nil
2.	Mild or Feels weakness	Able to walk with support	Motor weakness, brisk tendon jerks, ill sustained muscle clonus, muscle power grade III	Sensory dulling or paresthesia	Nil
3.	Moderate or weakness is more marked	Not able to walk Confined to bed Can move limbs	Brisk tendon jerks, sustained muscle clonus, muscle power grade I to II	Hypoesthetic or anesthetic patches	May be present
4.	Severe or Complete loss of power and control	Not able to move the limbs even in the bed	Paraplegia in extension, power grade 0	Total loss	Complete loss of bladder and bowel control and incontinence
			Paraplegia in flexion, power grade 0, flaccid paralysis		

Treatment

The aim of the treatment is to confirm the diagnosis, to clear the lesion from the bacteria, and to eliminate spinal deformity and spinal cord pressure. Rifampicin, isoniazid (INH), pyrazinamide and ethambutol form the basis of drug therapy as anti-TB drugs. British Medical Research Council[25] recommends combination chemotherapy for 6-9 months in the treatment of tuberculous spondylitis of the thoracolumbar spine. However, the work of this council does not include patients with vertebral involvement, cervical lesions, or patients with major neurological involvement. For this reason, many experts still recommend treatment for 9-12 months.

HIV increases the reactivation of the disease, the risk of more atypical and severe course. Studies on spinal tuberculosis and HIV show that good clinical outcomes can occur, regardless of HIV activation status and the presence of antiretroviral therapy[26].

Treatment of spinal tuberculosis with multidrug-resistant microorganism (resistant to INH and rifampicin) or extensively drug-resistant microorganism [(resistant to a quinolone and a parenteral drug (amikacin, kanamycin or capreomycin) with INH and rifampicin)] should continue in specialized centers experienced in management.

In the literature, controversy continues regarding the need for additional surgical intervention in the treatment of spinal TB. Jutte and Van Loenhout-Rooyackers[27], in their review with randomized controlled trials, compared spinal tuberculosis cases treated with chemotherapy only with those who received surgical treatment in addition to chemotherapy. In this study, deterioration in kyphosis angle, neurological deficit, bone fusion, recovery from disease and activity recovery rates at baseline or follow-up were evaluated, but no significant difference was found between these two groups in terms of these results. Nevertheless, many authors have proposed surgery in the presence of progressive neurological deficit, instability, progressive kyphosis above 50 degrees or disease unresponsive to drug treatment.

In surgery, after debridement, the correction of deformity for decompression and instrumentation can be performed for stabilization. It has been reported that grafting is effective for providing spinal fusion[28]. Emergency decompression surgery is indicated only in patients with acute spinal cord compression findings[29].

In some patient groups,there are also studies reporting that only instrumentation can be beneficial without radical debridement. Qian et al.[7], in the study on 74 patients with Frankel et al.[30] grading scores of D and E, compared the group with radical debridement, grafting and anterior instrumentation and group with posterior instrumentation only. In terms of operation time, blood loss, and 3rd and 6th month ESR, they found that only posterior instrumentation group had significantly better results, but could not find a significant difference in terms of kyphosis angles or fusion rates.

The surgical approach in spinal tuberculosis surgery is still under discussion. Although the anterior approach provides a larger surgical site and direct access to the lesion, it may create instability after decompression[31]. In addition, the use of the posterior approach increases due to the risk of vascular nerve damage, increased blood loss, prolonged operation time and length of hospital stay with the anterior approach[32,33]. However, when deciding on the approach, the region of the lesion, instability, patient-related factors and severity of deformity should be taken into account. In spinal tuberculosis with wide anterior destruction, where anterior stability is lost, only the posterior approach may result in poor decompression, poor correction and implant failure[34].

Spinal TB surgery should be performed by experienced surgeons in experienced centers. Among the effective techniques, choosing the technique that is the safest and well known by the surgeon will reduce the complication rates. Moon et. al.[35], in their study on 901 patients who underwent spinal tuberculosis surgery, reported increasing of the corrected kyphosis angle (32%) and graft failure (14%) as the most common complications associated with the disease. In the same study, thoracic cavity complications (43%), thrombophlebitis (26%) and sympatheticolysis symptoms (32%) were reported as surgical complications, especially in the anterior approach.

CONCLUSION

As a result, spinal tuberculosis is still an important disease and should be considered in differential diagnosis in patients with chronic low back pain and neurological symptoms. Imaging tests such as MRI and CT can help to diagnose the disease, but microbiological diagnosis is also required to confirm the diagnosis. Although the main treatment is drug therapy, it is useful to add surgical treatment in case of advanced deformity and paraplegia.

Authorship Contributions

Surgical and Medical Practices: A.M.Ö., M.I.T., Concept: M.I.T., A.M.Ö., Design: M.I.T., AM.Ö., Data Collection or Processing: M.I.T., AM.Ö., C.Y., Analysis or Interpretation: M.I.T., AM.Ö., C.Y., Literature Search: C.Y., M.I.T., A.M.Ö., Writing: C.Y., M.I.T., A.M.Ö.

Conflict of Interest: There are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

Financial Disclosure: The authors declared that there is no financial relationship with this paper.

REFERENCES

1. Ansari S, Amanullah MF, Ahmad K, Rauniyar R. Pott's spine: Diagnostic imaging modalities and technology advancements. N Am J Med Sci. 2013;5:404-11.
2. Wang H, Li C, Wang J, Zhang Z, Zhou Y. Characteristics of patients with spinal tuberculosis: seven-year experience of a teaching hospital in Southwest China. Int Orthop. 2012;36:1429-34.
3. Moon MS. Tuberculosis of spine: current views in diagnosis and management. Asian Spine J. 2014;8:97-111.

4. Hoffman EB, Crosier JH, Cremin BJ. Imaging in children with spinal tuberculosis. A comparison of radiography, computed tomography and magnetic resonance imaging. J Bone Joint Surg Br. 1993;75:233-9.
5. Desai SS. Early diagnosis of spinal tuberculosis by MRI. J Bone Joint Surg Br. 1994;76:863-9.
6. Zou MX, Li J, Lv GH, Wang B, Deng YW. Treatment of thoracic or lumbar spinal tuberculosis complicated by resultant listhesis at the involved segment. Clin Neurol Neurosurg. 2014;125:1-8.
7. Qian J, Rijiepu A, Zhu B, Tian D, Chen L, Jing J. Outcomes of radical debridement versus no debridement for the treatment of thoracic and lumbar spinal tuberculosis. Int Orthop. 2016;40:2081-8.
8. Alvi A, Raees A, Rehmani MAK, et al. Magnetic Resonance Image findings of Spinal Tuberclosis at first presentation. Int Arch Med. 2014;7:12.
9. McLain RF, Isada C. Spinal tuberculosis deserves a place on the radar screen. Cleve Clin J Med. 2004;71:543-9.
10. Chen CH, Chen YM, Lee CW, Chang YJ, Cheng CY, Hung JK. Early diagnosis of spinal tuberculosis. J Formos Med Assoc. 2016;115:825-36.
11. Schirmer P, Renault CA, Holodniy M. Is spinal tuberculosis contagious? Int J Infect Dis. 2010;14:e659-66.
12. Alli OAT, Ogbolu OD, Alaka OO. Direct molecular detection of Mycobacterium tuberculosis complex from clinical samples - An adjunct to cultural method of laboratory diagnosis of tuberculosis. N Am J Med Sci. 2011;3:281-8.
13. An HS, Seldomridge JA. Spinal infections: Diagnostic tests and imaging studies. In: Clinical Orthopaedics and Related Research. Lippincott Williams and Wilkins; 2006. bl 27-33.
14. Wolinsky E. Tuberculosis. In: Goldman L., Bennett JC (Eds.). Cecil's Textbook of Medicine. 21st Edition, WB Saunders Company, Philadelpia 2211; pp:1620-30.
15. Javed G, Laghari AA, Ahmed SI, Madhani S, Shah AA, Najamuddin F, et al. Development of Criteria Highly Suggestive of Spinal Tuberculosis. World Neurosurg. 2018;116:e1002-6.
16. Schmitz A, Kalicke T, Willkomm P, Grunwald F, Kandyba J, Schimitt O. Use fluorine-18 flouro- 2 - deoxy- D-glucose positron emission tomography in assessing the process of tuberculous spondylitis. J Spinal Disord. 2000;13:541-4.
17. Fan L, Chen Z, Hao XH, Hu ZY, Xiao HP. Interferon-gamma release assays for the diagnosis of extrapulmonary tuberculosis: A systematic review and meta-analysis. FEMS Immunol Med Microbiol. 2012;65:456-66.
18. Tortoli E, Russo C, Piersimoni C, Mazzola E, Dal Monte P, Pascarella M, et al. Clinical validation of Xpert MTB/RIF for the diagnosis of extrapulmonary tuberculosis. Eur Respir J. 2012;40:442-7.
19. Razak M, Kamari ZH, Roohi S. Spinal infection--an overview and the results of treatment. Med J Malaysia. 2000;55 Suppl C:18-28.
20. Kumar K. Tuberculosis of spine, natural history of disease and its judicious management. J West Pac Orthop Assoc. 1988;25:1-8.
21. S.M.Tuli. Judicious Management Of Tuberculosis Of Bones, Joints And Spine. Vol 19, Indian Journal of Orthopaedics. Medknow Publications; 2019. 147 bl.
22. Kumar K. Grading of Pott's paraplegia. J Neurol Orthop Med Surg. 1991;2:112-5.
23. Jain AK, Kumar J. Tuberculosis of spine: neurological deficit. Eur Spine J. 2013;22(Suppl 4):624-33.
24. Kumar K. A clinical study and classification of posterior spinal tuberculosis. Int Orthop. 1985;9:147-52.
25. The MRCWP on T of, (1986) S. A controlled trial of six-month and nine-month regimens of chemotherapy in patients undergoing radical surgery for tuberculosis of the spine in Hong Kong. Tenth report of the Medical Research Council Working Party on Tuberculosis of the Spine. Tubercle 1986;67(4):243-59.
26. Govender S, Annamalai K, Kumar KP, Govender UG. Spinal tuberculosis in HIV positive and negative patients: immunological response and clinical outcome. Int Orthop 2000;24:163-6.
27. Jutte PC, Van Loenhout-Rooyackers JH. Routine surgery in addition to chemotherapy for treating spinal tuberculosis. Cochrane database Syst Rev. 2006:CD004532.
28. Alam MS, Phan K, Karim R, Jonayed SA, Munir HKM, Chakraborty S, et al. Surgery for spinal tuberculosis: a multi-center experience of 582 cases. J Spine Surg. 2015;1:65.
29. Varatharajah S, Charles YP, Buy X, Walter A, Steib JP. Update on the surgical management of Pott's disease. Vol 100, Orthopaedics and Traumatology: Surgery and Research. Elsevier Masson SAS; 2014. bl 233-9.
30. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. Spinal Cord. 1969;7:179-92.
31. Yao R, McLachlin SD, Rasoulinejad P, Gurr KR, Siddiqi F, Dunning CE, et al. Influence of graft size on spinal instability with anterior cervical plate fixation following in vitro flexion-distraction injuries. Spine J. 2016;16:523-9.
32. Wang X, Pang X, Wu P, Luo C, Shen X. One-stage anterior debridement, bone grafting and posterior instrumentation vs. single posterior debridement, bone grafting, and instrumentation for the treatment of thoracic and lumbar spinal tuberculosis. Eur Spine J 2014;23:830-7.
33. Kulkarni SS, Lowery GL, Ross RE, Ravi Sankar K, Lykomitros V. Arterial complications following anterior lumbar interbody fusion: report of eight cases. Eur Spine J. 2003;12:48-54.
34. Yang P, Zang Q, Kang J, Li H, He X. Comparison of clinical efficacy and safety among three surgical approaches for the treatment of spinal tuberculosis: a meta-analysis. Eur Spine J. 2016;25:3862-74.
35. Moon MS, Kim SS, Moon YW, Moon Hanlim H, Kim SS. Surgery-related complications and sequelae in management of tuberculosis of Spine. Asian Spine J. 2014;8:435-45.