ISSN 1301-0336 • E-ISSN 2147-5903

turkishspine

JOURNAL OF TURKISH SPINAL SURGERY

JULY
2020
VOLUME: 31
ISSUE: 3

galenos yayınevi

www.jtss.org

JOURNAL OF TURKISH SPINAL SURGERY

Journal of Turkish Spinal Surgery

galenos yayınevi

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Web: www.galenos.com.tr | Publisher Certificate Number: 14521

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

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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.

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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

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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

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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.

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JOURNAL OF TURKISH SPINAL SURGERY

Dear Colleagues,

Once again, I'd like to say that I feel very privileged to be the person responsible for publishing this, the 3rd issue, of our professional journal this year. In this issue we have four international articles. They are from USA, India, Bangladesh and Jordan. I want to extend a heartfelt thanks to all the reviewers, assistant editors, secretaries and the Galenos publishing team for the effort they all put into publishing this issue. We updated our reviewer list, and, as a result, we now have a stronger team. I am happy to announce that The Journal of Turkish Spinal Surgery (www.jtss.org), is under evaluation by the following international indexes: Cabi, Ebscohost, Embase and Index Copernicus. I hope that, in the near future, our journal will be indexed by other important international organizations.

This issue includes one basic research study, ten clinical research studies, two case reports, and one review article. I hope that each of you will take the time to review this issue very carefully, and incorporate the information and insights contained herein, to your already very well informed knowledge bases.

The first study examines the reliability and validity of the Turkish version of the Walter Reed Visual Assessment Scale in adolescents with idiopathic scoliosis. The authors administered the translated Turkish version of WRVAS to 58 patients twice, at a one-week interval, to test reliability of the scale. The second study is "A Prospective Cohort Study Analyzing the Effectiveness of the Gensingen Brace in Treatment for Adolescent Idiopathic Scoliosis." Twenty-five patients diagnosed with AIS, and treated with a Gensingen brace, participated in this study. The third, is a clinical study, entitled "Clinical Results and Reoperation Rates after Long Adult Deformity Fusions from the Sacrum to the Thoracolumbar Spine." Sixty-three adult spinal deformity patients who underwent long fusion, from sacrum to thoracolumbar area, at a single specialty spine center, were reviewed. The fourth article is a single center experience entitled, "Spontaneous Regression of Lumbar Disc Herniation." 12 patients who had lumbar disc herniation regressions were retrospectively reviewed. The authors of the fifth study examined herniectomy without discectomy in extruded lumbar disc herniation. Should it be the gold standard? A total of 788 patients were retrospectively evaluated in the study. The sixth study compared the effectiveness of transforaminal epidural steroid injection alone, and combined with caudal epidural steroid injections, in multi-level lumbar disc herniation. In the seventh study, the authors evaluated a spino-semilaminafacet sparing technique which is a less invasive approach in isthmic spondylolisthesis. The eighth article is a retrospective study about posterior annulus repair after dynamic stabilization, while the ninth article is a basic research article investigating whether the consumption of green tea, or its derivative catechin, may improve neural regeneration in a rat spinal cord injury model. The tenth study is a retrospective study about the effectiveness of unipedicular kyphoplasty in osteoporotic thoracolumbar vertebrae compression fractures in elderly patients. The eleventh article, another retrospective study, examines the surgical outcomes of spinal gunshot wounds. A total of 32 patients over a 10-year period were evaluated in the study. The twelfth article is a case report about acute cord reperfusion injury and edema, after posterior cervical decompression, for chronic PLLO stenosis, and the thirteenth is a case report about asymptomatic extrusion of anterior cervical spine implant from hypopharynx. The fourteenth article is a review article about the COVID-19 pandemic and changing practices in spinal surgery.

Although the pandemic continues to wreak havoc in the world, it has not diminished the resolve of the people responsible for getting the July issue of our journal out to you. They are undaunted by the problems it poses, and continue to work tirelessly to provide you with an informative report on all of the cutting edge research in our field. I hope that all of our readers appreciate the effort that has gone into this issue. Our mission remains, as always, to keep you abreast of all the latest developments in our field. Once again, this issue is intended to further that goal.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

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ORIGINAL ARTICLES

JOURNAL OF TURKISH SPINAL SURGERY

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J Turk Spinal Surg 2020;31(3):125-9
DOI: 10.4274/jtss.galenos.2020.213

A STUDY OF THE RELIABILITY AND VALIDITY OF THE TURKISH VERSION OF THE WALTER REED VISUAL ASSESSMENT SCALE IN ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: The Walter Reed Visual Assessment Scale (WRVAS) was developed to evaluate deformity perception in patients with idiopathic scoliosis. The WRVAS has been shown to have a strong internal reliability and a high validity. This study aimed to determine the reliability and validity of the Turkish version of the WRVAS (WRVAS-TR).

Materials and Methods: The translated Turkish version of the WRVAS was administered twice to 58 patients in a one-week interval to test the reliability of the scale. Cronbach's alpha coefficient was used to assess the internal consistency. Convergent validity was assessed by analysing the correlation between the WRVAS-TR and the Scoliosis Research Society-22 (SRS-22) scales.

Results: The mean age of the patients was 12.8 years, maximum Cobb angle was 32.1° and maximum angle of trunk rotation was 9.9°. The intraclass correlation coefficient for the item-total score was 0.906 ($p<0.001$). The Cronbach's alpha coefficient for all the seven items was 0.783. Self-image scores of the SRS-22 had significantly negative correlations with the 1st ($p=0.03$) and 4th ($p=0.003$) questions and the total WRVAS-TR scores ($p=0.01$).

Conclusion: Improving the aesthetic appearance has been identified as one of the main goals of scoliosis management. For adolescents especially, cosmetic appearance is more important than the angles measured on X-rays. WRVAS-TR test-re-test results showed high reliability and significantly negative correlations with self-image scores of the SRS-22.

Keywords: Adolescent idiopathic scoliosis, body image, self-perception

INTRODUCTION

Over the last 20 years, treatment goals, patient expectations and the criteria for evaluating the treatment outcomes of adolescent idiopathic scoliosis have changed. Aesthetic appearance is one of these evaluation criteria and physical deformity as perceived by adolescents is considered as one of the most important dimensions of idiopathic scoliosis[1,2].

Improving the aesthetic appearance has been identified as one of the main goals of scoliosis management according to the consensus reached by the Society on Scoliosis Orthopaedic and Rehabilitation Treatment professionals[2]. Moreover, perceived body image in idiopathic scoliosis is an important factor affecting the quality of life[3]. School screenings performed in different cities across Turkey showed that the frequency of idiopathic scoliosis varied between 0.47% and 0.49%[4,5]. Despite the high incidence of idiopathic scoliosis, there is unfortunately no instrument in the Turkish language to assess the deformity perceptions of these adolescents.

The Walter Reed Visual Assessment scale (WRVAS) has been shown to be a valid scale to evaluate the cosmetic deformity perception in patients with scoliosis[1,6]. Sanders et al.[1] suggested that there is a strong correlation between curve magnitude and the WRVAS and that curves of ⩾30° can be clearly differentiated from lesser curves.

With the aim of making the WRVAS available for Turkish patients, the instrument was translated into Turkish, and the reliability and validity tests were conducted on adolescents with idiopathic scoliosis.

MATERIALS AND METHODS

This study included adolescents who were admitted to our institution and diagnosed with idiopathic scoliosis by a physician between September 2019 and December 2019. The

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study was approved by the institutional review board and was conducted in compliance with the Helsinki Declaration. Patients and parents were informed about the study and a written consent obtained.

The exclusion criteria were as follows: non-idiopathic scoliosis, a previous spinal surgery, accompanying mental disorders, muscular, neurological or rheumatic diseases. The Cobb angle and Risser sign were assessed on the anteroposterior radiographs. The angle of trunk rotation (ATR) was measured with a Bunnell Scoliometer™ and the readings were obtained in a standing position with forward bending.

The WRVAS is an instrument that was developed by Dr. Sanders to assess the subjective perception of physical deformity in patients with idiopathic scoliosis[1]. The internal consistency of the instrument has been found to be excellent and high correlations with the curve magnitude have been reported in previous studies[1,6]. This scale includes seven items with figures representing different aspects of the spinal deformity: spinal deformity, rib prominence, lumbar prominence, thoracic deformity, trunk imbalance, shoulder asymmetry and scapular asymmetry. The figures are scored from minimum (1, no deformity) to maximum (5, severe deformity) and summed up to yield a total score (minimum: 5 points, maximum: 35 points). It can be completed by the patient, the patient's family or the clinician. It is recommended for clinical assessment because the application and scoring are very simple[1,6,7].

Permission to translate was obtained from Sanders et al.[1] and the WRVAS was then translated into Turkish. The translation process was performed according to the Consensus-based Standards for the selection of health status Measurement Instruments criteria and the previously described guidelines[8,9]. The English version of the scale was translated into Turkish independently by two academicians with an advanced English language level. The translations were reviewed by the same persons and a consensus text was obtained. The Turkish version agreed upon was translated back into English by a physiotherapist and a PhD student with an advanced English language level. The translators and researchers compared the original, translated English versions and the consensus version, necessary corrections were made and the final Turkish version was produced (Figure 1). The sample instrument with Turkish headings was administered to 10 healthy adolescents who presented at the clinic to test its comprehensibility. To estimate the test-re-test reliability, the scale was re-administered to the same patients after a one-week interval.

The Scoliosis Research Society-22 (SRS-22) questionnaire is a patient-reported outcome instrument for the assessment of the health-related quality of life of patients with idiopathic scoliosis. It was then modified by Asher et al.[10] (SRS-22r), and a validated Turkish version was made available[11]. The SRS-22 consists of 20 questions that represent four dimensions: function/activity, pain, self-image and mental health and two additional questions about patient satisfaction with the treatment (these questions were not included in the present study). Each item and domain is scored from 1 (worst) to 5 (best), with higher scores indicating better outcomes[10].

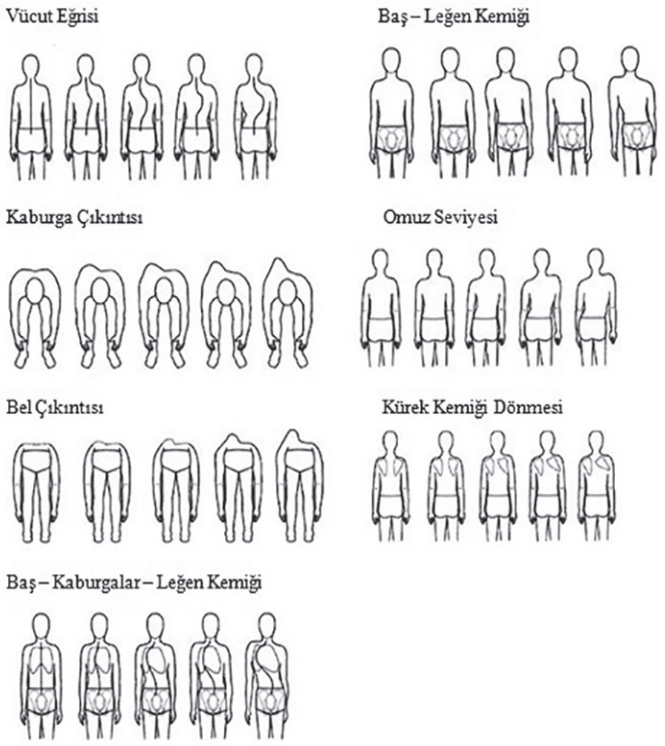

Figure 1. Turkish version of the Walter Reed Visual Assessment Scale

Statistical Analysis

Cronbach's alpha coefficient was estimated to assess the scale's internal consistency. The intraclass correlation coefficient was calculated for each item of the questionnaire. The convergent validity was analysed by measuring the correlation (Spearman's test) between the WRVAS-TR and the SRS-22 scales.

RESULTS

A total of 58 adolescents (51 females) with a mean age of 12.8±1.3 years (range; 10-16 years) and mean Risser sign of 1.4 (range; 0-3) were included in this study. The maximum Cobb angle was 32.1±8.6° (range; 20 to 60) and maximum ATR was 9.9±4.4° (range; 3-20).

No floor and ceiling effects were detected for the total WRVAS-TR score (Table 1). The mean scale score was 13.5±3.4 (range; 7-21) in the first assessment and 13.4±3.6 (range; 7-21) in the second assessment (Table 2). Test-re-test correlation coefficients for the item-total score was 0.906 ($p<0.001$). The Cronbach's alpha coefficient was 0.783.

Correlation analysis of the WRVAS-TR questions and SRS-22 sub and total scores (Table 3) showed that self-image scores of the SRS-22 had significantly negative correlations (low degree) with the 1st ($p=0.03$) and 4th ($p=0.003$) questions and total

scores of WRVAS-TR (p=0.01).

DISCUSSION

The results of this study showed that WRVAS as a high reliability for Turkish patients. The total WRVAS scores had a negative correlation with the SRS-22 self-image subscores.

The floor and ceiling effect analyses showed that the ceiling effect was notably low (1.7% to 6.9%), whereas the floor effect was somewhat higher (1.7% to 34.5%). These results were similar to those of Pineda et al.[6].

The WRVAS questionnaire was adapted linguistically and the reliability and validity for Turkish patients were evaluated in this study. Cronbach's alpha coefficient and item-total correlation are calculated to determine the reliability of a survey instrument. Cronbach's alpha values of 0.70 or higher indicate a good correlation between items[12]. In the present study, the Cronbach's alpha coefficient was 0.783. Internal consistency of the Turkish version of the WRVAS showed good reliability and the test-re-test results demonstrated high reliability. Pineda et al.[6] reported excellent Cronbach's alpha coefficient of the scale's English version (0.9). However, as no other study had investigated the validity of the WRVAS in a different language, comparisons of the test-re-test correlation and Cronbach's alpha coefficients of the WRVAS-TR could not be made.

Convergent validity shows the relationship between two measures that assess the same construct. In this study, the convergent validity of the WRVAS-TR was assessed by the correlation analyses between the Turkish versions of the SRS-22 sub and total scores and the WRVAS items. Significant positive correlations were determined between the 1st and 4th questions and the total scores of the Turkish version of the WRVAS and SRS-22 self-image subscores. Pineda et al.[6] showed a highly

Table 1. Floor and ceiling effects of the WRVAS questions

	Patients with a minimum score (%)	Patients with a maximum score (%)
WRVAS1	20.7	5.2
WRVAS2	31	6.9
WRVAS3	31	3.4
WRVAS4	17.2	1.7
WRVAS5	34.5	3.4
WRVAS6	29.3	1.7
WRVAS7	32.8	1.7
WRVAS (Total)	1.7	1.7

WRVAS: The Walter Reed Visual Assessment Scale

Table 2. Intraclass correlation coefficient for test-re-test reliability

	First assessment	Second assessment	ICC
WRVAS1	2.1±0.8	2.0±0.7	0.665 (p<0.001)
WRVAS2	1.7±0.5	1.7±0.6	0.589 (p<0.001)
WRVAS3	1.8±0.7	1.8±0.6	0.716 (p<0.001)
WRVAS4	1.9±0.5	1.9±0.6	0.677 (p<0.001)
WRVAS5	2.0±0.9	2.0±0.8	0.818 (p<0.001)
WRVAS6	1.9±0.7	1.8±0.6	0.680 (p<0.001)
WRVAS7	1.9±0.8	1.9±0.8	0.819 (p<0.001)
WRVAS (Total)	13.5±3.4	13.4±3.6	0.906 (p<0.001)

ICC: Intraclass correlation coefficient, WRVAS: The Walter Reed Visual Assessment Scale

Table 3. Correlation coefficients between the WRVAS questions and SRS-22 scales

	Function	Pain	Self-image	Mental health	SRS-22 (Total)
WRVAS1	−0.067	0.019	−0.285**	−0.157	−0.137
WRVAS2	0.008	0.134	−0.198	−0.015	−0.062
WRVAS3	0.016	0.227	−0.247	−0.064	0.004
WRVAS4	−0.210	0.048	−0.383**	−0.286**	−0.290**
WRVAS5	−0.025	0.185	−0.212	−0.123	−0.023
WRVAS6	−0.008	0.000	−0.214	−0.136	−0.096
WRVAS7	−0.082	−0.114	−0.238	−0.195	−0.265**
WRVAS (Total)	−0.080	0.109	−0.337**	−0.195	−0.157

WRVAS: The Walter Reed Visual Assessment Scale, SRS-22: The Scoliosis Research Society-22
**: p<0.05

significant correlation between the WRVAS and Cobb angle and a significant correlation between WRVAS and the SRS-22 self-image score in patients with idiopathic scoliosis having a mean age of 19.4 years. A Korean study reported a positive correlation (0.248) between the WRVAS score and the SRS-22 score in females with idiopathic scoliosis, and the mean age of the patients was 14.9 years[13].

Some doubts have been raised about the validity of the WRVAS drawings, as the scores for some deformity-related items do not correlate with the radiological values[14]. Moreover, its face validity has been called into question because of the unrealistic curves in the drawings. Mulcahey et al.[15] recently reported that adolescents have problems completing the questionnaire, due to difficulties in comprehending the drawings and reading the questions. Our clinical experience and observations suggest that adolescents with idiopathic scoliosis have no difficulty in understanding the questions, although they tend to have perceptions only of midline changes and are not aware of shoulder, waist and pelvis asymmetry or posterior rib hump size. It has been shown that scoliosis patients have a poorer perception of body image and brain responsiveness during visual vertical perception in comparison to healthy control groups[16,17]. The application of specific exercises in front of a mirror, providing information regarding the spine and scoliosis and evaluating X-rays together can improve body and deformity perception. However, the efficacy of treatment methods on the construct validity of WRVAS was not evaluated in this study.

Bago et al.[7] Reported that there is a discrepancy between the WRVAS item figures and what the patient "sees in the mirror". The figures' scores appear to correspond more with the subjective impression that patients have of their spine[7]. As patients do not usually see their own back, this impression is mainly based on the spinal X-rays. In addition, the scale mostly assesses the thoracic area deformity, while lumbar deformity, including both flank prominence and waist asymmetry, is poorly represented. Another drawback is that the WRVAS symbolises the deformities in only one direction[7].

Study Limitations

A limitation of this study was that no other means of evaluating the body image or deformity perception were applied. Future studies should investigate the effect of different treatment modalities, age groups, Cobb and hump magnitude and socio-cultural characteristics on deformity perception.

CONCLUSION

Aesthetic appearance improvement has been identified as one of the basic goals of scoliosis treatment and the perceived body image is also an important factor affecting the quality of life[1,2]. The WRVAS-TR test-re-test results showed high reliability and significant negative correlations between the self-image scores of the SRS-22. For adolescents especially, cosmetic appearance is more important than the angles measured on X-rays.

Ethics

Ethics Committee Approval: The ethics approval for the study was obtained from the Ethics Committee of Marmara University (26.09.2019/93).

Informed Consent: Informed consent was obtained from patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: İ.Ç., T.K.Ç., Design: İ.Ç., T.K.Ç., Data Collection or Processing: İ.Ç., T.K.Ç., Analysis or Interpretation: T.K.Ç., Literature Search: İ.Ç., T.K.Ç., Writing: İ.Ç., T.K.Ç.

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

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

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):130-4
DOI: 10.4274/jtss.galenos.2020.268

EFFECTIVENESS OF GENSINGEN BRACE TREATMENT FOR ADOLESCENT IDIOPATHIC SCOLIOSIS: A PROSPECTIVE COHORT STUDY

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ABSTRACT

Objective: The efficacy of brace treatment for patients with adolescent idiopathic scoliosis (AIS) remains controversial. This study aimed to evaluate the effectiveness of Gensingen brace treatment in patients with AIS (identified using the Scoliosis Research Society inclusion criteria) and explore factors affecting treatment success rates.

Materials and Methods: This study included twenty-five patients diagnosed with AIS and treated using a Gensingen brace between April 2015 and February 2018. Initial brace correction rates and progression of the main curves were evaluated. Treatment outcomes were classified into a) progression if ⩾6° increase in curvature was observed and b) improvement in case of ⩾6° decrease in curvature. The association between treatment success rate and age, gender, Lenke classification, Risser grade, initial Cobb angle, and rotation grade was examined.

Results: The spinal curvature was seen to progress in 13 cases, improve in two cases, and remain unchanged in 10 cases, yielding a success rate of 48% (12/25). Moreover, only three out of 25 cases exhibited progression of the Cobb angle above 45° requiring surgery. The mean pre-brace Cobb angle of the main curves was 27.9°±6.7° (range: 20° to 37°) and the mean duration of brace treatment was 37.2 months (range: 6-76 months). The mean Cobb angle at the end of treatment was 32.1°±8.2° (range: 15° to 45°). Successful treatment outcomes were correlated with initial Cobb angle (r=0.680; p=<0.001), rotation grade (r=-0.458; p=0.028), and main thoracic Lenke classification (r=0.481; p=0.020), although no such association with age and Risser grade was observed.

Conclusion: The patient's age, Risser grade, and gender showed no significant association with successful treatment outcomes, although initial Cobb angle, rotation of apical vertebra, and Lenke classification did.

Keywords: Brace treatment, Gensingen brace, adolescent idiopathic scoliosis, conservative treatment

INTRODUCTION

The ideal treatment plan for patients with adolescent idiopathic scoliosis (AIS) and Cobb angles between 10-25° is still unclear, with several studies suggesting rehabilitation and bracing as a viable conservative treatment option[1-3]. Bracing is usually suggested for patients with spinal curves of 20-30°, and a curvature improvement of 5° or more may be observed between subsequent visits. It can also be suggested as the treatment of choice in skeletally immature (Risser grade 2 or lower) patients with spinal curvatures of 30-45°[4]. To date, a wide range of braces, such as Boston, Milwaukee, Wilmington, Osaka Medical College, soft braces (SpineCor/TriaC), and night-time braces (Providence/Charleston) have been developed[3]. Orthopaedic braces, when used for the treatment of scoliosis, may prevent curvature progression in patients with AIS[5]. However, braces should be assessed individually as treatment outcomes often depend on various factors such as the percentage of in-brace correction, patient compliance, and duration of treatment[6-8]. As previous studies have reported increasing popularity of the Gensingen Brace due to greater patient satisfaction, the current study aims to evaluates its effectiveness in the treatment of AIS and explores the factors influencing treatment outcomes.

MATERIALS AND METHODS

This prospective clinical cohort study was conducted at our clinic between April 2016 and February 2018, and patients diagnosed with progressive idiopathic scoliosis were asked if they wanted to volunteer to partake. Ethical approval was acquired from the Research Ethics Board at the University (24.10.2018), and written informed consent was collected from all participants and their guardians.

Inclusion criteria: This study included all patients who met the Scoliosis Research Society (SRS) inclusion criteria, as follows: age >=10 years at the time of brace prescription; Risser stage 0-2; primary curvature angles between 25-40°, no

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prior treatment for AIS; either pre-menarchal or <1 year post-menarchal[9]; and available for a minimum follow-up period of two years.

Exclusion criteria: Patients with a history of brace treatment and co-morbidities that could change the course of AIS (such as genetic defects, neuromuscular disorders, metabolic disorders, and severe trauma) were excluded from this study.

Gensingen Boston type braces were fabricated and placement of the pressure pads were checked by the same certified orthopaedist. Standing anteroposterior (AP) X-rays were used to confirm in-brace correction as well as the patient's full spinal alignment, including the pelvis, while wearing the brace (Figure 1). The correction magnitude threshold was >50% reduction of the initial Cobb angle, and patients were instructed to wear the brace for a minimum of 23 hours per day at the start of treatment. Skeletal maturity was defined as fulfilment of the following three criteria: a) Risser stage equal to 4; b) completion of at least two years since the onset of menstruation (for girls); and c) two consecutive visits over at least one year where no more than 1 cm increase in height was observed. Brace treatment was stopped one year after skeletal maturity.

This study included twenty-five patients (22 girls and 3 boys) diagnosed with AIS, and the mean age of the cohort was 11.4±1.19 years (range: 10-14) at the start of treatment. X-rays were taken before commencement of treatment, at the start of treatment while wearing the brace, before and after each subsequent brace, and at skeletal maturity (after wearing the brace). In-brace X-rays were taken six weeks after the start of treatment, and again six months after completion of treatment

Figure 1. Patient treated using Gensingen type brace

or achievement of "skeletal maturity". All analyses of changes in Cobb angle were carried out by the senior author T.A. Patients were grouped into two main curvature types, main thoracic (Lenke I, II, or III; n=10) and main lumbar (Lenke V or VI, n=15). Rotation of apical vertebrae was measured using the Nash & Moe method, which is based on the relationship between the vertebral pedicles and the centre of the vertebral body in an AP X-ray[9]. Rotation was grouped into five degrees based on the position of the pedicles, with 0° representing no vertebral rotation where the pedicles were located halfway to the lateral margins of the vertebral bodies. The rotational degree progressed as the pedicles of the apical vertebrae moved towards the median line in the AP X-rays, with the highest value (4°) being reached when the pedicle crossed the median line.

Clinical outcomes were assessed using the SRS criteria. The Cobb angle was measured in patients (without the brace) using standing AP spine X-rays, and outcomes were classified into the following groups: (1) improved: Cobb angle decreased by 6° or more; (2) stable: no more than 5° progression or improvement; (3) progressed: increase in the Cobb angle by 6° or more; and (4) surgical: progression of the Cobb angle beyond 45° requiring surgical intervention.

Statistical Analysis

All statistical analyses were carried out using SPSS version 24.0 (IBM Corp, 2011, Armonk, New York). Descriptive statistics, including mean, standard deviation, median, frequency, ratio, and minimum and maximum values, were generated for the cohort. Quantitative comparisons were carried out between the two groups using Student's t-test for normally distributed data and Mann-Whitney U test when the distribution was not normal. Pearson chi-square test, Fisher Freeman Halton Exact test, and Fisher's exact test were used to compare qualitative data. The significance level was set at $p<0.05$ a priori.

RESULTS

This study included 25 patients, of which three were male and 22 were female. Three patients underwent surgery for scoliosis, and the curvature distribution in the cohort was as follows: main thoracic curvature (n=8), thoracolumbar curvature (n=10), lumbar curvature (n=5), double major curvature (n=1), and double thoracic curvature (n=1). The distribution of Risser stages was as follows: grade 1 (n=8 cases), grade 2 (n=8), and grades 2-3 (n=9). The apices of the main curves were at T6 in four cases and below T7 in 11 cases (T8 in four cases, T9 in three cases, T10 in one case, T11 in one case, T12 in two cases, L1 in two cases, L2 in five cases, and L3 in three cases). The mean pre-brace Cobb angle for the main curve was 27.9°±6.7° (range: 20° to 37°) and the mean duration of brace treatment was 37.2 months (range: 16-76 months). The mean Cobb angle at the end of treatment was 32.1°±8.2° (range: 15° to 45°). The distribution of rotation, as per the Nash Moe classification, in the cohort was as follows: grade 1 (n=12), grade 2 (n=6), grade 3 (n=2), and grade 4 (n=4).

The last follow-up consultation after completion of treatment showed that curvature had progressed in 13 cases, improved in two cases, and remained unchanged in 10 cases (Figure 2 A, B and 3 A, B). Only three cases exhibited progression of the Cobb angle beyond 45° and were recommended for surgery. Therefore, a success rate of 48% (12/25) was accomplished.

No correlation between age, Risser grade, and brace treatment outcome was observed. However, successful treatment outcomes were seen to be significantly associated with initial Cobb angle (r=0.680; p=<0.001), rotation grade (r=-0.458; p=0.028), and main thoracic Lenke classification (r=0.481; p=0.020).

DISCUSSION

Using age and simple morphologic classifications (Cobb, Lenke classification, and Risser grade), we definitively demonstrated a success rate of Gensingen brace treatment in AIS and the relationship between the uncomplicated parameters and brace benefit[10]. Thompson et al.[11], in their study examining treatment of 168 patients using thoraco-lumbosacral orthosis braces, reported that curvature improvement of ≥50°(p=0.0383) was observed in 35.8% (43 of 120) of patients with persistent main thoracic curves, 20.0% (6 of 30) of patients with persistent main lumbar curves, 12.5% (1 of 8) of patients with main thoracic curves that converted into main lumbar curves, and 0% (0 of 9) of patients with main lumbar curves that became main thoracic curves[10].

Thoracic curves are associated with a higher risk of brace failure than lumbar curves, independent of primary curve magnitude and the average duration of daily brace wear. This was corroborated by the findings of the current study, where patients with main thoracic curves exhibited a higher success rate than those with main lumbar curves. Additionally, rotation also exhibited correlation with successful treatment outcomes. While some clinical studies reported an association between

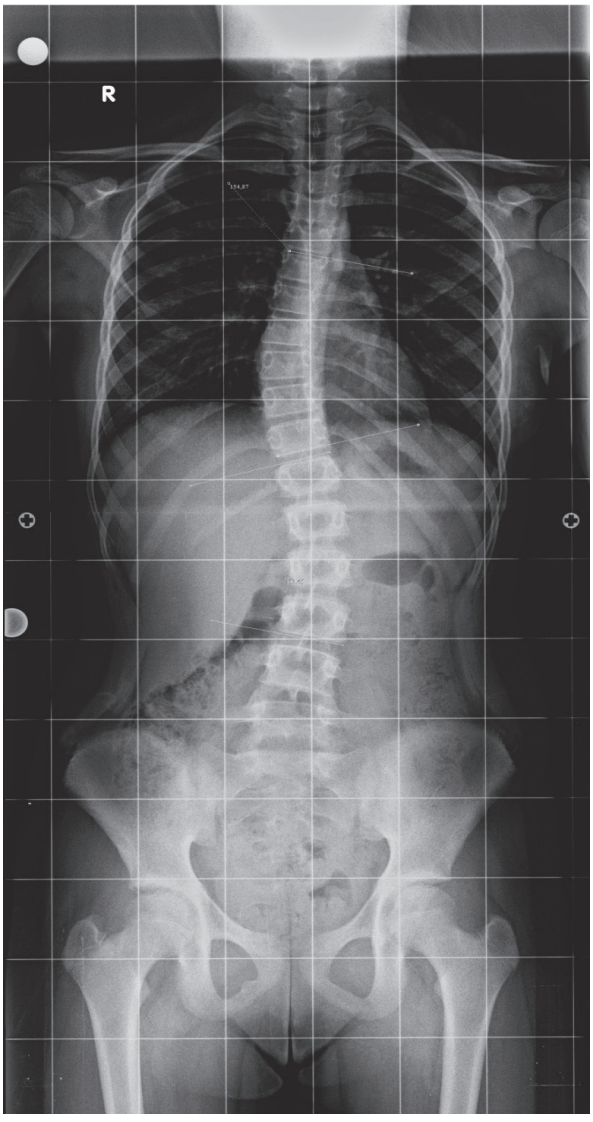

Figure 2. A) Standing anteroposterior radiograph of patient before commencement of treatment with Gensingen brace

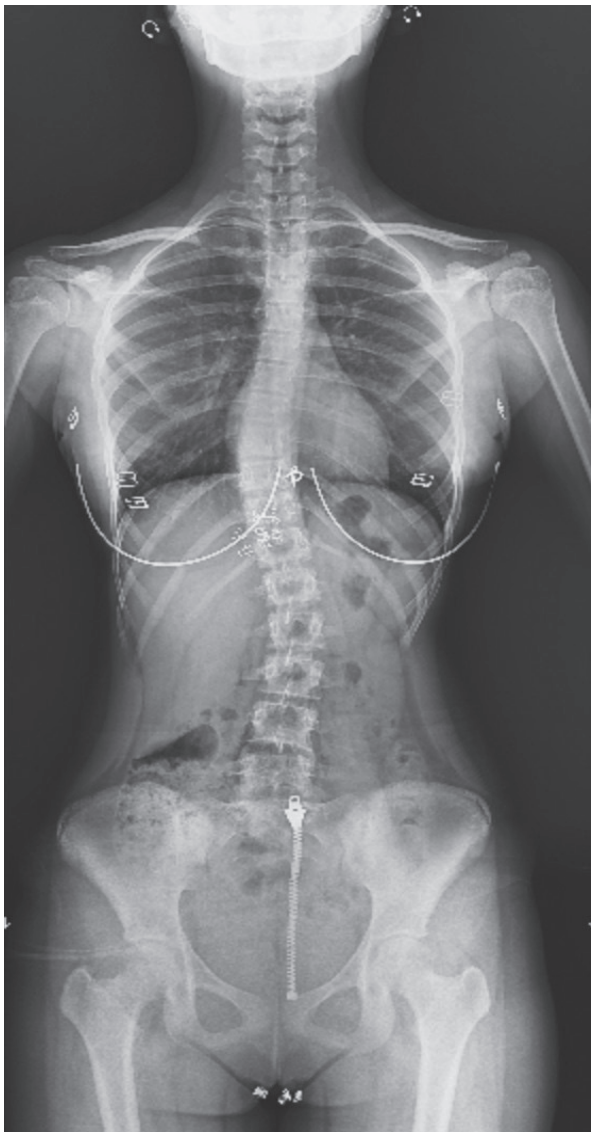

Figure 2. B) Successful treatment outcome observed upon removal of Gensingen brace

curve progression and younger age[11,12], others reported no evidence of a relationship between curve improvement and age. Cheung et al.[13], in their study consisting of 586 patients (mean duration of wearing brace: 3.8±1.5 years, mean post-bracing follow-up duration: 2.0±1.1 years), found that curve progression exhibited an association with younger age (Odds ratio: 0.71; 95% confidence interval: 0.55 to 0.91; p=0.008) [12]. Yrjönen et al.[14], in their study examining treatment of 102 patients with AIS using a Boston brace, reported no statistically significant association between the risk of curve progression and the patient's age, curve pattern, or curve magnitude[13]. Similarly, Peltonen et al.[15] examined 107 patients diagnosed with idiopathic scoliosis who were treated using a Boston brace (mean post-treatment follow-up duration of 3 years) and found no correlation between the patients' age at the start of the treatment and the treatment outcome[14]. The findings of the current study were in agreement with this, with no relationship between the patient's age and curve progression being observed.

Another key factor that affects treatment outcome is the initial spinal curvature exhibited by patients with AIS. Emans et al.[16] suggested that a Boston brace stated that higher primary curve magnitude enhanced the potential for surgery[15]. Katz and Durani[17]. reported that double curves with an initial thoracic curve >35° were more likely to exhibit progression, although this was contradicted by Ovadia et al.[18] who found that lower baseline Cobb angles were associated with limited progression rates, although their findings were not statistically significant. Kuroki et al.[19] observed lower success rates in patients with Cobb angles between 20° and 30° compared to those with Cobb angles above 30° (although this was not statistically significant), and concluded that there was no association between curve magnitude and treatment success. The systematic review conducted by Van Den Bogaart et al.[20] found moderate scientific evidence supporting no association between initial Cobb angle and treatment failure and inadequate evidence on treatment success. The present study

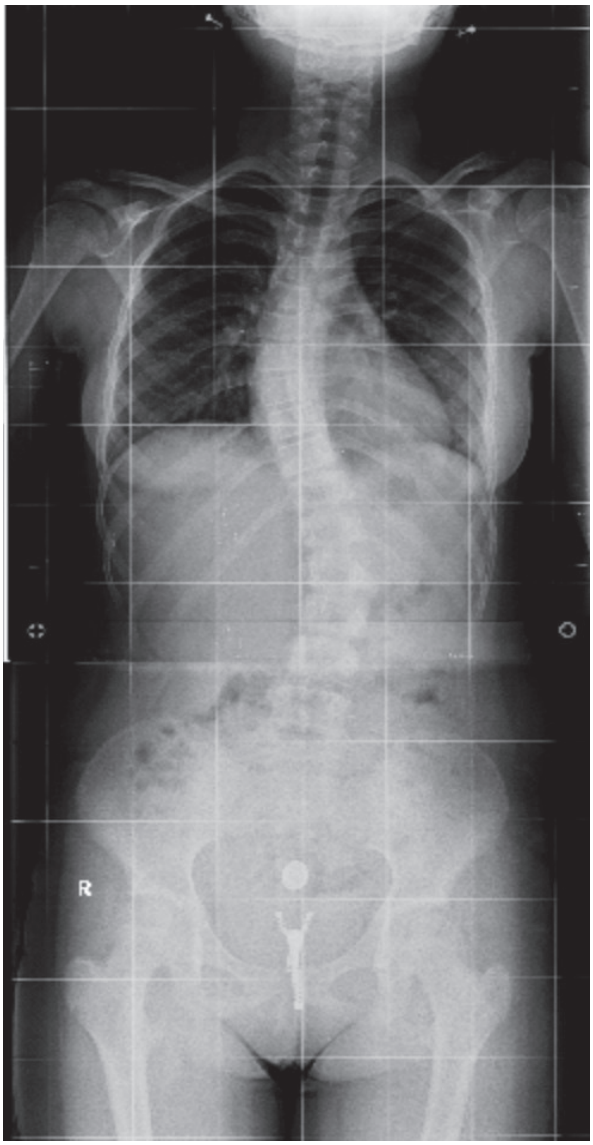

Figure 3. A) Standing anteroposterior radiograph of patient before commencement of treatment with Gensingen brace

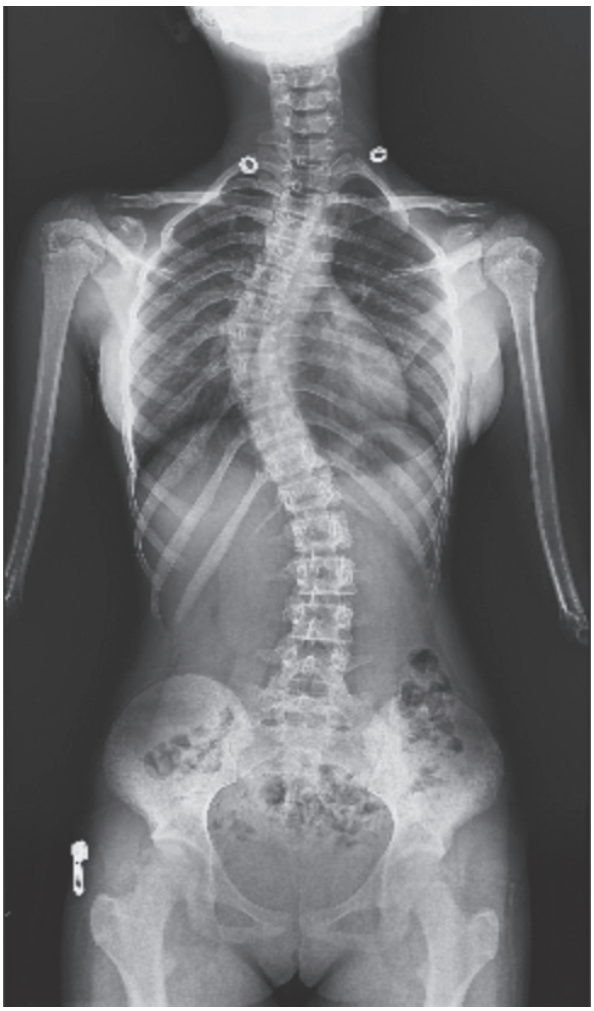

Figure 3. B) Curve progression observed upon removal of Gensingen brace

showed a notable correlation between the primary Cobb angle and treatment success.

Study Limitations

This study has several limitations including small sample size, relatively short follow-up period, and limited number of male patients, thus preventing examination of any associations between sex and treatment outcome. The small sample size also prevented accurate measurement of the Risser stage, which has been previously shown to influence brace success. Finally, the mean duration of daily bracing was not assessed, preventing examination of its effect on compliance and treatment success.

CONCLUSION

Treatment of AIS in skeletally immature patients using a Gensingen brace can significantly decrease risk of curve progression to the threshold requiring surgical intervention. This study found that the initial Cobb angle, rotation of apical vertebra, and Lenke classification were significantly associated with treatment success, while no such association was observed with the patient's age, Risser grade, and gender.

Ethics

Ethics Committee Approval: Ethical approval was provided by the institutional review board (24.10.2018).
Informed Consent: Informed consent was collected from all patients.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: Ş.K., Design: M.A.Ö., Data Collection or Processing: M.A., Analysis or Interpretation: S.B., Literature Search: S.B., Writing: T.A., S.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.

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J Turk Spinal Surg 2020;31(3):135-40
DOI: 10.4274/jtss.galenos.2020.99

CLINICAL RESULTS AND REOPERATION RATES AFTER LONG ADULT DEFORMITY FUSIONS FROM THE SACRUM TO THE THORACOLUMBAR SPINE

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ABSTRACT

Objective: To evaluate patient-reported outcome measures and reoperation rates after primary fusion surgery from the thoracolumbar spine to the sacrum for adult spinal deformity (ASD).

Materials and Methods: In this study, 63 patients with ASD who underwent primary fusion surgery from the sacrum to thoracolumbar area at a single specialty spine centre were reviewed. All patients were followed-up for a minimum of 2 years with a mean follow-up period of 44 months. The preoperative and final follow-up Oswestry disability index (ODI) scores and radiographs were reviewed. Patients who reached a minimal clinically important difference (MCID) were determined. Moreover, reoperations for any reason during follow-up were noted.

Results: The median ODI scores improved significantly from 40 preoperatively to 28 at the final follow-up ($p \leq 0.01$). A majority of patients achieved MCID (52%), and reoperation was performed in 33% of the patients. The reasons for reoperation were proximal junctional failure (n=7), implant irritation (n=5), pseudarthrosis repair (n=4), infection (n=4) and recurrent stenosis (n=1).

Conclusion: Primary instrumented fusion from the thoracolumbar spine to the sacrum for ASD is associated with high re-operation rates. A significant improvement in ODI was seen at the final follow-up in patients who did not receive a re-operation. Whereas, among the re-operated patients, only 19% achieved a MCID in ODI score.

Keywords: Adult spinal deformity, reoperation, MCID, ODI, clinical outcomes

INTRODUCTION

Adult spinal deformity (ASD) can be a relatively painless condition or cause intractable pain. While the minimally symptomatic patients can be treated non-operatively with medication and physical therapy, patients with severe symptoms may require surgical intervention[1,2]. Although surgery for ASD has been shown to improve function and alleviate pain, it is unfortunately associated with high complication and re-operation rates[3-5]. Moreover, surgical options can vary between minimally invasive decompressions to long construct fusions[4]. Many studies have evaluated the results of ASD surgery with different inclusion criteria, fusion levels and outcome assessments. Surgical procedures are typically multilevel and can often include the sacrum distally. Ending a construct at L5 instead of the sacrum has its own advantages and limitations. The advantages include it being less invasive, preserving lumbosacral motion and avoiding pseudarthrosis at that level, while the limitations are generally degeneration and loss of lordosis at L5-S1 leading to additional surgery due to axial pain, radiculopathy or sagittal imbalance[6]. In addition, the known complications when including the sacrum are pseudarthrosis, proximal junctional kyphosis and proximal junctional failure (PJF)[7,8]. This retrospective study evaluated patient-reported outcome measures and reoperation rates after primary instrumented fusion from the thoracolumbar area to the sacrum. Understanding the outcomes and possible complications leading to re-operation will help surgeons and their patients make informed treatment decisions and manage both the pre- and postoperative expectations.

MATERIALS AND METHODS

Ethics committee approval was obtained from Allina Health Institutional Review Board (no: 1403801). Institutional Review Board waived for this type of study.

This study has been approved by the institutional review board prior to the retrospective chart review and radiographic assessment. The study included consecutive patients with ASD who underwent surgery at a single specialty spine centre between 2008 and 2016. ASD was defined as a Cobb angle

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of 30º or greater or/and a sagittal vertical axis (SVA) of 5 cm or greater or/and pelvic tilt (PT) >25º. All included patients had at least five-level primary instrumented fusions from the sacrum-pelvis to the upper lumbar or thoracic spine (T9-L1). However, patients with prior lumbar fusion surgery, severe osteoporosis, neuromuscular disorders, infection or trauma and those who refused to be included were excluded from the study. Additionally, patients who had surgery within two years prior to the initiation of the study were also deemed ineligible to be included.

Statistical Analysis

Moreover, data were extracted from the patients' clinical and operative notes in the electronic health records of our local hospital system. Functional outcome analysis was based on the Oswestry disability index (ODI) before surgery and at the final follow-up. For further clinical outcome evaluation, the minimal clinically important difference (MCID) was calculated; and the threshold for MCID was 12.8[9]. In addition, the number of instrumented levels, the surgical approach and whether iliac fixation or osteotomy (Smith-Petersen) was performed were assessed. Additionally, re-operation during follow-up for any reason was recorded. Radiographic measurements were done on digitally archived posterior-anterior and lateral radiographs from two time points-preoperative and at final follow-up or pre-revision. Statistical tests included chi-square or Fisher's exact tests for categorical variables, Student's t-tests and paired t-tests for normally distributed continuous variables and Kruskal-Wallis tests for non-normally distributed data. The threshold for statistical significance was p=0.05.

RESULTS

In total, 449 fusion cases were reported between 2008 and 2016. Of these, 210 were excluded due to a history of previous spine fusion. Among the 239 primary cases, 167 patients had instrumented fusion proximal to S1. Moreover, 72 patients received instrumented posterior fusion from the lower thoracolumbar spine (T9-L1) to the sacrum with or without pelvic extension. Nine patients were excluded due to a history of osteomyelitis (n=1), no consent to research (n=2), and failure to follow-up (n=6)[6]. Finally, 63 patients were eligible for the study (Table 1). These were nine males and 54 females. Their mean age was 63 years. While the median follow-up was 34 months, the median number of levels fused was seven. For 80% of the patients, the uppermost instrumented level was T10 or T11. Most patients (91%) received an interbody fusion implant in addition to posterior screws and rods. Fixation to the pelvis was employed in two-thirds of the subjects. All patients received either interbody fusion or pelvic fixation, or both, at L5-S1, depending on surgeon's preference. Additionally, Smith-Petersen osteotomies were performed in 29% of the patients.

Table 2 summarises the radiographic data and compares the variables between patients receiving a re-operation due to PJF and the other study subjects. A significant improvement was observed in their lumbar lordosis in both groups; however, patients who were re-operated due to PJF had smaller changes in their lumbar lordosis and SVA. In addition, patients re-operated for PJF had a larger preoperative and postoperative PT. While the PT improvement was significant in non-PJF patients, it was insignificant in patients who had PJF.

Interestingly, a 30% improvement (Table 3) in the patient-reported outcomes (mean ODI scores) was observed among all patients (i.e. from 40 preoperatively to 28 at the final follow-up), which was significant (p<0.01). Among the patients who were re-operated, the change in ODI was −4 points. The final outcome for these patients (46 points) was statistically different from the patients who did not receive a reoperation, whose final outcome was 20 points (p=0.01). Of the total study population, 52% of the patients achieved MCID in ODI (Table 4). While the patients who were re-operated achieved only 19% MCID, those who were not, achieved a 69% MCID. The difference between the two groups was therefore significant (p<0.01).

Further, re-operations during the follow-up period were performed on 21 of the 63 included patients (33%) (Table 5). The reasons for re-operation included PJF (n=7), implant irritation (n=6), pseudarthrosis repair (n=4), surgical site infection (n=4) and recurrent stenosis (n=1). One subject, however, presented with both infection and pseudarthrosis.

DISCUSSION

In a prospective observational study comparing non-operative and operative treatments for symptomatic ASD, patients showed significant improvement with surgical treatment[10].

Table 1. Demographics and surgical factors

Factor, measure (statistic)	All patients (n=63)
Age, years (mean ± SD)	62.9±9.8
Gender (M:F)	9:54
BMI (mean ± SD)	28.6±5.9
Follow up, months (median, range)	34 (24-103)
Number of fused levels (median, range)	7 (5-9)
Upper instrumented level, n	
T9	4 (6%)
T10	25 (40%)
T11	25 (40%)
T12	8 (13%)
L1	1 (2%)
Interbody procedure, n	
ALIF	39 (62%)
XLIF and/or TLIF	18 (29%)
No interbody	6 (10%)
Iliac fixation, n (%)	40/63 (63%)
Osteotomy, n (%)	18/63 (29%)

SD: Standard deviation, n: Number, M: Male, F: Female, BMI: Body mass index, ALIF: Anterior lumbar interbody fusion XLIF: Extreme lateral interbody fusion, TLIF: Transforaminal lumbar interbody fusion

Among the operative subjects, the mean pre- to postoperative improvement in ODI was 14, however, there was no significant change in patients treated non-operatively. In other study comparing changes in back and leg back pain after operative or non-operative treatment, a significant improvement with surgical intervention was observed. Of the surgically treated

Table 2. Radiographic parameters for patients with and without proximal junctional failure

Factor	All patients (n=63)	PJF (n=7)	No PJF (n=56)	p value
Lumbar lordosis, degrees (mean ± SD)				
Preoperative	36±17	35±16	36±17	0.30
Final follow-up	52±12	48±14	53±12	
p value (preoperative vs final)	<0.01	<0.01	<0.01	
Delta (preoperative-final)	-	-12±10	-17±14	
Pelvic incidence, degrees (mean ± SD)	57±10	58±10	56±10	0.63
Pelvic tilt, degrees (mean ± SD)				
Preoperative	24±7	27±9	24±7	0.57
Final follow-up	22±8	25±6	21±8	
p value (preoperative vs final)	<0.01	0.28	<0.01	
Delta (preoperative-final)	-	1±6	3±7	
SVA, mm (mean ± SD)				
Preoperative	50±50	30±50	52±50	0.10
Final follow-up	29±37	25±47	30±37	
p value (preoperative vs final)	<0.01	0.37	<0.01	
Delta (preoperative-final)	-	5±23	23±45	
Coronal cobb angle degrees (mean ± SD)				
Preoperative	42±13	41±10	43±14	0.71
Final follow-up	19±9	16±10	19±9	
p value (preoperative vs final)	<0.01	<0.01	<0.01	
Delta (preoperative-final)	-	25±6	24±10	
Coronal plane decompensation, mm (mean ± SD)				
Preoperative	26±26	15±13	29±27	0.08
Final follow-up	15±13	10±11	15±13	
p value (preoperative vs final)	<0.01	0.02	<0.01	
Delta (preoperative-final)	-	5±7	13±23	

PJF: Proximal junctional failure, n: Number, SD: Standard deviation, SVA: Sagittal vertical axis

Table 3. Patient reported outcomes (median, range)

Patient reported outcome	All patients (n=63)	Re-operation (n=21)	No re-operation (n=42)	p value
Preoperative ODI	40 (8-80)	42 (8-67)	39 (16-80)	0.98
Postoperative ODI	28 (0-82)	46 (0-82)	20 (0-80)	0.01
p value	<0.01	0.97	<0.01	-

ODI: Oswestry disability index, n: Number

Table 4. Patients achieving a minimal clinically important difference on Oswestry disability index

MCID	All patients (n=63)	Re-operation (n=21)	No re-operation (n=42)	p value
Yes (percent)	33 (52%)	4 (19%)	29 (69%)	<0.01
No (percent)	30 (48%)	17 (81%)	13 (31%)	

MCID: Minimal clinically important difference, n: Number

Table 5. Reasons for re-operation

Reason for re-operation	Number	Study population (n=63), %	Re-operated patients (n=21), %	Months to occurrence median (range)
Surgical site infection	4	6%	19%	1 (0-40)
Proximal junctional failure	7	11%	33%	12 (6-50)
Pseudoarthrosis	4	6%	19%	14 (12-29)
Painful instrumentation	6	10%	29%	16 (8-35)
Recurrent symptoms	1	2%	5%	30

n: Number

patients, 49% achieved MCID, while <10% of the non-operative patients achieved MCID[11]. Our study also showed an overall significant improvement in ODI with surgical treatment (40 preoperatively to 28 at the final follow-up). Additionally, 52% of our subjects achieved MCID.

Typically, re-operation after primary fusion surgery for ASD is reportedly high. Transfeldt et al.[12] reported 37% re-operation rate among patients with long fusions for degenerative scoliosis with radiculopathy. Likewise, Mok et al.[13] reported a 26% reoperation rate including infection, adjacent segment problems, implant failure, painful implant or pseudarthrosis. They included patients with long fusion (least five levels). Instrumented levels varied both proximally and distally. We were more homogeneous in terms of always including the sacrum and ending at the upper lumbar/lower thoracic spine, but we still observed a high re-operation rate (33%). Our reasons for re-operation were similar to other findings: PJF, painful implant, pseudarthrosis, infection and recurrent stenosis. Apparently, one-third of ASD patients receiving multilevel surgery are at risk for reoperation.

PJF is one of the main reason for re-operation after adult spine deformity. Its incidence in the literature has been reported between 1% and 35%[7]. The aetiology of PJF is most likely multifactorial and several risk factors have been defined for PJF, including fusion to the sacrum-pelvis, anterior-posterior combined fusion and upper-instrumented vertebra level at the thoracolumbar junction[7,14]. Yagi et al.[15], in their study, reported a 1.4% incidence of PJF in surgically treated ASD patients with a minimum of two-year follow-up. Park et al.[14] reported an 18% PJF in patients who underwent a long instrumented fusion to the sacrum for ASD. In this study, PJF was the main reason for re-operation. Its overall incidence was 11%, and it accounted for one-third of the re-operated patients. The high incidence of PJF in this study may be related to our surgical inclusion criteria where all patients had fusion to sacrum-pelvis and their upper-instrumented vertebra level were at thoracolumbar junction. In addition, most of our patients had anterior-posterior-combined surgeries and only pedicle screws were utilised for posterior instrumentation. Our radiographic results showed that patients had significant improvement in their lumbar lordosis and mild changes in their SVA. However, patients who had PJF had higher pre- and postoperative PT. Additionally, improvement in PT was significant in patients who did not develop PJF and insignificant for patients who did. Higher preoperative PT was reported as a risk factor for PJF, and patients who continue to have high PT postoperatively can be evaluated as having under correction of their sagittal alignment[16].

Pseudarthrosis after primary fusion surgery for ASD can be painful and may require re-operation. In a meta-analysis of pseudarthrosis in adult and paediatric spinal deformity surgery, a 6.3% incidence of pseudarthrosis has been reported[17]. Including the sacrum is a risk factor for pseudarthrosis[6,18]. Kim et al.[18] reported a 24% incidence of pseudarthrosis after long instrumentation to the sacrum in ASD patients. Further, after a combination of sacral screws and iliac screws, Tsuchiya et al.[19] reported a 7.5% non-union in their study. Our results showed 6% pseudarthrosis requiring revision surgery. While all of our patients had fusion to sacrum, the vast majority also had supplemental pelvic fixation. Our relatively lower rate of pseudarthrosis might be related to this utilisation of pelvic fixation. In addition, the large majority of our patients (92%) had interbody fusion at the L5/S1 level. Schroder reported that a high fusion rate can be expected with the usage of interbody fusion (anterior lumbar interbody fusion or transforaminal lumbar interbody fusion) at the treatment of L5/S1 degenerative pathologies[20].

Despite their efficacy, iliac screws can themselves be a source of pain or irritation that requires implant removal. In one study, 6.1% of ASD patients who had fusion to the sacrum required removal of iliac screws[21]. In our study, removal of painful iliac instrumentation was required in six of 63 patients (10%); 40 patients had iliac screws for pelvic fixation, which means 25% incidence of painful implants in this subgroup. All patients reported relief without sequelae after iliac screw removal.

The surgical site infection after primary fusion surgery for ASD is a frequent complication with a reported incidence of 1.2-10.9%[22-24]. Within the deformity population in our study that underwent surgery, 6% had surgical site infections requiring re-operation, which is consistent with the literature. The median time to presentation was one month. One patient was treated with irrigation and debridement and others with vacuum-assisted wound closure. All patients were infection free at their final follow-up.

Symptomatic recurrent or remnant stenosis after spine surgery has been described and re-operation was considered as an appropriate treatment option for patients having predominant leg or mixed leg/back pain[25]. In this study, recurrent leg pain and foraminal stenosis was confirmed in one patient through diagnostic imaging studies. Diagnosis was also supported with selective nerve root block. This subject underwent decompression surgery during follow-up with significant improvement.

We found that reoperation and patient-reported outcomes were related. Patients who received a re-operation expressed lower patient-reported outcome measures at the final follow-up compared to those who did not. A number of investigators have established relationships between reoperation and clinical symptoms[13,26-28], however, the link between patient-reported outcomes and reoperation rates is novel.

Study Limitations

Our study has several limitations, which create bias. First, being a retrospective study, we cannot adjust for statistical power nor can we establish causation between pre- and postoperative factors. Second, patients who were lost to follow-up or who did not consent to participate were excluded from the study. Results could have been different if all patients were included. Third, there were a considerable number of patients with a history of previous fusion who were excluded from this study; therefore, our results are applicable to patients receiving primary fusion surgery and cannot be generalised to the whole population of adults with deformity and those who are candidates for fusion surgery. Fourth, the follow-up periods varied between subjects. Patient-reported outcomes are subject to change over time, especially with the onset of new symptoms. Last, results could have been different if fusions had been extended to the pelvis for all patients.

CONCLUSION

A significant improvement was seen in patient-reported outcome measures in the patients who underwent primary fusion from the thoracolumbar spine to the sacrum for ASD. MCID was achieved in the majority of patients. The rate for re-operation was high; one-third of the patients had revision (33%) at long-term follow-up. Moreover, knowing potential expected clinical outcomes and possible reasons for re-operation in ASD surgery is important for counselling patients and managing their expectations.

Acknowledgment: The authors wish to acknowledge the encouragement and support of Ensor E. Transfeldt, MD and John M. Dawson, PhD.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from Allina Health Institutional Review Board (no: 1403801).

Informed Consent: Institutional Review Board waived for this type of study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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

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

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J Turk Spinal Surg 2020;31(3):141-7
DOI: 10.4274/jtss.galenos.2020.124

SPONTANEOUS REGRESSION OF LUMBAR DISC HERNIATIONS

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ABSTRACT

Objective: Lower back and back pain are among the most common disease symptoms. On the other hand, herniated nucleus pulposus (HNP) is a common condition that triggers radiculopathy or myelopathy. If radiculopathy affecting the foot occurs concurrently with back pain, the patient is very likely to have lumbar disc herniation. Medical treatment, bed rest and physical therapy are primarily recommended to patients with radicular pain. This study aimed to describe the factors associated with spontaneous disc regression.

Materials and Methods: Patients who were admitted to the outpatient clinic with lower back and leg pain were closely followed-up. After magnetic resonance imaging (MRI) scans revealed lumbar (HNP), a conservative medical treatment was recommended. When the patients' radicular pain disappeared or neurological exams became normal, control MRI scans were done. Then, we retrospectively reviewed these patients.

Results: We detected a total of 12 patients with lumbar disc regression, including six males and six females, in the last 3 years of follow-up. The mean age of the patients was 41.83±6.83. LHNP was present at the L4-5 space in five patients and at the L5-S1 space in seven patients. Eight (62.5%) of the patients had sequestrated disc herniation, while four had subligamentous disc herniation. Four of the sequestrated discs were up-migrated, and four of them were down-migrated. The mean time to pain disappearance of the patients was 2.33±1.23 months.

Conclusion: A conservative treatment and bedrest are primarily recommended to patients with lumbar disc herniation and pain complaints. Time should be given for the body to regress the lumbar disc herniation with an inflammatory response. Surgery is inevitable in cases of unbearable pain and emergency conditions.

Keywords: Lumbar disc herniation, radiculopathy, spontaneous regression

INTRODUCTION

Lumbar disc herniation occurs due to posterior longitudinal ligament (PLL) rupture, and the symptoms of this condition begin with low back pain[1]. It can cause radiculopathy or myelopathy as a result of the nerve root inflammation, with a compression effect due to the disc material[2,3].

Lumbar disc herniation affects approximately 9% of the world's population[4,5], and it has been observed to increase is with ageing. No specific causes can be found in 85% of lower back pain cases[6,7]. Of the patients with lumbar disc hernias, 30-40% are asymptomatic based on imaging[8].

Lumbar herniated nucleus pulposus (LHNP) is most frequently observed at the L5-S1 level (45-50%), followed by the L4-5 level (40-45%) and the L3-4 level (3-10%), respectively[1].

The Lasegue straight leg raising test is positive (+) in 83% of cases, and this test is sensitive, but not specific[1].

Of all the patients with lumbar disc herniation, only 1-2% consult surgeons. Cauda syndrome occurs in approximately 0.0004% of all patients with lower back pain[1].

MATERIALS AND METHODS

Patients who were admitted to the outpatient clinic with lower back and leg pain were followed-up, and neurological exams were conducted. Patients who needed an emergency surgery were excluded. Medical treatment, painkillers, muscle relaxants, short-term steroids, bed rest and physical therapy were recommended to all the patients. Due to the possible complications of surgery, patients who did not agree to the surgery were advised to undergo a close clinical follow-up. We retrospectively reviewed these patients between March 2017 and March 2019. A total of 20,000 patients were admitted to all the neurosurgery outpatient clinics in the last 3 years, and the mean number of patients who underwent lumbar disc surgery in the last 3 years was 1,200. However, we detected regression only in 12 patients. We discussed the probable mechanisms and predictive factors of lumbar disc resorption. This article received ethical approval from Haseki Research and Training Hospital Ethics Committee (139-17/6/2019), and informed consent was obtained from all the patients.

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Statistical Analysis

Statistical analysis was performed using SPSS v20.0 (SPSS Inc.). Descriptive data were expressed in terms of frequency, rate, arithmetic mean and standard deviation. Data were analysed using the Student's t-test. A p value of <0.05 was considered statistically significant.

RESULTS

We detected a total of 12 patients with lumbar disc regression, six males and six females, in the last 3 years of follow-up. LHNP was present at the L4-5 space in five patients and at the L5-S1 space in seven patients. Six patients had pain in the right side, while six had pain in the left side (Table 1).

On physical examination, the Lasegue test was positive in all the patients, and six patients had a neurological deficit. The symptoms regressed after medical treatment. In addition, seven patients received physical therapy (Table 1).

Eight (62.5%) of the patients had sequestrated disc herniation, while four had subligamentous disc herniation. Four of the sequestrated discs were up-migrated, while four were down-migrated (Table 1) (Figure 1-12).

The mean age of the patients was 41.83±6.84 years. The mean time to pain disappearance of the patients was 2.33±1.23 months. The mean time until the control lumbar magnetic resonance imaging (MRI) was 7.16±6.49 months.

The independent t-test indicated no statistical significance between the sequestrated disc herniation cases in terms of age, gender, side, pain disappearance time and time until the new MRI.

There was no significant correlation between receiving medical or physical therapy and age, gender, pain disappearance time, disc space and undergoing a second MRI.

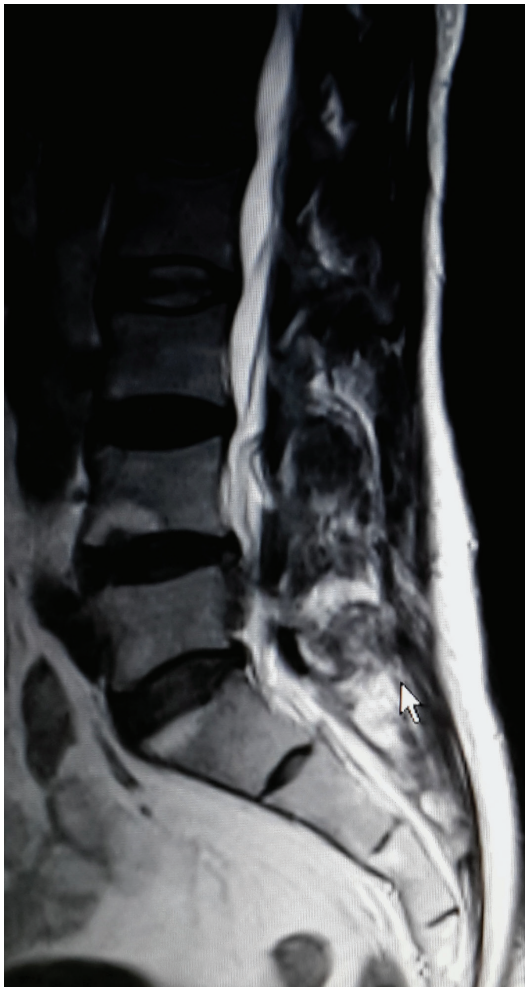

Figure 1. Sagittal T2-weighted MRI demonstrating a large sequestered disc fragment at the L4-5 level with a caudal migration (a 46-year-old female patient with lower back and leg pain)
MRI: Magnetic resonance imaging

Table 1. Demographic data

Age	Sex	Side	Level	SQ	Laseque	Neurologic deficit	MT	PT	MRI control time	Pain loss time
40	Male	R	L5-S1	-	+	-	+	+	3	3
23	Male	L	L5-S1	-	+	-	+	-	14	3
39	Male	R	L4-5	+	+	+	+	+	3	3
44	Female	L	L5-S1	+	+	-	+	-	3	2
50	male	R	L4-5	+	+	+	+	+	2	2
46	Female	L	L4-5	+	+	+	+	-	6	3
41	Male	R	L5-S1	+	+	-	+	+	3	1
43	Female	L	L5-S1	-	+	+	+	+	12	5
40	Female	R	L5-S1	-	+	+	+	-	6	1
48	Male	L	L4-5	+	+	+	+	+	24	1
46	Female	L	L4-5	+	+	-	+	+	4	1
42	Female	R	L5-S1	+	+	-	+	-	6	3

R: Right side, L: Left side, SQ: Sequestration, MT: Medical therapy, PT: Physical therapy, L5-S1: Lumbar level (L), sacral (S)

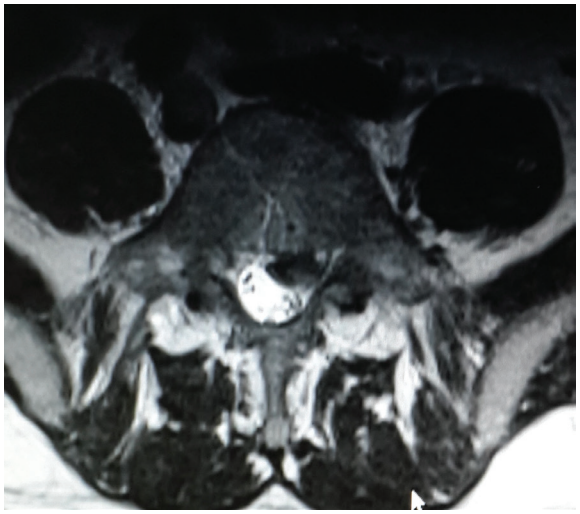

Figure 2. Axial T2-weighted MRI demonstrating a large sequestered left-sided paracentral disc fragment at the L4-5 level (pain relievers, muscle relaxants and bed rest were recommended to the patient
MRI: Magnetic resonance imaging

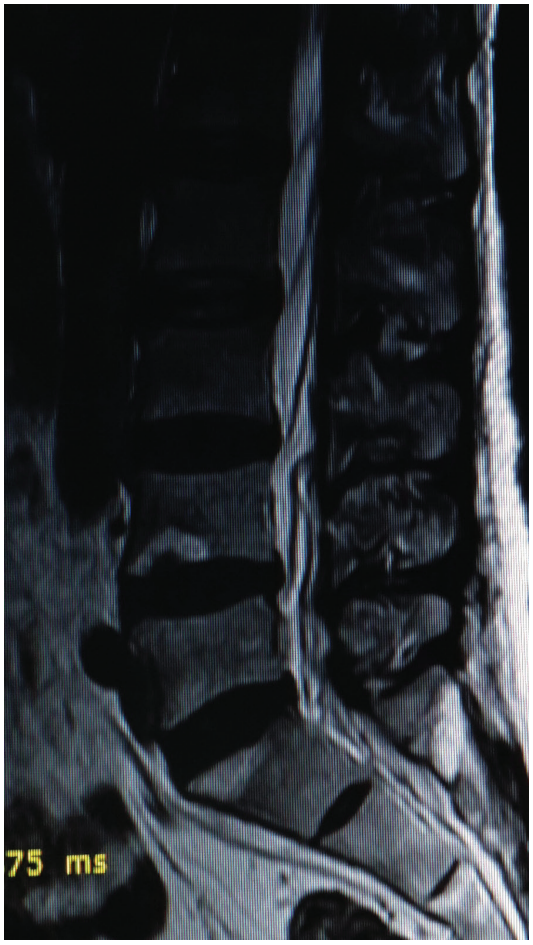

Figure 3. Sagittal T2-weighted second round MRI showed almost complete regression of the herniated nucleus pulposus at the L4-5 level (her complaints were resolved 12 weeks later)
MRI: Magnetic resonance imaging

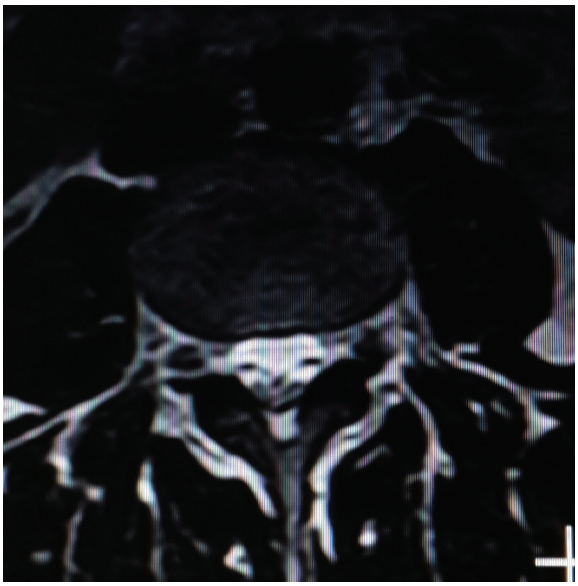

Figure 4. Axial T2-weighted second round MRI showed almost complete regression of the herniated nucleus pulposus at the L4-5 level without nerve root compression
MRI: Magnetic resonance imaging

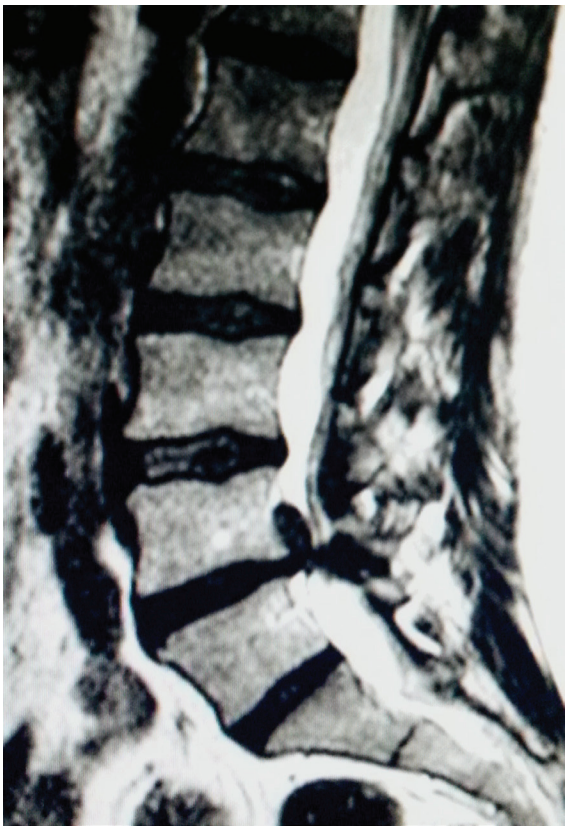

Figure 5. Sagittal T2-weighted MRI showed cranial migration of the herniated nucleus pulposus at the L4-5 level (a 48-year-old male patient with complaints of lower back pain and left-sided sciatalgia)
MRI: Magnetic resonance imaging

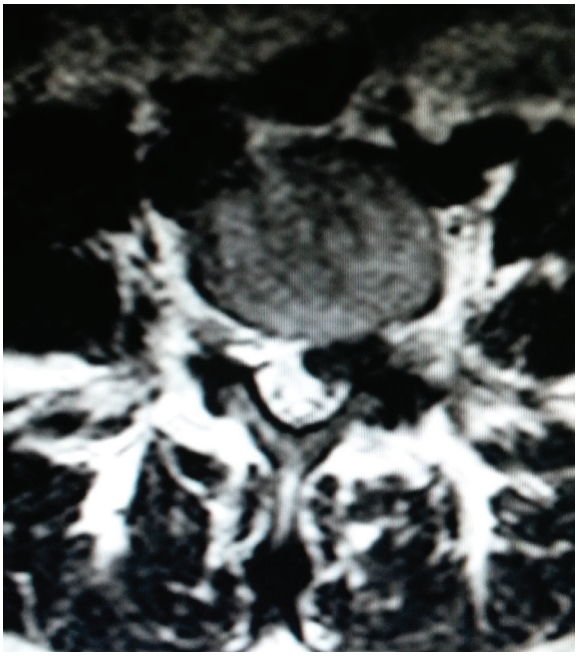

Figure 6. Axial T2-weighted MRI showed left-sided posterolateral extruded disc fragment at the L4-5 level (a 48-year-old male with axial sign; physical therapy was recommended after medical treatment)
MRI: Magnetic resonance imaging

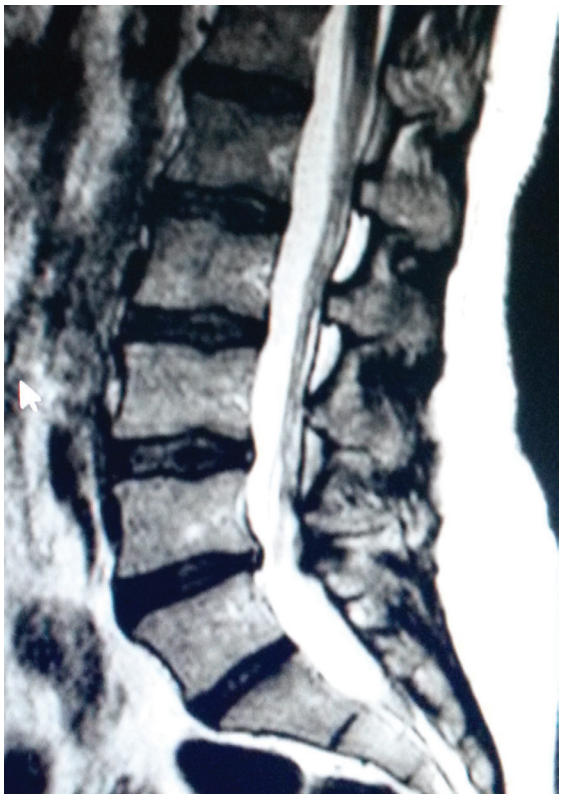

Figure 7. Control sagittal T2-weighted MRI showed almost complete regression of the herniated nucleus pulposus at the L4-5 level (his pain disappeared after a month; he came for control 24 months later)
MRI: Magnetic resonance imaging

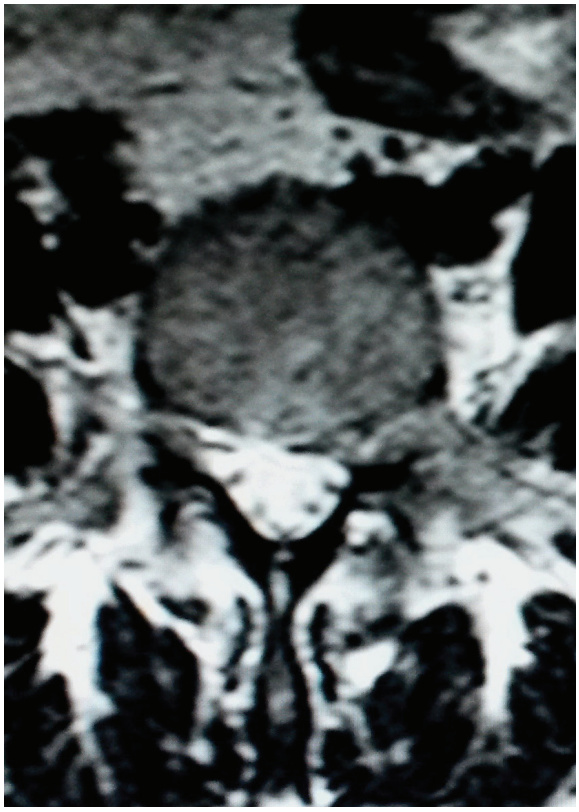

Figure 8. Control axial T2-Weighted MRI showed almost complete regression of the herniated nucleus pulposus at the L4-5 level
MRI: Magnetic resonance imaging

DISCUSSION

Over 90% of lumbar disc patients who develop acute radiculopathy can recover without the need for any surgical intervention. The painful phase can be made more tolerable with adequate pain relievers, muscle relaxants, short-term steroids and bed rest during the recovery period[1,6,9].

Partial or complete regression of lumbar disc herniation has been reported in the literature. The most frequently affected space is the L4-5 space[10].

The regression is accelerated young patients, and the recovery rate is the fastest between the ages of 41 and 50[10].

Protruded and sequestered discs show rapid regressions. Large and sequestered discs tend to regress more easily than smaller and protruded discs, if they are laterally located with a craniocaudal migration[2,6,10-14].

The mechanism of spontaneous disc herniation has many uncertain factors. These factors include the age of the patient, dehydration of the nucleus pulposus, resorption of a hematoma, revascularisation, HNP, PLL, cartilage and annulus fibrosus[2,4,6,11].

There are several mechanisms of spontaneous disc herniation. The disc material is reduced with dehydration and shrinkage as observed by MRI[15,16]. The PLL retracts the herniated disc back[4]. The enzymatic effect, inflammation, neovascularisation and phagocytosis stand out in preclinical and clinical evidence[12-14].

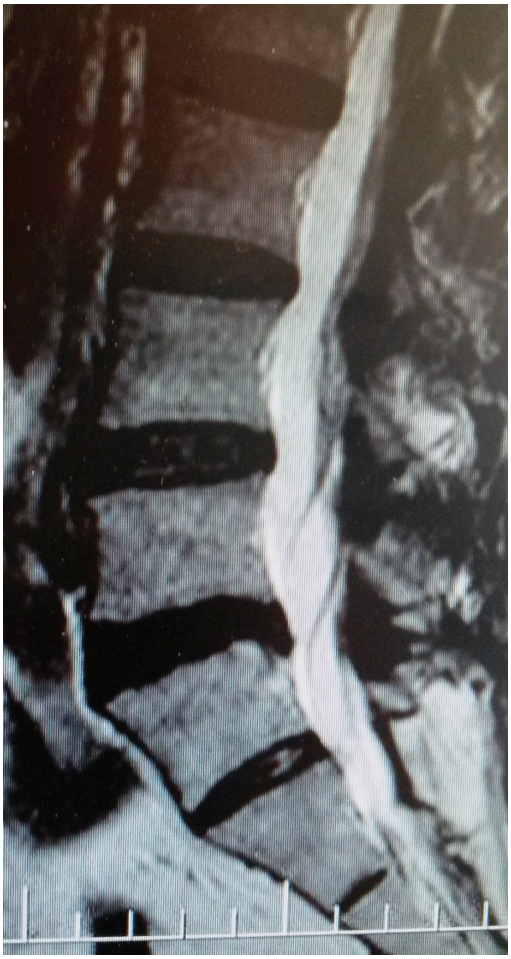

Figure 9. Sagittal T2-weighted MRI showed signs of a caudal migrated disc fragment at the L5-S1 level (a 41-year-old male with right leg pain)
MRI: Magnetic resonance imaging

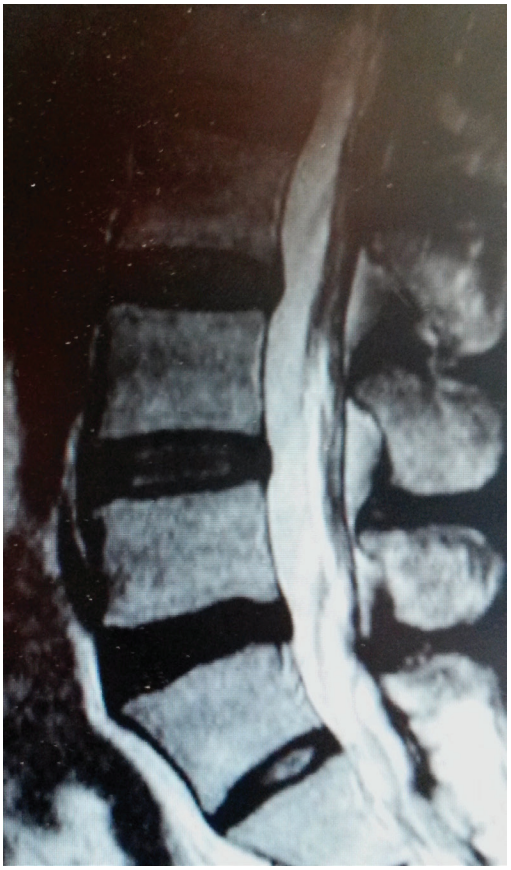

Figure 11. Sagittal T2-weighted MRI showed signs of complete regression of the herniated nucleus pulposus (in the third month, his neurological examination was normal, his muscle strength was full in the outpatient control visit in our neurosurgery department and the disc was observed to have regressed on the control MRI in the third month control visit)
MRI: Magnetic resonance imaging

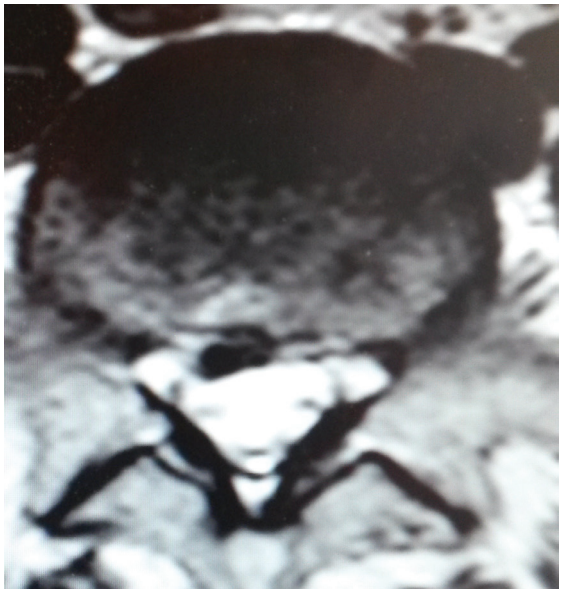

Figure 10. Axial T2-weighted MRI showed signs of right paracentral side disc fragment at the L5-S1 level (a 41-year old)
MRI: Magnetic resonance imaging

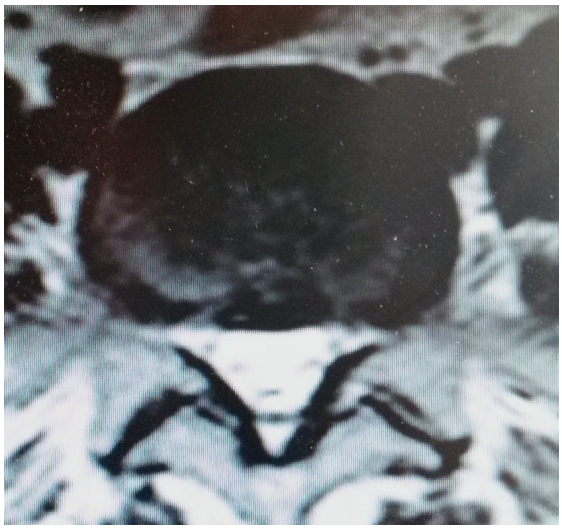

Figure 12. Axial T2-weighted MRI showed signs of complete regression of the herniated nucleus pulposus (the patient's third month control axial sign)
MRI: Magnetic resonance imaging

The intervertebral disc region is the largest avascular organ and an immune-privileged site of the body. Fas ligand belongs to the apoptosis group of the tumour necrosis factor (TNF) family and is affected by cytotoxic T cells and natural killer cells[15-17]. Macrophages are the key players. They induce phagocytosis by releasing enzymes from their lysosomes[18,19]. The exact role of monocytes in the intervertebral disc has not yet been elucidated. Monocyte chemoattractant protein-1 (MCP-1) allows macrophages to infiltrate the disc[4,20,21]. Immune mediators in the intervertebral disc are interleukin (IL)-6, 8, 4 and 12; NO; prostaglandin E2; matrix metalloproteinase-2,3,7 and 9; interferon-α and γ and MCP-1[19,20,22-25]. They appear with matrix remodelling and angiogenesis in the neovascularisation and inflammation cascade[4]. CD 68 (+), macrophages and B lymphocytes are involved in the disc herniation. TNF-α and IL-1 β are released on the first day, while MCP-1 is released on the third day[4]. Disc regression is caused by pulsation of the cerebrospinal fluid to the herniated parts[11,26,27].

PLL rupture is more important than the disc size. The subligamentous, transligamentous and sequestrated disc regression rates can be 17%, 48% and 82%, respectively[4,26,28,29]. Three percent of all discs are sequestrated, and sequestrated discs are more likely to be regressed compared to other discs. These discs are up-migrated by 65%. Of the cases with regressed lumbar discs, 37.7% are sequestrated. Sequestrated discs are most frequently seen at the L4-5 space (58.3%), followed by the L5-S1 (25%) and the L3-4 spaces (12.5%)[10,28-34].

As for our cases, L4-5 HNP was observed in seven lumbar discs, while L5-S1 HNP was observed in five lumbar discs.

The L4-5 space was affected in five of the sequestrated disc patients, while the L5-S1 space was affected in four of them. In addition, the L4-5 space was affected more in our patient group. Discs were superiorly migrated in four cases and caudally migrated in four cases (50%).

A sequestrated disc was separated from the main disc material in the lumbar region. An intraspinal mass can be observed as a cyst, abscess or hematoma, and should also be considered in the differential diagnosis[10].

Sequestrated disc dehydration and shrinkage are seen radiologically at a faster improvement rate. Like a free fragment, a sequestrated disc rapidly increases inflammation and activates vascularity and the immune system[4,10].

In the literature, pain occurring among cases with regressed lumbar disc herniation has been reported to disappear after 1.33±1.34 months, and radiological recovery was achieved in 9.27±13.32 months. In our series, the mean time to pain disappearance of the patients was 2.33±1.23 months, while the mean time until the control lumbar MRI was 7.16±6.49 months.

Study Limitations

On the other hand, this study has limitations such as the small sample size, short follow-up period and retrospectively design. In addition, none of the patients could be randomised to a treatment, and there were no control subjects.

Surgical intervention is the preferred method of treatment in patients with larger herniated discs imaged on MRI and associated with radiculopathy, myelopathy or both. Emergency surgery is planned in cases of persistent pain, conditions that negatively affect social life, foot drop, urinary and stool incontinence or cauda conditions.

CONCLUSION

Bed rest and conservative treatment are primarily recommended to patients with lumbar disc herniation. Time should be given for the body to regress the lumbar disc herniation with an inflammatory response. Surgery is inevitable in cases of unbearable pain and emergency conditions.

Ethics

Ethics Committee Approval: Ethical approval has taken for the retrospective study from Haseki Research and Training Hospital Ethics Committee (139-17/6/2019).

Informed Consent: Informed consent was obtained from the patients.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):148-53
DOI: 10.4274/jtss.galenos.2020.154

HERNIECTOMY WITHOUT DISCECTOMY IN EXTRUDED LUMBAR DISC HERNIATION; SHOULD IT BE THE GOLD STANDARD?

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ABSTRACT

Objective: Microdiscectomy in lumbar disc herniation (LDH) is the gold standard treatment, but conventional discectomy is still the most widely used across the world. This study aimed to evaluate the treatment outcomes of herniectomy compared to conventional discectomy for an extruded lumbar disc.

Materials and Methods: A total of 788 patients were included in the study. Of this population, 548 were males and 240 were females. This was a retrospective study that was conducted from 2009 to 2018. Conventional discectomy and herniectomy for the treatment of extruded LDH were compared. Minimum follow-up period was 2 years.

Results: Most of the patients were pain-free in both procedures (herniectomy and conventional discectomy). The surgical outcome of herniectomy did not significantly differ by age, gender, educational background, preoperative VAS for back, preoperative VAS for radicular pain, Oswestry disability index score, return to the previous job and level of herniation in comparison to conventional microdiscectomy.

Conclusion: Herniectomy in extruded lumbar disc prolapse is similar compared to conventional discectomy in terms of pain removal and recurrent disc prolapse. Furthermore, removal of only the herniated disc preserves the disc height, which has many advantages including functional mobility and no alteration in the diameter of the intervertebral foramen. Also, a decrease in the incidence of adjacent level disc prolapse may be due to low stress in relation to conventional discectomy. It is still not clear whether the herniectomy in extruded lumbar disc surgery should be a gold standard or not.

Keywords: Herniectomy, disc herniarion, extruded lumbar, discectomy

INTRODUCTION

Lumbar disc herniation (LDH), which primarily consists of back pain and radiculopathy, is a common condition occurring in most elderly peoples in a lifetime. In the general population, the incidence of LDH is reported as 1% to 2% and 4.86 per 1000 young population[1-3]. LDH can cause severe symptoms, such as intermittent low back pain, sciatica in patients, etc. In such cases, the treatment goal is to reduce pain and inflammation[4]. The implementation of microsurgical techniques has marked a significant development in the treatment of lumbar discs herniation. Microsurgery is considered today as a gold standard procedure. LDH surgery can be done using a camera, known as an endoscope, as well as micro-incisions of the skin. Furthermore, advanced technological devices such as special surgical microscopes and microsurgical instruments, which in current neurosurgical practice are considered the gold standard, can be used to imagine the three-dimensional and distorted images of herniated discs and tissues[5]. Postoperative complications such as neural tissue damage can be decreased with the surgical procedure, and disc material can be removed safely. There is evidence that although re-herniations occur in approximately 10% of patients, clinical deterioration is mostly attributable to chronic lower back pain in up to 75% of patients after 10 years[6,7]. A less invasive method was demonstrated earlier, the so-called limited discectomy, which involved removing only extruded fragments and any loose pieces in the disc space using only pituitary forceps to remove the free fragments. Subsequently, there was a growing interest in conservative surgery leading to minimal clearance of intradiscal tissue, which is microscopic herniectomy/sequestrectomy/free fragmentectomy. In this subpopulation of disc herniations, it requires only the simple excision of the disc fragment. The herniated fragment was established as the offending agent; however, it has always been considered necessary to extract either a fragment or the entire disc. The incidence of herniectomy in the treatment of LDH is gradually increasing. The term "herniectomy" is defined as the elimination of the herniated disc fragment only, while the

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conventional discectomy is the elimination of the herniated disc and degenerative nucleus from the intervertebral disc space. In this study, we conducted a comparative analysis between conventional discectomy and herniectomy in extruded LDH. Our main goal of the study is to determine whether herniectomy should be the first choice of surgery in an extruded lumbar disc in comparison to conventional discectomy.

MATERIALS AND METHODS

This is a retrospective study conducted from 2009 to 2018 in three private hospitals, Dhaka, Bangladesh. IRB/Ethical Committee approval was not taken. For this study, informed written patient consent as well as written consent for publication was taken from 788 patients.

Patient Data, Study Design and Study Criteria

This comparative study between conventional discectomy and herniectomy was performed in patients with extruded LDH. Patients who suffer from extruded LDH, of both genders and who meet the inclusion criteria were included in the study. From 2009 to 2018, among 1.200 patient's retrospective data chart, a total of 788 patients met the inclusion criteria and they were randomly and equally assigned to both groups (conventional discectomy and herniectomy). Of this population, 548 were males and 240 were females. A single surgeon (author) operated in all the patients. All the patients consented to the surgical procedures, and written informed consent was obtained from all patients for publication of their cases and accompanying images.

Patients having back pain with sciatica who were not improved by conservative treatment for 8 weeks were included in the study. Patients having more than one level herniation, spinal canal stenosis, instability and incomplete follow up were excluded from the study. From the patients' hospital records, age, gender, occupation, recurrence time (days), the level herniations and the type of surgery were examined by the same surgeon. Patient data were obtained from chart reviews and patient-based outcome questionnaires or follow-ups. Each patient was followed-up at 6 weeks, 6 months, 1 year and 2 years. At each follow-up, the patients completed questionnaires that reflected their functional state and pain severity. The patient's pain levels were assessed using the visual analogue scale (VAS) score. The functional state was assessed using the Oswestry disability index (ODI). Magnetic resonance imaging of the lumbosacral spine was evaluated at 6 weeks postoperatively where patients were nonresponsive to conservative treatment for persistent symptoms like back or leg pain, weakness and also considered for patients having recurrent symptoms at any time (Figures 1, 2, 3). The long-term surgical outcomes were evaluated.

In our study, we observed that among 788 patients, a total of 70% (551 patients) were heavy workers. There, we found that 58% (457 patients) were male-heavy workers and 12% (94 patients) were female-heavy workers (Table 1).

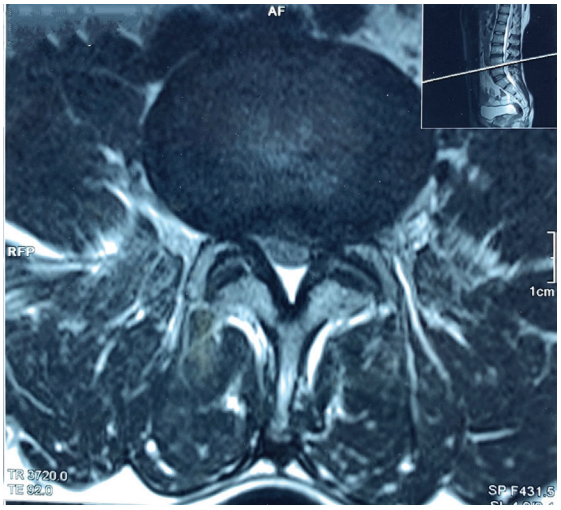

Figure 1. Axial T2-weighted MRI image of the Lumbar spine showing herniated disc on left L4/5 space
MRI: Magnetic resonance imaging

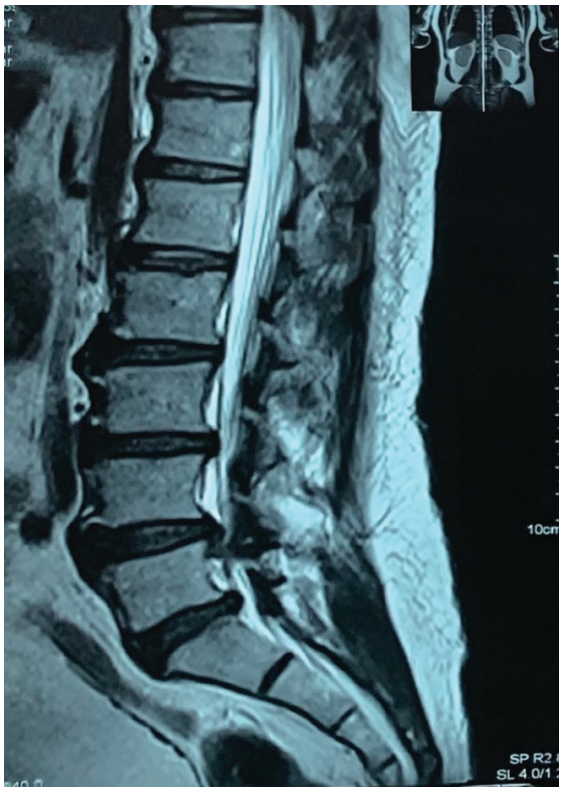

Figure 2. Sagittal T2-weighted MRI image of the lumbar spine showing downward herniated disc at L4/5 on the right side
MRI: Magnetic resonance imaging

Table 1. Job types of selected patients

Gender	Heavy workers	Educated*
Male	457 (58%)	91 (11%)
Female	94 (12%)	146 (19%)
Total	70%	30%

*Educated-selected patients who can write their names

Statistical Analysis

The comparison between pre and postoperative clinical outcomes in pain and functional state was performed using repeated-measures analysis. Using descriptive statistical methods, the mean and standard deviation was assessed by the SPSS version 25 statistical package. All analyses were performed here using the SPSS tool. P values <0.05 were considered significant.

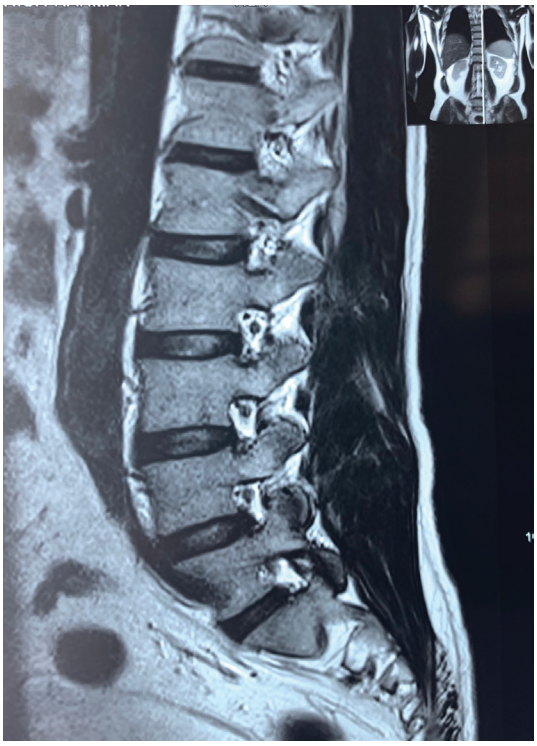

Figure 3. Sagittal T2-weighted MRI image of the Lumbar spine showing left intervertebral foramen in a post herniectomy patient
MRI: Magnetic resonance image

RESULTS

The outcome of herniectomy did not significantly differ by age, gender, level of re-herniation in comparison to conventional microdiscectomy. In our study, among the 788 patients, 394 patients underwent herniectomy and 394 patients conventional discectomy. The mean ages were 47.32±53.90 years in the herniectomy group and 52.67±21.38 years in the conventional discectomy group. Recurrence was observed in 24 (6%) patients in the herniectomy group and 32 (8%) patients in the discectomy group. Although the discectomy group had a higher recurrence rate, this was not a significantly different (p=0.530). Recurrence levels ranged in the order of common cases and the average recurrent intervals were 20 weeks in herniectomy and 22 weeks in conventional discectomy group (Table 2). In comparison to the conventional discectomy group, the herniectomy group had low recurrences, probably due to decreased mechanical load to the lumbar spine (male-heavy workers were more in the conventional discectomy group).

The VAS score was obtained before and two weeks after surgery. Some patients score was unobtainable in both the herniectomy and conventional discectomy groups (Table 3).

Among all the patients in our study, the level of disc herniations are shown in Table 4. Also, the preoperative and postoperative diameter of intervertebral disc foramen in both groups are shown in Table 5. The amount of reduced disc height and foramen diameter in both group of patients are shown in Table 5.

The mean preoperative ODI score was 63.28% in herniectomy group and 62.56% in the conventional discectomy group. In the herniectomy group, the mean postoperative ODI score was reduced to 35.81%, 24.73%, 17.37% and 16.02% at postoperative 6 weeks, 6 months, 1 year and 2 years, respectively (p<0.001). And in the conventional discectomy group, the mean

Table 2. Characteristics of patients according to herniectomy and conventional discectomy

Characteristics	Herniectomy (n=394)	Conventional discectomy (n=394)	p value
Gender (male, female)	272,122	276,118	0.069
Mean age	47.32±53.90	52.67±21.38	0.082
Recurrence	24 (6%)	32 (8%)	0.530
Mean length of time of recurrence	20 weeks	22 weeks	0.089
Adjacent level disc prolapse	0	2	0.061

n: Number

Table 3. Visual analogue scale comparison

Groups	Preoperative VAS	Postoperative VAS	p value
Microdiscectomy (n=394)	6.9	1.8	0.081
Herniectomy (n=394)	7.2	1.3	0.063

VAS: Visual analogue scale, n: Number

postoperative ODI score was reduced to 38.25%, 28.62%, 19.82% and 18.59% at postoperative 6 weeks, 6 months, 1 year and 2 years, respectively ($p<0.001$) (Figure 4). The total reduction of ODI score after 2 years was 47.26% in herniectomy group and 43.97% in the conventional discectomy group.

Most of the patients were pain-free after surgery. We found that in the herniectomy group, more (39.35%) patients had a good outcome and 33.02% patients had an excellent outcome. In the conventional discectomy group, 38.10% patients had a good outcome and 28.43% patients had an excellent outcome. Also, only a few patients' surgical outcome was poor in both groups (Figure 5). The surgical outcome was comparatively better in the herniectomy than the discectomy group.

Other than recurrences of disc prolapse, there were some complications observed in patients of both groups. The worsening of neurological deficit, incidental durotomy, hematoma, discitis and deep vein thrombosis were the side effects in patients (Table 6).

The study showed that patients treated with herniectomy had an equal length of hospital stay compared with those treated with microdiscectomy. The mean time of returning to normal life was 17.19 and 22.04 days in the herniectomy and microdiscectomy

Table 4. Level of the disc herniations

Level of disc herniation	Herniectomy (n=394)	Conventional discectomy (n=394)
L1/L2	2	2
L2/L3	5	6
L3/L4	14	11
L4/L5	190	195
L5/S1	183	180

n: Number

Table 5. Diameter of the intervertebral disc foramen in magnetic resonance imaging

Level of disc herniation	Intervertebral foramen diameter (mm)			
	Herniectomy		Conventional discectomy	
	Preop	Postop	Preop	Postop
L1/L2	17.27 mm	17.27 mm	17.22 mm	16.43 mm
L2/L3	18.19 mm	18.19 mm	18.18 mm	17.33 mm
L3/L4	17.45 mm	17.45 mm	17.41 mm	16.30 mm
L4/L5	16.71 mm	16.71 mm	16.79 mm	15.58 mm
L5/S1	15.23 mm	15.23 mm	15.45 mm	13.94 mm

Preop: Preoperative, Postop: Postoperative

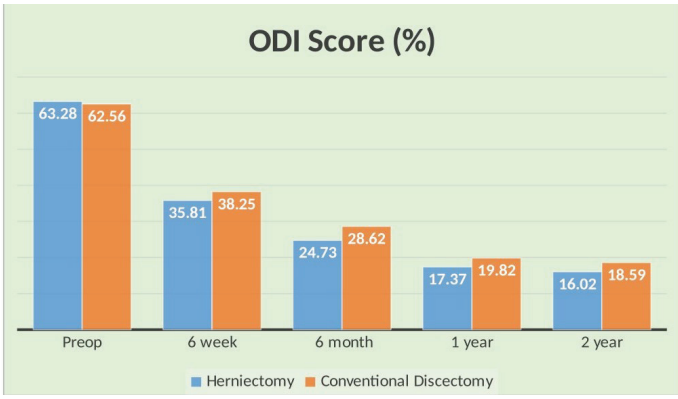

Figure 4. Oswestry disability index scores obtained in the preop and postop periods in both groups

ODI: Oswestry disability index, Preop: Preoperative, Postop: Postoperative

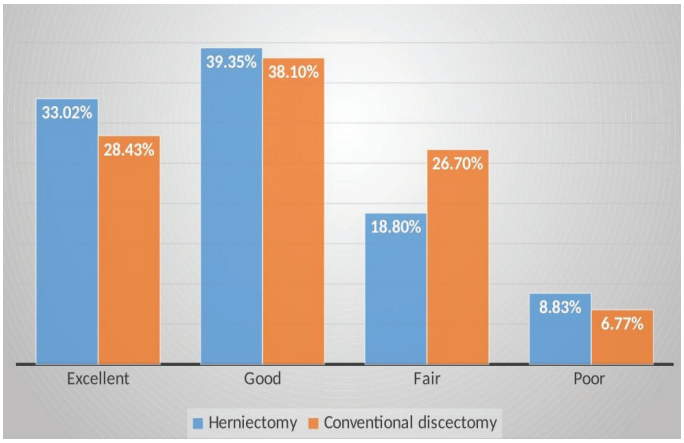

Figure 5. Level of outcome after surgery in both groups

groups, respectively. The patients of both groups showed an almost similar response, but patients with herniectomy recovered earlier than those in the microdiscectomy group (Table 7).

DISCUSSION

Our study found that in comparison to conventional discectomy, the herniectomy group had better and more effective outcomes. Here, the herniectomy group had lower recurrent cases and lower complication rates as compared to conventional microdiscectomy in LDH. The disc heights were preserved by removing the herniated discs. It was very beneficial as there was no change in functional mobility and intervertebral foramen diameter in herniectomy.

In 1978, Williams[8] recommended a conservative surgical approach to the virgin herniated lumbar disc by making only blunt perforation in the fibrous wiring. Conventionally, microdiscectomy-related neural decompression was accomplished by excising the herniated disc material, resection of any possible intervertebral tissue and endplate curettage[9]. This conventional microdiscectomy technique was based on the assumption that by increasing the amount of resected disc tissue, the probability of re-herniation would be reduced[10]. Complete removal of all disc material is impossible[11,12]. Repeated surgeries could therefore not be stopped when these methods were used[13,14].

Herniectomy results were pleasingly compared with those achieved after a microdiscectomy in this study. Although no statistical differences were observed, the rate of recurrence was 6% in the herniectomy group and 8% in the microdiscectomy group. In our study, most (70%) patients were heavy workers. This type of occupation is one important reason for these cases. Recurrences were lower in herniectomy probably because of less mechanical load to the lumbar spine, as there were more heavy workers in the conventional discectomy group. Upon excision of only the herniated fragments, a study reported a recurrence rate of 21% (7 of 33 patients)[15]. A study reported that within the first 9 months, 92% of re-herniations occurred, and another study indicated that most recurrences occurred within the first 6 months[15,16]. Despite the need for a longer follow-up study, we believe our findings provide some proof that re-herniations after herniectomy are not significantly increased.

The postoperative VAS of the conventional discectomy group declined in a similar manner to that in the herniectomy group. This may be because the postoperative VAS was checked one week after the surgery. However, we expect that the long-term VAS and clinical outcomes in the herniectomy group will show a better result.

Two years after surgery, postoperative mean ODI was decreased to 16.02% in the herniectomy group and 18.59% in the conventional discectomy group. In comparison to the preoperative scores, more reduction was observed in herniectomy group. A reduction in the ODI score of more than 20% was considered clinically relevant[17,18].

A systematic review study suggests that herniectomy may result in shorter operating time and faster return to work[19]. Our studied patients of the herniectomy group also returned to normal life faster than the discectomy group. The additional advantage of herniectomy is that abdominal or retroperitoneal damage is prevented due to non-entry into the disc space.

Study Limitations

This retrospective study has limitations. First, better procedures are required for exploring outcome prediction and identifying accurate predictors of surgical outcome in long-term follow-up after LDH surgery. In addition, further studies are needed to improve the prediction accuracy and identify reliable predictors of surgical outcomes in patients with a variety of LDH.

Table 6. Complications

Factors	Herniectomy n (%)	Conventional discectomy n (%)
Worsening of neurological deficit	7 (1.8%)	8 (2%)
Incidental durotomy	15 (3.8%)	16 (4%)
Hematoma	3 (0.7%)	3 (0.7%)
Recurrent disc prolapse	24 (6%)	32 (8%)
Discitis	2 (0.5%)	2 (0.5%)
Deep vein thrombosis	1 (0.25%)	1 (0.25%)

Table 7. Comparison of mean operating time, hospital stay and returning to daily life between both groups

Groups	Operating time (Minutes; mean)	Hospital-stay (Day; mean)	Returning to daily life (Day; mean)
Herniectomy (n=394)	38.19	2.4	17.19
Microdiscectomy (n=394)	42.76	2.4	22.04

n: Number

CONCLUSION

The herniectomy is successful with shorter operating time, lower perioperative complication rates and lower re-herniation rate as compared to conventional microdiscectomy in LDH. Compared with conventional discectomy, performing herniectomy in the extruded lumbar disc prolapse is similar to pain removal and recurrent disc prolapse. However, the removal of only the herniated disc preserves the height of the disc, which has many advantages including functional mobility and no alteration of intervertebral foramen diameter, as well as a decrease in the incidence of adjacent disc prolapse due to low stress in comparison to conventional discectomy, which may need a much longer follow-up for exact evaluation. Herniectomy did not seem to entail a higher rate of recurrences compared with a conventional discectomy in this series. It is still not certain whether herniectomy in extruded lumbar disc surgery should be a gold standard treatment or not.

Acknowledgments

The author would like to thank all the members who were part of this research for their cooperation and help in preparing all the information.

Ethics

Ethics Committee Approval: This is a retrospective study conducted from 2009 to 2018 in three private hospitals, Dhaka, Bangladesh. IRB/Ethical Committee approval was not taken.

Informed Consent: For this study, informed written patient consent as well as written consent for publication was taken from 788 patients.

Peer-review: Externally peer-reviewed.

Financial Disclosure: No specific funding was provided for this research paper.

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):154-9
DOI: 10.4274/jtss.galenos.2020.195

COMPARISON OF THE EFFECTIVENESS OF TRANSFORAMINAL EPIDURAL STEROID INJECTION ALONE WITH THAT OF COMBINED TRANSFORAMINAL AND CAUDAL EPIDURAL STEROID INJECTION IN MULTI-LEVEL LUMBAR DISC DISEASE

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ABSTRACT

Objective: This study compared the effectiveness of transforaminal epidural steroid injection (TFESI) alone with that of combined transforaminal and caudal epidural steroid injection (CESI) in multi-level lumbar disc disease, which does not require surgery and does not respond to conservative treatment.

Materials and Methods: A total of 99 patients, who were administered TFESI alone or in combination with CESI for radicular pain between November 2018 and August 2019, were analysed retrospectively.

Results: The visual analogue scale (VAS) and the Oswestry Disability index (ODI) scores of the patients were evaluated in the pre-injection and post-injection periods in the 3rd week, 3rd month and 6th month. Both the ODI and VAS scores were significantly lower in the early and late post-injection periods than in the pre-injection period in both groups. Combined TFESI and CESI for multi-level lumbar disc disease provided significant improvement in pain management and functional capacity compared with TFESI alone.

Conclusion: Combined transforaminal and CESIs should be considered in patients with multi-level lumbar disc disease, which is difficult to manage.

Keywords: Multi-level disc disease, lumbar, transforaminal, caudal, epidural steroid injection

INTRODUCTION

Intervertebral disc disease is the most common cause of lumbosacral radiculopathy. Approximately 10-15% lumbar disc diseases require surgical treatment[1,2]. Radiculopathy is treated by conservative treatment options, such as bed rest, medical treatment and physical therapy[3-5]. Multi-level lumbar disc disease is a common clinical entity and can occur at any age; however it is common in the elderly[6]. The treatment of multi-level lumbar disc disease is controversial. Most agree that conservative treatment should be the first option, unless surgical indications are absolute[7].

Epidural steroid injection (ESI) is a minimally invasive treatment for patients who do not benefit from conservative treatments and do not require surgery[8]. ESI can be performed through the pre- or post-ganglionic transforaminal, interlaminar or caudal route. The choice of method depends on the aetiology and location of pain[9-13].

This study aims to compare the effectiveness of transforaminal epidural steroid injection (TFESI) alone with that of combined transforaminal and caudal epidural steroid injection (CESI) in multi-level lumbar disc disease that does not require surgery or respond to conservative treatment.

MATERIALS AND METHODS

Since it is a retrospective data analysis, ethics committee approval is not required. Informed consent was obtained from the patients.

Patient Inclusion and Exclusion Criteria

The medical records of patients, referred to our clinic between November 2018 and August 2019, with unilateral or bilateral radicular leg pain or multi-level lumbar disc disease (bulging and/or protrusion) detected by magnetic resonance imaging (MRI) (Figure 1A-C), with no neurological deficits, for whom symptoms were not relieved by conservative treatment, who were not candidates for surgery, and did not undergo TFESI alone

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or combined TFESI and CESI, were analysed retrospectively. Patients who had single-level lumbar disc herniation; lumbar spinal stenosis or spondylolisthesis; previous lumbar surgery or injection; psychiatric, oncologic and infective disease and spinal trauma history; extruded or sequestered disc herniation visible on the lumbar MRI scan; radicular leg pain for no longer than three months; been getting conservative treatment currently; undergone TFESI or combined TFESI and CESI but had restricted relief with medical or physical therapy; and not been to follow-up examinations were excluded from this study.

Intervention (TFESI and CESI) Procedure

TFESI and CESI were performed in the operating room by the same surgical team on the prone patient. All patients had intravenous access. Blood pressure, electrocardiogram, pulse and oxygen saturation were monitored. If necessary, sedation was performed with midazolam and fentanyl.

TFESI Procedure: The vertebral level was determined in the prone position with anterior-posterior (A-P) positioning of the C-arm fluoroscope following skin antisepsis and draping. The C-arm fluoroscope was placed in an oblique position at 15°, and an appropriate view was provided for the intervertebral foramen. Local anaesthetic (1 mg, 1% lidocaine) was applied to the skin and subcutaneous tissue. TFESI was performed using the preganglionic approach described by Lee et al.[14,15] After the skin and subcutaneous tissue were passed, a 21-gauge 90 mm spinal needle (Egemen International, İzmir, Turkey) was directed toward the intervertebral foramen under the guidance of C-arm fluoroscopy. After correct positioning was achieved, the C-arm fluoroscope was placed in the A-P position and 1 mL of contrast solution (Omnipaque 300; iohexol, 300 mg iodine/mL, Amsterdam Health, Princeton, NJ, USA) was injected to control epidural flow (Figure 1D). After the location of the spinal needle was confirmed, aspiration was performed to check for blood or cerebrospinal fluid. Subsequently, 40 mg methylprednisolone acetate (Depo-Medrol, Pfizer İlaç Ltd. Şti., Lüleburgaz, Kırklareli, Turkey) and 10 mg bupivacaine hydrochloride (Marcaine 0.5%, Astra Zeneca, İstanbul, Turkey) were slowly injected for an average of 2 min. The process was repeated for each level.

CESI Procedure: In the prone position, local anaesthetic (1 mg, 1% lidocaine) was applied to the skin and subcutaneous tissue on the upper part of the natal cleft, following skin antisepsis and draping. The 21-gauge, 90 mm spinal needle (Egemen International, İzmir, Turkey) was advanced along the sacrococcygeal ligament under the control of a laterally positioned C-arm fluoroscope and then advanced 1-2 cm into the caudal canal, passing through the sacral hiatus palpated in the middle of both sacral horns (Figure 1E). The level of the spinal needle did not exceed the S2 level in any case. After the aspiration test resulted negative, the position of the spinal needle was confirmed by injecting contrast medium (Omnipaque 300; iohexol, 300 mg iodine/mL, Amsterdam Health, Princeton, NJ, USA). In addition to 40 mg methylprednisolone acetate (Depo-Medrol, Pfizer İlaç Ltd. Co., Lüleburgaz, Kırklareli, Turkey) and 10 mg bupivacaine hydrochloride (Marcaine 0.5%, Astra Zeneca, İstanbul, Turkey), 20 cc of 0.9% sodium chloride was slowly injected. Thereafter, the patients were kept under observation for 2-4 h and discharged. The patients were not given non-steroidal anti-inflammatory drugs except paracetamol.

Pre- and Post-intervention Assessment and Follow-up

The pain scores of the patients were evaluated using the visual analogue scale (VAS), where 0 and 10 indicate the absence of pain and severe pain, respectively. The restriction of the patients' routine activities was evaluated using the Oswestry Disability index (ODI). The VAS and ODI scores of the patients were recorded during the pre-injection period in the 3rd week, 3rd month and 6th month of outpatient clinic visits.

Statistical Analysis

Statistical analyses were performed using the SPSS software version 21 (SPSS, Chicago, IL, USA). The numerical variables were investigated using visual (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov or Shapiro-Wilk test) to determine normal distribution. Mean and standard deviation were used for normally distributed variables, and median and minimum-maximum were used for non-normally distributed variables. The chi-square test or Fisher's exact test were used to compare proportions in different groups. As age was normally distributed, Student's t-test was used to compare between groups. As follow-up time was non-normally

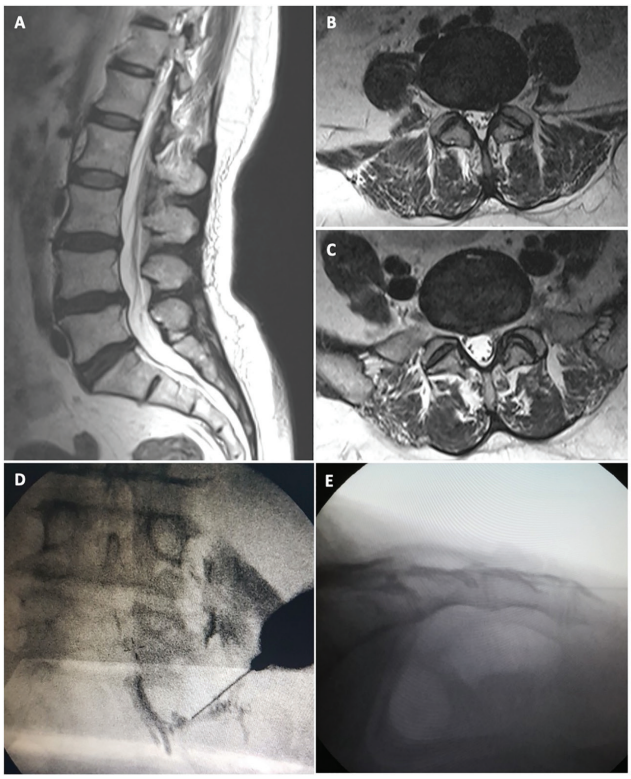

Figure 1. A-C) Pre-injection magnetic resonance imaging. Axial and sagittal sections show multi-level lumbar disc disease. **D)** Transforaminal epidural steroid injection. **E)** Caudal epidural steroid injection

distributed, the Mann-Whitney U test was used for comparison. Repeated measures ANOVA was used to compare VAS and ODI among patients according to the presence or absence of caudal injection. A p value less than 0.05 was considered statistically significant.

RESULTS

Of 99 patients included in the study, 48 were administered TFESI alone, whereas 51 were co-administered TFESI and CESI. The average age of the TFESI group was 47.0±11.2 years and that of the TFESI + CESI group was 45.3±9.2 years. The TFESI group comprised 19 (39.6%) men and 29 (60.4%) women, whereas the TFESI + CESI group comprised 20 (39.2%) mean and 31 (60.8%) women. In the TFESI group, 12 (25%) patients had disc hernias at L3-L4 and L4-L5 and 36 (75%) patients had disc hernias at L4-L5 and L5-S1. In the TFESI + CESI group, seven (13.7%) patients had disc herniation at L3-L4 and L4-L5 and 44 (86.3%) patients had disc hernias at L4-L5 and L5-S1. The median follow-up was determined for 18 months in the TFESI group and 17 months in the TFESI + CESI group. No significant difference was found between the groups in terms of demographics and clinical features (Table 1).

The VAS and ODI scores of the patients were evaluated in the pre- and post-injection periods in the 3rd week, 3rd month and 6th month. The mean VAS score of the patients was 8.29±1.03 in the pre-injection period, 3.51±1.57 in the 3rd week, 4.18±1.50 in the 3rd month, and 6.83±1.18 in the 6th month. Regression in the VAS score was statistically significant in the early, mid, and late periods (p<0.001). In the TFESI group, the mean VAS score was 8.44±0.80 in the pre-injection period, 4.69±1.11 in the 3rd week, 5.17±1.21 in the 3rd month, and 7.44±0.85 in the 6th month. In the TFESI + CESI group, the mean pre-injection VAS score was 8.16±1.21, 2.39±1.04 in the 3rd week, 3.25±1.11 in the 3rd month, and 6.25±1.16 in the 6th month. The VAS scores of the TFESI + CESI group were significantly lower than those of the TFESI group in the 3rd week, 3rd month and 6th month post-injection (p<0.001) (Table 2, Figure 2). The mean ODI score of the patients was 57.37±6.75 in the pre-injection period, 29.96±6.33 in the 3rd week, 31.78±6.43 in the 3rd month, and 53.70±7.23 in the 6th month. Regression in the ODI score was statistically significant in the early, mid, and late periods (p<0.001). In the TFESI group, the mean ODI score was 57.46±5.86 in the pre-injection period, 32.96±6.60 in the 3rd week, 34.46±6.64 in the 3rd month, and 56.38±6.00 in the 6th month. In the TFESI + CESI group, the mean ODI score was 57.29±7.55 in the pre-injection period, 27.14±4.57 in the 3rd week, 29.25±5.12 in the 3rd month, and 51.18±7.43 in the 6th month. The ODI scores of the TFESI + CESI group were significantly lower than those of the TFESI group in the 3rd week, 3rd month and 6th month post-injection (p<0.001) (Table 2, Figure 3).

Table 1. Demographics and clinical characteristics of the study population

	TFESI + CESI (n=51)	TFESI (n=48)	p
Age, years	45.3±9.2	47.0±11.2	>0.05
Gender, n (%)	20 males (39.2) 31 females (60.8)	19 males (39.6) 29 females (60.4)	>0.05
Level			>0.05
L3-L4 + L4-L5, n (%)	7 (13.7)	12 (25)	-
L4-L5 + L5-S1, n (%)	44 (86.3)	36 (75)	-
Follow up, median (min-max)	17 (7-31)	18 (7-32)	>0.05

TFESI: Transforaminal epidural steroid injection, CESI: Caudal epidural steroid injection, min: Minimum, max: Maximum, n: Number

Table 2. Comparison of the results of TFESI alone with combined TFESI and CESI

	Pre-injection	3th week	3th month	6th month	p
VAS					
Total	8.29±1.03	3.51±1.57	4.18±1.50	6.83±1.18	<0.001
TFESI + CESI	8.16±1.21	2.39±1.04	3.25±1.11	6.25±1.16	<0.001
TFESI	8.44±0.80	4.69±1.11	5.17±1.21	7.44±0.85	<0.001
ODI					
Total	57.37±6.75	29.96±6.33	31.78±6.43	53.70±7.23	<0.001
TFESI + CESI	57.29±7.55	27.14±4.57	29.25±5.12	51.18±7.43	<0.001
TFESI	57.46±5.86	32.96±6.60	34.46±6.64	56.38±6.00	<0.001

TFESI: Transforaminal epidural steroid injection, CESI: Caudal epidural steroid injection, VAS: Visual analog scale, ODI: Ostwestry Disability index

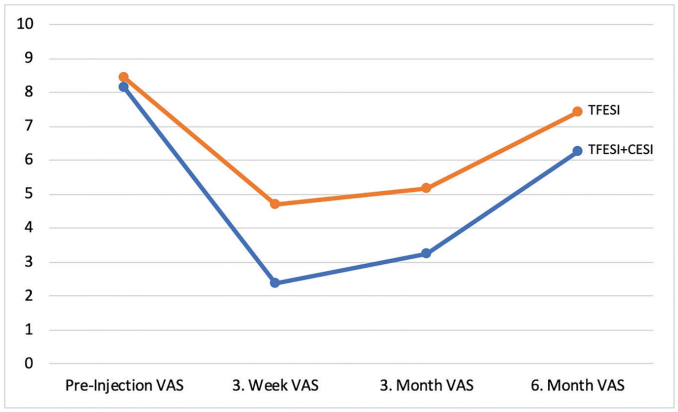

Figure 2. Changes in visual analogue scale (VAS) score of the transforaminal epidural steroid injection (TFESI) alone and TFESI + caudal epidural steroid injection (CESI) groups

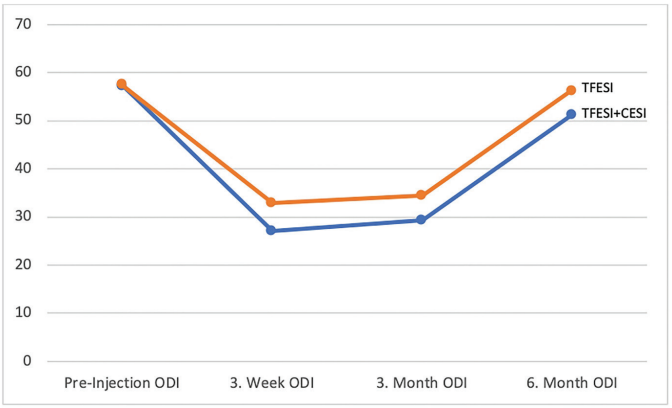

Figure 3. Changes in the Oswestry Disability index (ODI) score of the transforaminal epidural steroid injection (TFESI) alone and TFESI + caudal epidural steroid injection (CESI) groups

DISCUSSION

Although medical therapy, physiotherapy, ESI, and surgery are good options for lumbar disc herniation treatment, presence of cauda equina syndrome and severe paresis are absolute indications for surgery[16]. Pain unrelieved by medical and/or conservative treatment, greater than 3/5 muscle strength, pain longer than six weeks, and recurrent pain are relative indications for surgery[16]. The rate of postoperative reoperation can increase up to 26% in lumbar disc disease[17]. Complications related to lumbar microdiscectomy decrease success rate. Notably, complications due to surgery or recurrence are greater in multi-level lumbar disc disease. The fact that conservative or minimally invasive treatment modalities are the first choice in multi-level lumbar disc disease, which is seen in the elderly and the treatment of which is controversial,[18] can have more satisfying results for the patient and the surgeon.

ESI is a minimally invasive, non-surgical treatment option. ESI can be applied via three routes: transforaminal ESI (TFESI), interlaminar ESI (IESI), and caudal ESI (CESI)[9-12]. TFESI has several advantages over the other methods. It is applied directly to the pathologic region, it can reach the anterior epidural space, and it requires a lower volume of drugs[19,20]. CESI has a lower complication ratio because it reaches the epidural space easily; however, it requires more drugs volumetricalls[21]. IESI is minimally invasive and non-specific as injected drugs can migrate caudally, cranially and anteriorly[22]. In all three methods, steroids injected into the epidural space suppress ischaemia and inflammation caused by the migrating leukocytes and several neuropeptides, which are released when the nucleus pulposus occupies the epidural space[23].

Many studies have analysed the effectiveness of TFESI and CESI for radicular pain caused by lumbar disc disease and found TFESI to be most effective[14,24,25]. Several reviews have indicated that TFESI is effective for lumbosacral radicular pain[20,26]. CESI is also effective against lumbosacral radicular pain[27-30]. The two methods were compared by Kircelli et al.[31], who found that combined treatment was more effective than TFESI alone.

Although many studies have analysed the effectiveness of TFESI and CESI, few studies have been conducted on multi-level lumbar disc disease. Manchikanti et al.[32] examined the effectiveness of TFESI, IESI and CESI in radicular pain caused by lumbar disc disease. The effectiveness of TFESI, IESI and CESI was similar in the two-year follow-up; however, the effectiveness of ESI in multi-level lumbar disc disease was not analysed. Ökmen and Ökmen[33] applied IESI to 120 patients with multi-level lumbar disc disease and found that the VAS and ODI scores decreased significantly after the procedure compared with that in the preoperative period. Singh et al.[34] found significant improvement in radicular pain in patients who underwent two levels of TFESI.

Although TFESI and CESI are minimally invasive treatment modalities, many complications, such as death, paraplegia, spondylodiscitis, nerve damage, spinal cord infarction, headache, dizziness, nausea and vomiting, can develop[35-40]. In our patient group, no serious complications were observed; however, four patients complained of dizziness.

In our study, the medical records of patients with multi-level lumbar disc disease with radicular pain and ESI were retrospectively analysed. The 99 patients were divided into two groups: TFESI was administered to 48 patients, whereas TFESI and CESI were co-administered to 51 patients. Statistical analysis of the changes in the VAS and ODI scores showed that combined therapy was more effective in improving pain management and functional capacity. Our results showed that the need for surgical treatment can be reduced by combining TFESI and CESI for multi-level lumbar disc disease, which is difficult to manage. As the number of surgeries decreases, the incidence of complications secondary to surgery decreases. Therefore, it will be possible to obtain more satisfactory results for the patient and the surgeon.

Study Limitations

This study has two main limitations: the retrospective nature of the study and the analgesic treatments used by the patients during the post-injection period not being followed up.

CONCLUSION

Co-administration of CESI with TFESI in multi-level lumbar disc disease showed significant improvement in pain management and functional capacity. Combined TFESI and CESI should be considered in patients with multi-level lumbar disc disease, which is difficult to manage.

Ethics

Ethics Committee Approval: Since it is a retrospective data analysis, ethics committee approval is not required.
Informed Consent: Informed consent was obtained from the patients.
Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: O.B., Design: O.B., Data Collection or Processing: Ş.E., Analysis or Interpretation: O.B., Literature Search: O.B., Ş.E., Writing: O.B.
Conflict of Interest: The authors declare no competing financial interests and no sources of funding and support, including any for equipment and medications.
Financial Disclosure: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):160-6
DOI: 10.4274/jtss.galenos.2020.240

A LESS INVASIVE APPROACH IN ISTHMIC SPONDYLOLISTHESIS: SPINO-SEMILAMINA-FACET SPARING TECHNIQUE

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ABSTRACT

Objective: Our study aimed to describe the Spino-Semilamina-Facet Sparing Technique for the surgical treatment of patients with isthmic spondylolisthesis and to present our clinical results.

Materials and Methods: Forty-four patients who were treated with the above-mentioned technique between 2013 and 2015 were retrospectively evaluated. We included patients with grade 1 isthmic listhesis on neutral lumbar X-rays, who usually had a dominant unilateral radicular pain, but did not require discectomy via the approach side. The 12th month low back pain visual analogue scale (VAS) scores, leg pain VAS scores and Oswestry Disability index (ODI) scores were analysed both preoperatively and postoperatively.

Results: The average age of the patients was 46.3 years. Significant improvements were observed in the patients' radicular VAS scores at the approached side 12 months after the surgery ($p<0.0001$). There were also statistically significant improvements in minor radicular complaints when decompression was performed from the contralateral side compared to when it was done on the approached side ($p<0.0001$). Significant improvements were observed when ODI and low back pain VAS scores were compared between the preoperative and postoperative periods ($p<0.0001$, $p<0.0001$, respectively). To date, no additional intervention was applied to any patient.

Conclusion: The technique described in our study provides less invasive principles. The biggest advantages are that there is no need to perform a total laminectomy and the clinical outcomes are favourable.

Keywords: Isthmic spondylolisthesis, less invasive listhesis surgery, spino-semilamina-facet sparing

INTRODUCTION

Isthmic spondylolisthesis (IS) is one of the most common spinal disorders. It may lead to significant disability, morbidity and loss of the ability to work. The first treatment for IS should always be a conservative medical treatment (medical and physical therapies, injections and corsets), as it will be of some benefit to many patients. However, patients will require surgical treatment, particularly those with persistent back and/or radicular pain after 6 months of conservative treatment and those with progressive neurological deficits[1,2]. The ideal surgical treatment for IS is still controversial. A variety of surgical procedures and approaches have been described, with various grafts and implants used for fusion. Continued efforts are being made to find the optimal surgical modality, determined both radiologically and clinically. Here we present a new surgical technique in IS surgery, namely the Spino-Semilamina-Facet Sparing Technique, encompassing the most widely accepted principles.

MATERIALS AND METHODS

Study Design

This study was approved by Okan University Ethics Committee (decision no: 56665618-204.01.07, date: 11.06.2020).

Forty-four patients who were treated with the described technique between 2013 and 2015 were retrospectively evaluated. We included patients who had a dominant unilateral radicular pain, did not require bilateral discectomy or had only chronic lower back pain with grade 1 isthmic listhesis as determined by lumbar magnetic resonance images. The pars defects were bilateral in all the patients, with 38 at the L5-S1, one at the L3-4 and five at the L4-5 levels. In the surgical treatment of the patients, interbody cage applications and medial facetectomies were performed on the side of the dominant radicular complaints. The patients who needed discectomy via the medial facetectomy side were excluded in the study. Hence, no patient underwent bilateral discectomy at the level of the listhetic. Besides, there were patients

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who needed decompressions or discectomies at other levels. The contralateral nerve roots in the listhetic segment were decompressed with a contralateral view. In four patients who did not have a similar leg pain or had no radicular pain with chronic lower back pain, the side of the surgery was selected according to the preference of the surgeon.

Clinical outcomes were evaluated by considering the preoperative and postoperative 12th month lower back pain and bilateral leg pain visual analogue scores (VAS). Preoperative and postoperative 12th month Oswestry Disability Index (ODI) scores of the patients were also evaluated.

Surgical Technique

We preferred to perform stabilisation at the start of the surgery because of the opportunity for disc space distraction to benefit the discectomy and to avoid the unexpected appearance of neurological tissue in the surgical field at the screwing stage. Subsequently, laminofacetectomy was performed, i.e. decompression was initiated at the side where the interbody cage was placed. The spinolaminar junction was broken along the whole lamina by osteotome or cut with the high speed drill on the medial side (Figure 1a). The pars defect was revealed. Circulating fibrous tissue was opened and cleaned by monopolar diathermy or blunt dissection (Figure 1b). Large bone graft (laminofacet) was carefully removed with en-bloc resection. (Figure 1c). A large part of the removed graft (usually facet) was used as an autograft for interbody fusion (Figure 1d1). Autografts can also be resected from large bones in appropriate sizes if the graft is available (Figure 1d2, 3) or from other decompression regions. Unilateral laminofacetectomy was followed by upper root (L5 root for L5-S1 listhesis) decompression through the foramen. (Figure 1e). The well-relaxed spinous process was easily bent to the opposite side with a microdisc retractor and the contralateral nerve roots was easily decompressed (Figure 1e). Bone fragments (lamina) obtained from the large bone graft were placed under the rod between the unstable segment (Figure 1f). Bone fragments obtained from decompressions of the other levels, if any, were placed around the screw heads among the surfaces of the opposite side pars defect and on the preserved interlaminar region at the opposite side (Figure 1g) for fusion purposes. Listhesis screws can provide reduction at the listhetic vertebra according to the listhesis degree. After distraction and reduction were achieved with the screws, a large autograft (facet; Figure 1d1) obtained from the removed laminofacet was placed in the curetted intervertebral disc space.

Statistical Analysis

The analyses were performed using the SPSS software (Statistical Package for the Social Sciences, Version 21.0, SSPS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation and categorical variables were expressed as percentages. Analysis of normality was performed with the Kolmogorov-Smirnov test. Differences in parametric continuous variables for two groups were analysed using the Independent t-test. Non-parametric continous variables for two groups were analysed using the Mann-Whitney U test. Differences in two different time measures were analysed by repeated measures of analysis of variance. Statistical significance was tested for a level of alpha=0.05

RESULTS

The mean age was 46.3 years (24-68 years). There were 37 female and seven male patients. Mean follow-up period was 26.3 months (18-38 months). The mean Body Mass index was 29.8.

There were no major complications during the surgical treatment, although two patients had a dural tear and one patient had a superficial wound effusion that did not require additional antibiotic therapy and intervention.

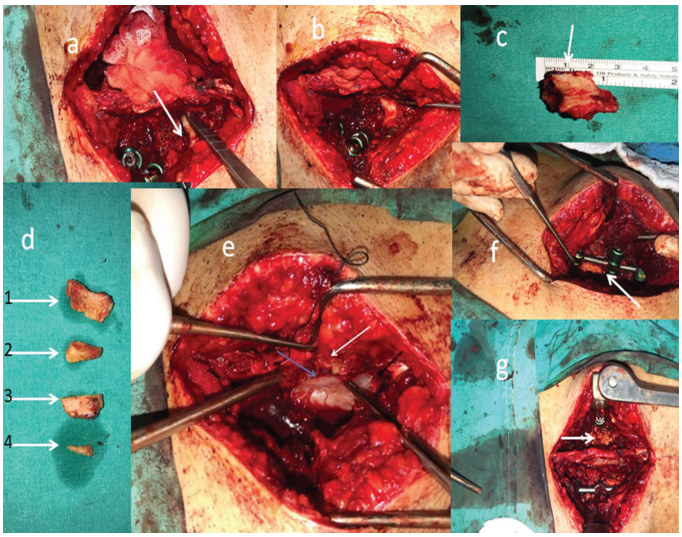

Figure 1. a) Black arrow shows pars defect. Spinolaminar junction is seperated by osteotomy.
b) Appearance before the en-bloc extraction, after seperating from bone junction sites. **c)** Extracted bone graft. Black arrow shows spinolaminar line seperated with osteotomes. **d)** 1-The main bone graft (facet) placed in front of the interbody TLIF. 2-Bone graft to be placed around the screw heads or interlaminar area before shredding to the pieces (it can be obtained from laminofacet bone graft if the size of graft is available or from other decompression regions). 3-Graft to be placed under the rod (lamina). 4-Graft to be placed between the faces of the pars defect at the opposite side. (it can be obtained from a laminofacet bone graft if the size of graft is available or from other decompression regions) **e)** After left laminofacetectomy and excision of soft tissue, we found that the well-relaxed spinous process is easily bended on the opposite side with a microdisc retractor. Blue arrow: Right L5 root, white arrow: spinosus processus, black arrow: right S1 root **f)** The placement of a bone graft (Figure 1d3) under the rod between the screws that are placed to the instable segments. **g)** White arrow: Autograft bone chips obtained from laminofacetectomy (Figure 1d2) and from other decompressions can be applied to the interlaminar area
TLIF: Transforaminal lumbar interbody fusion

The mean preoperative lower back pain VAS score was 7.86±1.32, while the mean postoperative lower back pain VAS score was 2.20±1.21. Thus, postoperative back pain was significantly reduced compared with preoperative lower back pain (p<0.0001; Table 1). Therefore, surgical treatment was effective in reducing the lower back pain complaints of these patients.

The mean preoperative and postoperative ODIs were 77±8.93 and 23.27±6.42, respectively. Thus, the mean of the postoperative scores was significantly lower than that of the preoperative scores (p<0.0001; Table 1).

Significant improvements were seen in the leg pain VAS scores on the side where the primary decompression was performed (p<0.0001 in each group; Table 2). Additionally, significant improvements were seen in the contralateral leg pain VAS scores, although contralateral decompression was performed (p<0.0001 in each group; Table 2). These results showed that the contralateral decompression in IS was effective in terms of pain control.

We also examined whether the improvement of the contralateral and ipsilateral leg pain differed according to the location of the defect and found no significant difference between the two (Table 3).

We also compared the mean of the difference in lower back VAS and ODI scores between the preoperative and postoperative periods in term of the location of defect (Table 3).

Regarding lower back pain VAS scores, the mean preoperative-postoperative difference in L4-5 + L3-4 and L5-S1 patients was 6.16±2.13 and 5.57±1.81, respectively. This difference was not statistically significant (Table 3). Regarding ODI scores, the mean preoperative–postoperative difference in L4-5 or L3-4 and L5-S1 patients was 53.50±9.58 and 53.763±10.276, respectively. This calculated difference was not statistically significant (Table 3).

Considering these analyses, we can deduce that our technique led to a significant improvement in both the lower back and bilateral leg pain VAS scores and ODI scores independently from the location of the defect.

No additional intervention or revision surgery was performed to any patient till date. Fusion rates were assessed with lumbar computed tomography (CT), and fusion was observed in 38 (86.3%) patients.

Illustrative Case 1

A 24-year-old male patient was admitted to our clinic with bilateral leg pain (Dominant on the left side), which began 3 years ago, but became more severe in the last 8 weeks.

Table 1. The comparisons of visual analogue scale and Oswestry Disability index values betweeen the preoperative and postoperative periods

	Mean	SD	p
Preoperative right leg pain VAS score	5.54	3.15	<0.0001
Postoperative right leg pain VAS score	1.31	1.11	
Preoperative left leg pain VAS score	4.45	2.88	<0.0001
Postoperative left leg pain VAS score	1.15	1.01	
Preoperative low back pain VAS score	7.86	1.32	<0.0001
Postoperative low back pain VAS score	2.20	1.21	
Preoperative ODI score	77.00	8.93	<0.0001
Postoperative ODI score	23.27	6.42	

VAS: Visual analogue scale, ODI: Oswestry disability index, SD: Standard deviation

Table 2. The comprasions of the legs pain according to the side of the surgery

		Mean	SD	p
Side of surgery = Left	**Preoperative right leg pain VAS score**	2.45	1.63	<0.0001
	Postoperative right leg pain VAS score	0.60	0.68	
Side of surgery = Left	**Preoperative left leg pain VAS score**	7.15	1.53	<0.0001
	Postoperative left leg pain VAS score	1.65	1.08	
Side of surgery = Right	**Preoperative right leg pain VAS score**	8.12	1.07	<0.0001
	Postoperative right leg pain VAS score	1.91	1.06	
Side of surgery = Right	**Preoperative left leg pain VAS score**	2.20	1.44	<0.0001
	Postoperative left leg pain VAS score	0.75	0.73	

VAS: Visual analogue scale, ODI: Oswestry disability index, SD: Standard deviation

Table 3. The comparisons of the improvement differences between preoperative and postoperative periods according to the location of defect

Group statistics					
Location of defect		**N**	**Mean**	**SD**	**p**
Difference between preoperative–postoperative contralateral leg pain VAS score	L4-5 or L3-4	6	3.50	2.16	NS
	L5-S1	38	3.44	2.91	
Difference between preoperative–postoperative ipsilateral leg pain VAS	L4-5 or L3-4	6	3.50	2.34	NS
	L5-S1	38	4.15	2.33	
Difference between preoperative–postoperative lowback pain	L4-5 or L3-4	6	6.16	2.13	NS
	L5-S1	38	5.57	1.81	
Difference between preoperative–postoperative ODI score	L4-5 or L3-4	6	53.50	9.58	NS
	L5-S1	38	53.76	10.27	

VAS: Visual analogue scale, ODI: Oswestry disability index, SD: Standard deviation, NS: Not statistically significant, N: Number

Dorsiflexion weakness was present in the left foot of the patient (4/5). The patient's preoperative lower back pain VAS score was 9, right leg pain VAS score was 3, left leg pain VAS score was 9 and ODI score was 80%. L5-S1 bilateral pars interarticularis defect and L4-5 and L5-S1 left paracentral disc herniation were present on radiological examination. The patient was operated upon according to the technique that we have described earlier (Figure 1a, b, c, d, e, f, g). Postoperative early-stage CT is shown in Figure 2 a, b, c, d, e and f. No complications occurred and the patient was discharged on the third postoperative day. The patient's postoperative 12th month lower back pain VAS score was 2, right leg pain VAS score was 0, left leg pain VAS score was 0 and ODI score was 24%.

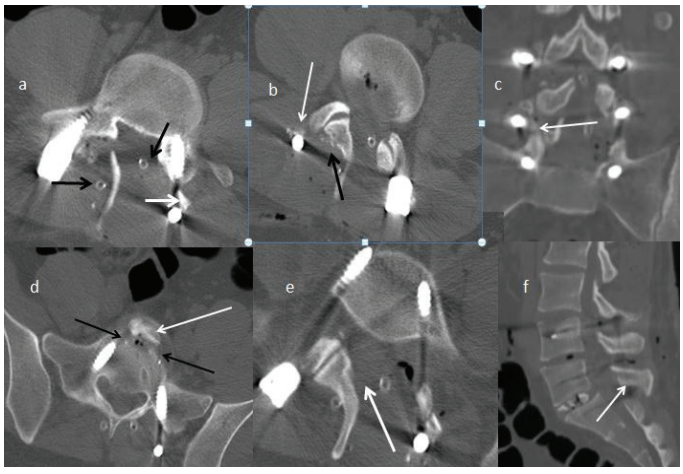

Figure 2. a) White arrow: Bone graft (lamina) placed under rod. Black arrows: Hemovac drains. **b)** White arrow: Bone grafts around the screw heads. Black arrow: Bone grafts applied to the interlaminar region. **c)** White arrow: Autograft placement between the faces of the pars defects at the opposite side. **d)** White arrow: Large piece of autograft (facet) in front of the cage at the disc space. Black arrows: the landmarks of the TLIF cage **e)** White arrow: The route of bilateral decompression from the unilateral approach. **f)** Sagittal view in the postoperative course. White arrow: Preserved L5 spinosus processus
TLIF: Transforaminal lumbar interbody fusion

Illustrative Case 2

A 48-year-old female patient was admitted to our clinic with bilateral leg pain dominant on the right side, and severe lower back pain for the past 2 years. She had not benefited from conservative treatments and had no motor weakness. The patient's preoperative lower back pain VAS score was 8, right leg pain VAS score was 8, left leg pain VAS score was 4 and ODI score was 76%. L3-4 bilateral pars interarticularis defect and L3-4 right paracentral foraminal disc herniation were present on the radiological examination. The patient was operated according to our technique and the postoperative CT is shown in Figure 3. No complication occurred and the patient was discharged on the third postoperative day. The patient's

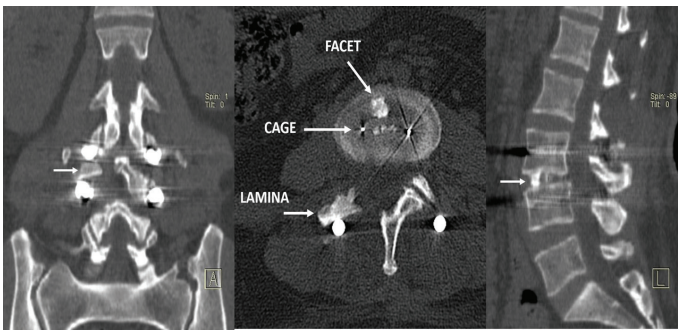

Figure 3. White arrow in the coronal section of L3-4 short segment stabilised patient shows the lamina originated bone graft placed under the rod; white arrow in the sagittal section shows the facet orginated interbody graft. Axial section demonstrates that the surgical treatment is performed with a one side laminofacet sparing

postoperative 12th month lower back pain VAS score was 2, right leg pain VAS score 1, left leg pain VAS score 1 and ODI score 16%.

DISCUSSION

IS is a spinal disorder that can be seen in young and adult age groups, often involving L5-S1 and L4-5 defects, affecting up to 8% of the general population[1,2]. It is defined as the forward slippage of a vertebra due to a defect in the pars interarticularis. Medical, conservative and physical therapy may be recommended to patients with IS[3-5]. Surgical options range from simple decompression to stabilisation with or without fusion[1,6-10]. Decompression alone is no longer recommended[11,12].

Many authors have developed many surgical techniques to treat IS by providing stability via fusion. These surgical options include posterolateral intertransverse process fusion; Buck direct repair, facet joint screws; and transforaminal lumbar interbody fusion (TLIF), anterior Lumbar Interbody Fusion (ALIF) and posterior lumbar interbody fusion (PLIF) applications with or without combined anterior and posterior fusion[13-17]. Fusion surgery with decompression has become the primary treatment because patients undergoing fusion surgery can be controlled for pain by stabilising the unstable segments. When we looked at the outcomes of the patients who underwent fusion surgery, the preoperative lower back pain VAS and ODI scores of the patients showed a significant improvement in the postoperative period.

Until now, various surgical approaches and different comparisons have been reported in many articles. The width of the fusion area is important in fusion surgery[3]. Posterolateral fusion is very common in transpedicular fixation. Interbody fusion in IS surgery is usually meaningful for success in fusion, but fusion between the laminae will expand the field of fusion and serve the main purpose of this surgery[18,19]. This protected interlaminar space can be used for posterior fusion because of the bone grafts. Mobile or semi-mobile lamina is not necessarily involved in the stabilisation effort, but will increase the chances of success. Previously, laminoplasty had been applied to IS, and Kotil[20] reported the 5-year follow-up outcomes and stated that the results were excellent. However, it is also possible to protect the lamina without its removal and without performing laminoplasty. We can protect one side of the lamina with unilateral laminofacetectomy. The bone graft repair was first described by Kimura in 1968[21]. To date, direct repair-related studies and their positive outcomes and the follow-up outcomes have been published[22-24]. In the practice of spinal fusion surgery in IS, the procedure using the bone graft that is placed into the pars defect was not preferred frequently, but it would be logical to use it to expand the field of the fusion area.

Posterolateral fusion is still the most commonly used fusion strategies in instabilities. Some publications show that there is no significant difference between posterolateral fusion and interbody fusion, a large number of authors have indicated that posterolateral and interbody fusions give excellent results when used together[25,26]. We tried to achieve a posterolateral fusion with a single bone graft placed under the rod between the unstable segments. Placing a single piece of bone graft under the rod also prevents the graft from being lost in the paravertebral muscles.

There are numerous articles about the use of interbody grafts. Allografts cannot provide enough support to be used as interbody grafts, whereas high fusion rates have been reported for autografts. Even 100% fusion rates were reported in certain studies that used cages combined with iliac wing and/or spinous process autografts[27-29]. The use of the interbody cage also increases the fusion success. It is shown that the interbody cage with autogenous bone grafting and pedicle screw fixation are more useful in adult spondylolisthesis for improving the fusion rate and preventing long-term instabilities, compared with the simple cage alone with pedicle screw fixation[30]. The iliac wing is frequently used as an autograft, but this increases both patient morbidity and the source of pain and infection. It often requires an additional incision[31-33]. Positive radiological and clinical outcomes were reported in a study in which a single piece of spinolaminar process was used as an autograft[12]. We used the large piece of the inferior articular face of the facet joint as an interbody graft, which is already separated from the large bone graft (laminofacet). We partially performed decortication and prepared it as one tricortical large piece of autograft.

Decompression plays an important role in IS surgery and neurosurgery. Decompression is frequently performed in spinal disorders using minimally invasive techniques and less bone removal. The aim of minimally invasive spinal surgery is to achieve the same purposes as the other open surgical techniques via a less traumatic approach[34]. Bilateral decompression from one side is one of the commonly used minimally invasive techniques. To date, numerous articles about bilateral decompression from one side have been written[35-37]. Additionally, it has been described that these approaches achieved very important clinical outcomes for the contralateral side symptoms[38,39]. Bilateral decompression via the unilateral approach was not defined in IS surgery to date. After a one-sided laminofacetectomy, the preserved spinolaminar bone, which is already easy to mobilise, is partly tilted, and the patient is partially rotated to the opposite side and microscopical decompression can be achieved for the contraletaral side (flavectomy + foraminotomy). Up to four nerve roots can be decompressed with such a minimal approach (i.e. L5, S1 bilateral nerve roots for L5-S1 listhesis). Indeed, we found a significant improvement in postoperative ipsilateral and contralateral leg pains. Ipsilateral and contralateral leg pains were also compared according to the side where the decompression was applied and significant improvements were seen. On the other hand, according to the analysis of

the location, a significant improvement was observed in the ipsilateral and contralateral leg pain. In other words, even if the location changes, contralateral decompression can provide significant improvement in these patients.

Decompression is provided without removing or cutting the posterior tension band in this surgery. This also helps in suturing the fascia tightly at the mid-line, in the closure phase at the end of the surgery. This also ensures that no dead space is left in the surgical area that can give rise to infections and subcutaneous collections[40]. Preserving the posterior tension band and not applying total laminectomy as a less invasive approach decreases the dead space and complications in the surgical field[41]. No epidural hematoma, subcutaneous collection, sub-fascial collection or infection was seen in our patients.

We applied the interbody cage, which is almost always recommended to be performed in IS surgeries. After the facetectomy on one side, it was possible to apply the TLIF cage in the interbody space and enlarge the fusion area, in order to maintain the foraminal distraction and disc height[42]. Although there were no significant differences between the TLIF and PLIF in terms of surgical outcomes in the literature, recommending the use of TLIF is more intense[43-45]. We also used Banana TLIF for bilateral and anterior support from one side. Providing anterior support further increases the chance of fusion[30,46,47]. Beside these, we avoided additional cost (avoiding allograft use) by using autografts. We did not perform any extra incision to the patient for autograft. Extra incision for autograft also increases the duration of hospital stay and treatment cost[48,49]. Consequently, we did not apply a revision surgery to any of the patients that we operated using this technique. Significant improvement in lower back pain VAS, leg VAS and ODI scores were observed in all the patients.

Study Limitations

This study has some limitations. The follow-up period was short. In addition, no comparison was made with patients operated using the standard surgical techniques. Besides this, variables such as comorbidity and risk factors in the sample group of these patients were not included in the study.

CONCLUSION

With this surgical technique, it is possible to perform bilateral decompression from one side and to maintain the interlaminar space in order to keep the fusion area wider, to preserve the posterior tension band, and to perform interbody fusion with a one-piece large autograft obtained from a one-sided facetectomy. Hence, we believe our technique can be described as the spino-semilamina-facet sparing approach in IS.

Ethics

Ethics Committee Approval: This study was approved by Okan University Ethics Committee (decision no: 56665618-204.01.07, date: 11.06.2020).

Informed Consent: The informed consents received.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: O.K., A.Ö., S.D., Design: O.K., A.Ö., Data Collection or Processing: O.K., M.Y., S.D., Analysis or Interpretation: O.K., A.Ö., S.D., Literature Search: O.K., A.Ö., Writing: O.K., A.Ö., S.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.

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J Turk Spinal Surg 2020;31(3):167-9
DOI: 10.4274/jtss.galenos.2020.247

POSTERIOR ANNULUS REPAIR AFTER DYNAMIC STABILISATION

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ABSTRACT

Objective: Intervertebral disc herniations with wide annulus defects have been stabilised with the posterior dynamic stabilisation method following microlumbar discectomy.

Materials and Methods: The injured anulus is divided into two groups; a) the anulus weakens without losing its integrity and b) tearing all layers of the annulus.

Results: In a one year control, it was found that the annulus was adequately repaired in both groups. The repair process in the full-layer tear occurred with connective tissue. There was no recurrence.

Conclusion: Posterior transpedicular stabilisation is an effective treatment method for annulus repair.

Keywords: Disc herniation, dynamic system, annulus repair

INTRODUCTION

Development and recurrence of disc herniations have tight relationship with the size of annulus defect[1,2].

Intervertebral disc herniation occurs after the development of an annulus defect whose sizes differ. The large defects are more problematic in regard to the development of recurrent disc herniation. During the discectomy, the piece of fragments pressing on the nerve root is removed. When the patient is mobilised after the discectomy, the body weight overlaps the anulus defect and triggers the formation of recurrence.

There is currently no accepted technique to repair the annulus. We examined the annulus of patients with disc herniation who were stabilised with dynamic constructs after discectomy.

MATERIALS AND METHODS

Since this study is a retrospective study, ethics committee approval was not obtained. The patients with disc herniations whose posterior annulus defect was large (>6 mm) were included in the study. Large defects were identified in 20 patients of whom 11 were female and nine were male with mean age was 52.2 (ranges: 35-80). Foraminal and extraforaminal herniations were excluded from the study.

The size of the annulus defects of the patients was evaluated by magnetic resonance (MR). Defect types were categorised in two groups. The first group comprised of 12 patients with undisrupted annulus integrity, average thickness of the annulus taken in the axial section, and the defect between the point where the thickness began to decrease in the posterior wall and the point where the thickness returned to normal again was accepted as defective area (Figure 1a). The second group, made up of eight patients had the herniations developed through the totally ruptured annulus. The distance between the points where the annulus rupture began and ended was accepted as a defect and measured (Figure 1b).

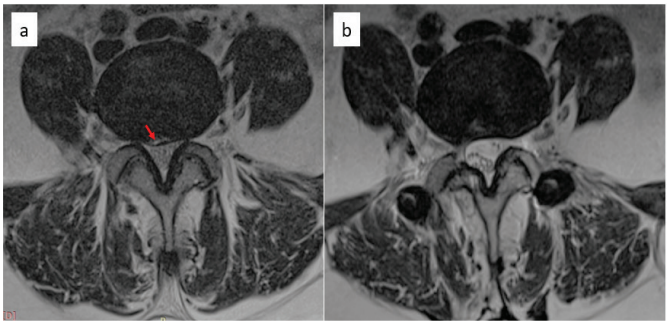

Figure 1. a) weaken but preserved integrity of posterior annulus, preop axial T2 image **b)** postop 1-year axial; T2 image shows healing of annulus

Postop: Postoperative

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In microlumbar discectomy procedure for the first group, they tried to preserve the integrity of the wall, and only an incision was made parallel to the annulus fibres and the intact part of the nucleus was not touched. The degenerative parts of the nucleus that moved into the annulus fibers were removed.

For the second group, classic microlumbar discectomy procedure was performed. All the patients in two groups were stabilised under C-arm scopy. The Dynesys system (Zimmer Inc., Warsaw, IN, USA) was placed as posterior dynamic stabilisation (PDS) method.

After one year of follow-up, all patients were examined with MR protocol and the results were compared with preoperative MR findings.

RESULTS

After one year of follow-up, annulus repair was achieved in all patients in both groups. The patients in the first group with unimpaired annulus integrity observed the annulus healed close to the original, while those in the second group with full-layers rupture, observed the defects repaired with connective tissue (Figure 2 a,b).

Another remarkable observation was that, the annulus defect healed by making an inward fold in some patients (Figure 3). Recurrence was not detected in both groups.

DISCUSSION

Disc herniation develops as a result of weakening and tearing of the annulus. The greater the defect, the greater the risk of developing herniation. The relationship between the size of the defect and recurrence was systematically emphasised by Carragee et al.[2] for the first time. He noticed that there was a close relationship between annulus defect size and recurrence rate.

Subtotal discectomy is recommended to minimise recurrence rate in microlumbar discectomy patients. From our own experience, the general opinion is that subtotal discectomy reduces recurrence rates. However, it is also known that segmental instability is not tolerated by some patients where severe painful clinical picture appear[3].

The proper healing of the annulus is the most important point after discectomy. However, if the patient does not have strong muscle compensation, it is almost impossible to repair the annulus properly. Nucleus fragments, which remained under load after discectomy, leak through the defect and prevent proper healing process.

Anatomically, in wide annulus defects, after discectomy, the only barrier between the residual disc tissue inside and the spinal canal is the posterior longitudinal ligament. This ligament is thick in the midline and weakens laterally. From this point of view, after the defect was developed in the annulus, there was no barrier to protect nerve tissue, whether discectomy was performed or not. Subtotal discectomy reduces the nucleus stock that will come out from the inside, but does not completely eliminate the risk.

In subtotal discectomy, it is a known fact that the disc, which has been severely damaged after surgery, spontaneously fused in the long term. Another fact is that, the level of fusion over the years cause disruption of adjacent segments, therefore, we stabilise the patients with large annulus defects using the posterior transpedicular dynamic system. If the disc is not severely damaged, the annulus heals and the disc recovers itself, and in some cases rehydration may occur. In this case, since the movement is preserved, stress in the adjacent segment is reduced and adjacent segment degeneration risk

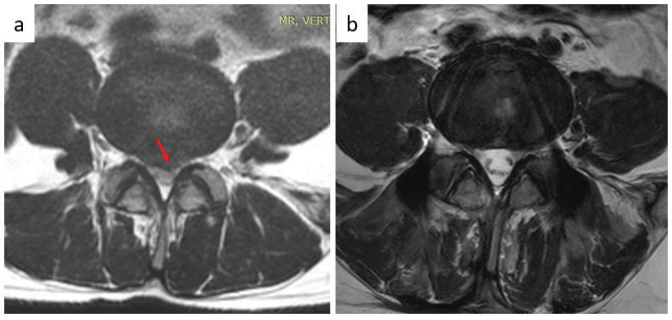

Figure 2. a) All layers of ruptured annulus and extrude herniation **b)** The posterior annulus, one year after

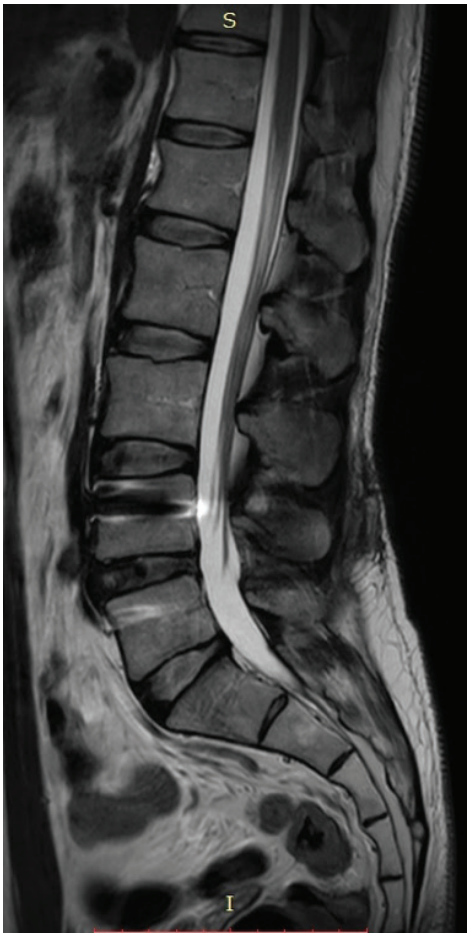

Figure 3. Annulus defect healed by making an inward fold

is less[4]. However, in cases where the disc is severely damaged, spontaneous fusion develops even if the level is stabilised with dynamic constructs. The patient would be painless; however, the possibility of adjacent segments problem cannot be eliminated.

CONCLUSION

The annulus integrity is important for recurrent disc herniation. One should bear in mind that dynamic stabilisation accomplishes this reality and this surgical method should be chosen in patients with significant annulus defects. Moreover, the PDS provides stability, therefore the risk of painful period following surgery is less.

Ethics

Ethics Committee Approval: Since this study is a retrospective study, ethics committee approval was not obtained.
Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.
Financial Disclosure: The author declared that this study received no financial support.

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):170-5
DOI: 10.4274/jtss.galenos.2020.200

CONSUMPTION OF GREEN TEA OR ITS DERIVATIVE CATECHIN MAY IMPROVE NEURAL REGENERATION IN A RAT SPINAL CORD INJURY MODEL

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ABSTRACT

Objective: Tea contains antioxidant compounds from the polyphenol group known as catechins. The most abundant of catechins is Epigallocatechin-3-gallate (EGCG). Epidemiological studies show that tea has a protective effect against cancer, neuronal damage after transient global ischemia and cardiovascular diseases. This study aimed to investigate a possible neuroprotective effect of EGCG in a rat spinal cord injury (SCI) model.

Materials and Methods: The study was performed with 35 Albino-Wistar rats. Rats were divided into five groups: daily consumption group (intraperitoneal given ECGC 1.7 mg/kg/day), treatment groups (intraperitoneal given ECGC 5 mg/kg/day and 10 mg/kg/day), saline group and control group for 14 days prior to trauma. All groups, other than the control group, injured with a pressure of 35 g/cm^2 and 1-minute compression. These operations were applied to the spinal cord at level T9-T10. In all groups, nerve samples were taken after 28 days and examined biochemically and histopathologically.

Results: In our study, daily consumption ECGC group, 5 mg/kg ECGC group and 10 mg/kg ECGC group statistically significant lower level of lipid peroxidation. Especially daily consumption ECGC group and 5 mg/kg ECGC group were positively decreased histological degeneration and oedema. Histological evaluation, white-grey matter sparing, glial scar formation, protoplasmic astrocytes' number, cavity size, also had better results in these groups.

Conclusion: In this study, it has been shown that catechin group antioxidant substances in tea have a protective effect in neuronal damage such as SCI.

Keywords: Spinal cord injury, epigallocatechin-gallate, immunostaining, electron microscope, lipid peroxidation, green tea

INTRODUCTION

Traumatic spinal cord injury (SCI) is a serious medical condition caused by damage to the central nervous system. Complications of SCI are a frequent cause of morbidity and mortality and lead to motor paralysis, sensory and autonomic disturbances, for which appropriate treatment has not yet been developed[1]. SCI is most commonly caused by motor vehicle accidents or falls, and SCI victims are usually young[2]. Long-standing experimental and clinical academic works have demonstrated the major pathological changes that cause all SCI-induced signs and symptoms. The spinal cord contains many blood vessels, and like the blood-brain barrier, the microcirculation is tightly controlled by the blood-spinal cord barrier (BSCB), which is a distinct anatomical barrier[3]. After the traumatic SCI, disruption of the BSCB, plasma and blood cell extravasation, central sensitisation of nociceptive spinal cord neurons, cell necrosis, release of inflammatory mediators, reactivation of glial cells and increased potassium and glutamate levels' neurotoxic excitatory amino acids in the extracellular space are the major changes observed in the damaged spinal cord[4]. SCI triggers the beginning of a response with a series of biochemical changes in the spinal cord. Increased myeloperoxidase activity, neutrophil infiltration and the release of inflammatory mediators cause elevation of lipid peroxidation level[5]. Lipid peroxidation is a toxic chain reaction that progresses with positive feedback[5,6]. It causes cell damage by directly disrupting membrane function or indirectly damaging cell components. It has been shown in the literature that the measurement of lipid peroxidation level at first hours, 1 and 2 days after trauma, gives better results[7]. All these biochemical and cellular changes are observed in the first week of injury. At last, microglial cells and reactive astrocytes form a glial scar all over the lesion site. Regeneration of central axons along the lesion site is observed. Bare axons

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are seen after apoptosis of oligodendrocytes and wallerian degeneration. We should treat SCI effectively to improve the quality of life of patients. Therefore, we need to investigate appropriate therapeutic strategies to reduce the destruction of BSCB.

Green tea (*Camellia sinensis*) is a mixture of polyphenols, polysaccharides, thiamine, flavonoids, flavonols and amino acids, organic acids and vitamins[8]. It contains polyphenol and polyphenol oxidase enzymes. Catechins are a type of polyphenol and are the main antioxidant component in green tea. The most abundant catechins are epicatechin-3-gallate, epicatechin, epigallocatechin-3-gallate (EGCG) and epigallocatechin. Approximately 30-45% of the dry weight of green tea contains phenolic compounds. EGCG is the most common that constitutes approximately 50-80% of the total catechins[9]. It has been shown in the literature that EGCG is protective against tumoral structures, especially with antimutagenic and antiproliferative action. The anti-inflammatory, antioxidant, antiallergic and neuroprotective effects of EGCG have been demonstrated in several *in vitro* and *in vivo* studies[10].

EGCG, reportedly, has protective effects in maintaining blood-brain barrier integrity by reducing caveolin-1 expression, down-regulation of pro-inflammatory cytokines and by increasing the expression of proteins associated with a tight junction in the initial stage of brain ischaemia[11]. These results showed that EGCGs could alter the permeability of BSCB after SCI. Thus, EGCGs can be considered as a potential neuroprotective agent against SCI because of its multiple protective effects on the neuronal injury, BSCB leakage, oedema and inflammation.

MATERIALS AND METHODS

First, the study protocol was approved by the ethics committee of our hospital, Ankara Training and Research Hospital, and the test procedures were performed in compliance with the study guides of the Animal Laboratory of the same hospital (decision no: 0309, date: 14.01.2009). Thirty-five male Wistar rats with an average weight of 210 g (200-220 g) were selected for the study. Adequate food and water were provided to the rats; they were then exposed to a 12-hour light cycle and 12-hour dark cycle in a standardised laboratory cage, and the ambient temperature was standardised at 18-21 °C, 40-60% humidity[12,13].

Rats were divided into five groups: daily consumption group, treatment groups, saline group and control group. Each group consisted of seven rats. Other groups except the control group received compression-induced injury caused by clips closed with a pressure of 35 g/cm^2 for 1 minute. Group A, daily consumption group, was given 1.7 mg/kg/day EGCG dissolved in saline, intraperitoneally for 2 weeks to mimic daily the amount consumed. Group B was given 5 mg/kg/day EGCG (Sigma-Aldrich, Catalog No E4268®) for 7 days after SCI. Group C received 10 mg/kg/day EGCG (Sigma-Aldrich, Catalog No E4268®) for 1 week after SCI. D group was the normal serum physiologic group; 0.25 cc normal saline was given intraperitoneally daily for 1 week after SCI. SCI was not found in the control group, and no injection was administered[10].

Samples were taken from all groups of rats after 28 days of trauma, and dry tissue samples were transferred to the biochemical analysis with −4 °C cold chain. For histopathological examination, samples were determined by neutral formalin and were transferred to the hospital laboratory. Groups A, B and C were compared with saline-treated rats (group D) and control group (group E). 2'3'-cyclic nucleotide 3'-phosphodiesterase (CNP) (CNPase Ab-1), glial fibrillary protein (GFAP) (Cat. #MS-280-), nuclear factor (NF) (κ) kappa (Cat. #RB-1638) and endothelial nitric oxide synthase (eNOS) (Cat. #RB-9279) primary antibodies were applied to the sections taken into the slides. Tissues were evaluated in the Leica DM 4000 image analysis system. Immunohistochemical markers such as CNP, eNOS, NF-κ and GFAP were used to assess SCI injury and the efficacy of treatment.

Statistical Analysis

Data were expressed as mean ± standard deviation. The statistical analysis was performed by using the t-test and X2-test for SPSS Windows 13. Differences were noted significant if $p<0.05$.

Surgical Procedure

All rats were fasted overnight before the procedure. For anaesthesia, 10 mg/kg Ksilon (Rompun®, 2% solution, Bayer, İstanbul, Turkey) and 50 mg/kg ketamine hydrochloride (Ketalar®, 5% solution, Parke Davis-EWL, Eczacıbaşı, İstanbul, Turkey) intraperitoneal were applied[14]. The rats were placed in the prone position; the skin incision was then made along the dorsal midline, and the muscles were dissected and the vertebrae were clearly exposed. After that, a laminectomy was performed to expose the T9-T10 level without any damage to the dura mater and spinal cord. SCI was shown by compressing the spinal cord of each rat for 1 minute using an aneurysm clip (Tator clip) with a closing pressure of 35 g/cm^2[15]. The tissue was then closed anatomically. All rats were anaesthetised after 28 days, and samples of the damaged spinal cord, comprising the proximal and distal spinal cord sections of 0.5 cm, were collected from previous incision sites. Finally, intra-atrial phenobarbital was applied, and the rats were sacrificed.

Biochemical Examination

The lipid peroxidation value per gram of tissue for each rat was calculated in nanomoles.

Histology and Immunohistochemistry

Tissue samples were divided into three parts, with each part consisting of 1 mm. The fragments were fixed in 0.1 M phosphate buffer (pH=7.4) containing 2.5% glutaraldehyde for 2 hours. The samples were then washed three times with buffer. After fixation, 1% osmium tetroxide was used. Fixed tissues were dehydrated in alcohol. Lastly, the tissues were processed with propylene oxide. Then, it was mounted on tissue blocks using the Araldite CY212 kit. In the incubator, the hardened

block from the polymerised tissues for 48 hours at 56 °C was cut and made into semi-thin sections. It was then stained in the Toluidine Blue solution to examine by light microscopy. Thin sections obtained from these regions were stained with uranyl acetate and lead citrate and monitored by Carl Zeiss EVO LS 10 + ED transmission electron microscope and indicated by suitable magnifications.

Histopathological tissue samples were analysed under light microscopy. White-grey matter sparing, glial scar formation, protoplasmic astrocytes' number and cavity size were evaluated. Twelve or more microscopic domains were randomly selected from the spinal cord of each rat, and the degenerated axons were counted from the first right corner of the rectangular area to the last left corner in accordance with the protocol. Tissues were evaluated by two independent histopathologists who blinded this study.

RESULTS

Change in the body weight of rats was unnoticeable (approximately 1%) throughout the study. Death associated with EGCG treatment was also not observed in the experiment.

Biochemical Results

Biochemically, the bioavailability of lipid peroxidation was measured. Statistical analysis of biochemical values showed no significant difference between group D and groups E, A, B and C ($p>0.05$) (Table 1). However, a significant difference was found between groups A, B and C and group D ($p<0.05$). Another study shows that daily and therapeutic doses of EGCG after SCI decrease the grade of lipid peroxidation statistically significantly (Figure 1).

Histological Results

In all rats, morphometric measurements were recorded to keep the preservation of the spinal cord simple after SCI. In the EGCG-treated groups (A, B and C), the white matter of the spinal cord was essentially preserved in the cranial part of the spinal lesion, but it was not statistically significant. EGCG treatment provided more protection of grey matter in both the cranial and caudal parts of the spinal lesion than in the controls and was caudally significant at 5 mm from the centre of the lesion ($p<0.05$). The volume of the cavities was alike in all three treated groups and not statistically significant. Glial scar formation was compared between EGCG-treated groups (A, B and C) and saline-treated group (D). The glial scar site was larger in rats treated with saline (D) than rats treated with EGCG (A, B and C) but not statistically significant ($p<0.05$). To measure the axonal sprouting level, the number of GAP-43 positive fibres were examined. Axonal sprouting in EGCG-treated groups (A, B and C) was significantly higher than that of saline-treated rats ($p<0.05$).

Immunohistochemistry

CNP immunostaining was used to assess oligodendrocyte distribution in the large and small magnified image in the medulla spinalis section. The control group (group E) was evaluated as normal SCI-induced immunoreactivity. In groups, B and C (EGCG-treated groups), oligodendrocytes around the tracts were observed to have regular localisation. In addition, CNP uptake in oligodendrocyte sections was more intense in both grey- and white matter than in the previous group. When these groups were compared with each other, no statistically significant difference was found. In group D, only trauma-induced immunoreactivity was observed (Figure 2).

eNOS immunostaining of D group (SCI + saline group) showed immunoreactivity in the cell membrane and cytoplasm of a few large neurons in medulla spinalis sections. In groups A, B and C, eNOS reactivity was evident in the cell membrane and

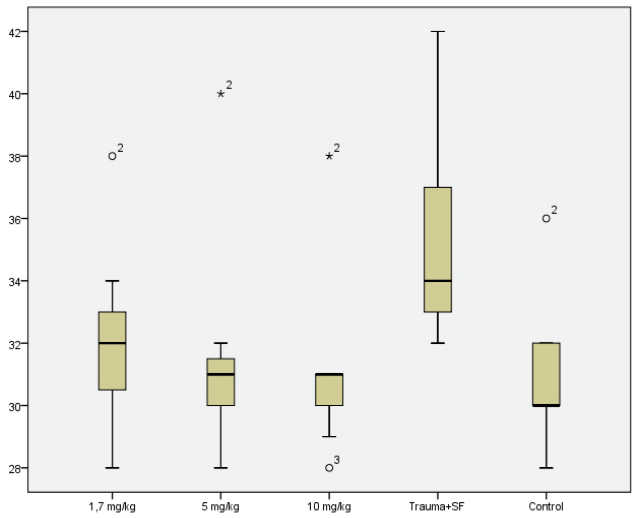

Figure 1. Multiple comparison of lipid peroxidation values between the 1.7 mg/kg/day, 5 mg/kg, 10 mg/kg/day trauma + saline, control groups respectively

Table 1. Distribution of biochemical values by groups

Groups	Mean values of raw data	nmol/gr wet tissue/lipid peroxidation mean values
Group A	0.165	32.443
Group B	0.175	31.744
Group C	0.164	31.258
Group D	0.182	36.128
Group E	0.153	30.063

cytoplasm, similar to the D group. Cytoplasmic involvement was found to be relatively elevated in these four groups as compared to the control group. In group C, given high-dose EGCG, strong involvement of eNOS in neurons was observed at the membranous and cytoplasmic level.

GFAP immunostaining was used to monitor the distribution of astrocytes in the medulla spinalis sections. When the D group was examined, it was determined that astrocytes with GFAP immunoreactivity were intense in the section. In the small magnified images, it was observed that the place of astrocytes in the vicinity of the capillary structures was interrupted. In the enlarged picture, the presence of very intense GFAP + astrocytes was observed around the large neurons. In groups A, B and C, GFAP + astrocytes, which shape the BSCB around the blood vessel, were interrupted occasionally. In group C, the central channel of the medulla spinalis section and the GFAP + astrocytes were observed in some areas in the grey matter (Figure 3).

NF immunostaining was performed to detect strong NF immunoreactivity in ependymal cells. In group D, NF immunoreactivity in ependymal cells was observed, and large neurons were found negative for NF. Some astrocytes showed NF involvement, and some astrocytes did not show immunoreactivity. It was noted in the A, B and C experimental groups that the involvement of the ependymal cells in the medulla spinalis sections increased significantly. Strong NF-κ immunoreactivity in astrocytes was detected in large-scale examinations. Strong immunoreactivity was differentiated in small neurons, whereas there was weak involvement in the perinuclear area in large neurons. On the other hand, cell membrane and peripheral cytoplasm were found to be weakly affected.

Clinical trials with CNP primary antibody demonstrated that myelinisation was raised at the grey matter in groups A and B. Immunostaining with GFAP to evaluate the pattern of astrocytes showed a well perivascular organisation in group B (5 mg) than group C (10 mg). These findings display that 5 mg EGCG was associated with neuroprotective results, nevertheless, a dose of 10 mg was associated with deterioration of the BSCB.

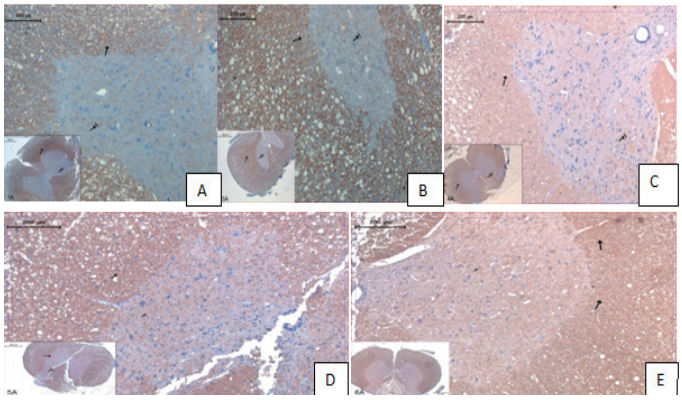

Figure 2. Oligodendrocytes is showed in medulla spinalis with CNP immunoreactivity; **A)** Control group, normal distrubition of parenchyma, **B)** In group D, normal configuration of medulla spinalis was impaired after injury, increased CNP immunopositivity was showed both white and grey matter, vacuolation was also prominent, **C)** In group A; Distribution of CNP reactivity is equally with normal tissue on the white and grey matter , a regular in habiting of oligodendrocytes was seen around of the tractus; **D)** : In group B; Immonoreactivity of oligodendrocytes with CNP was increased than group A, **E)** In group C, CNP reactivity was similar with group B, but, it was showed that immunoreactivity was denser on the grey matter. →: CNP (+) axon in white matter and →ı grey matter (Immunoperoxidase & Hematoxylene **A** x 100 - **B** x 400)

CNP: 2'3'-cyclic nucleotide 3'-phosphodiesterase

DISCUSSION

Traumatic SCI is a disease that causes serious mortality and morbidity in young people due to their aetiology[16]. There is still no common decision on treatment[17,18]. After SCI, it causes autonomic dysfunction, motor paralysis and sensory anaesthesia under the lesion site. Like neuropathic pain, it can lead to a syndrome that greatly reduces the quality of life[19]. Experimental and clinical trials have showed the primary pathological changes that cause SCI symptoms, including neuropathic pain[4]. Post-SCI, oxidative stress-induced cell structure deterioration and ischaemia developed[19]. Antioxidants have the potential to prevent the tissue's harmful effect of the inflammatory reaction. In our study, EGCG, a polyhydroxy polyphenolic compound with antioxidant properties and present in the widely used green tea plant, was used in an SCI model with daily intake of 1.7 mg

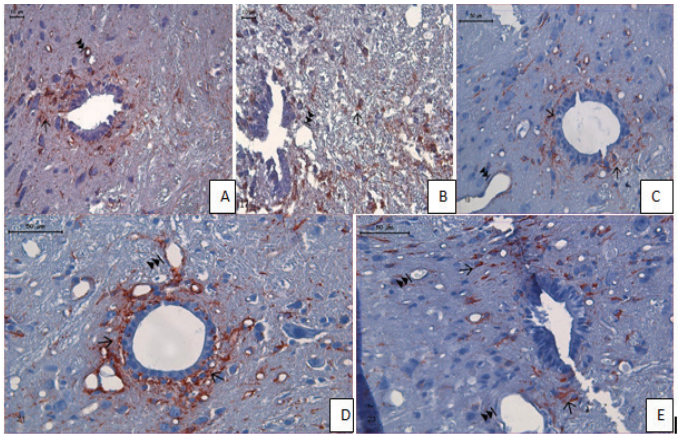

Figure 3. GFAP immunoreactivity was shown in the medulla spinalis sections, **A)** Control (group E), **B)** In group D, GFAP immunoreactivity of the astrocytes was widely. Arrangement of astrocytes was disrupted in patches around the capillary. GFAP (+) astrocytes was stronger around the large neurons, **C)** In group A, GFAP immunopostivity was denser than group D and E , but blood-brain barrier was also disrupted, **D)** In group B showed similar findings with group A, contrary to expectations that blood-brain barrier was not healthy, **E)** In group C, GFAP reactivity was stronger than other groups, especially, around the central canal and grey matter, however, blood brain barrier is unhealed still; →: GFAP (+) Astrocytes, ⏭: Blood-brain barrier around the capillary (Immunoperoxidase & Hematoxylene x 400)

GFAP: Glial fibrillary protein

/kg/day and in treatment doses (5 mg/kg/day and 10 mg/kg/day). EGCG has significant antioxidant activity on SCI, measured by various biochemical assays. However, it has been shown to cause impairment in BSCB, especially in the high-dose group (10 mg/kg).

Local tissue damage develops in the spinal cord after the primary mechanical impact. This damage causes interruption of ascending and descending nerve tracts in the spinal cord. Afterwards, a regular complex called secondary spinal cord injury (SSCI) leads to an increase in damage by initiating a cascade of biochemical, cellular and molecular mechanisms[18]. SSCI causes additional tissue loss and functional impairment[16]. Although these mechanisms were initiated during injury, they consisted of interacting, progressive chain reactions[17]. These reactions can lead to microvascular damage and cause endoneural oedema. Naturally, endoneural fluid pressure increases. Elimination of compression results in the resumption of oxygen and nutrient supplying blood flow. This rises the formation of lipid peroxidation and free oxygen radicals. The spinal cord is rich in lipids. In this case, lipid peroxidation is more severe than other tissues. Pro-inflammatory cytokines (e.g. IL-1, IL-6, TNF-α), reactive oxygen species (ROS), proteases and glutamate excitotoxicity are responsible for the tissue damage, neuronal loss and axonal degeneration resulting in permanent neurological deficits[19]. Lipid peroxidation products disrupt cellular integrity by increasing membrane permeability for ions. These products also damage many functional components such as membrane proteins and enzymes[10]. Extracellular calcium enters the cell because of the damaged cell membrane and causes apoptosis and oedema.

EGCG increases nerve retention after SCI due to its antioxidant properties[20]. Biochemical analysis showed that myeloperoxidase activity in EGCG-treated rats was markedly lower than control group rats without EGCG. This showed that EGCG inhibited neutrophil infiltration in the injured spinal cord tissue and reduced the expression of pro-inflammatory agents (TNF-α, IL1-β, iNOS and COX_2)[21].

Experimental studies in rats showed that high-dose EGCG (50 mg/kg) resulted in severe liver necrosis and death. In addition, hepatotoxic effects were also observed in green tea extracts[22]. Conversely, there is proof that refined green tea extracts are hepatoprotective in certain doses *in vivo*. These study results analyse that the drug containing EGCG may be hepatotoxic or hepatoprotective depending on the administration and dose[22]. In our study, the biochemical values of tissue samples were compared. The levels of lipid peroxidation in the treatment groups, namely, groups A, B and C, were shown to be statistically lower than the control group (group E) and the group treated with saline (group D). EGCG reduces secondary ischaemic damage following SCI as shown in the literature[21]. EGCG also reduces morbidity by reducing neurodegeneration associated with the spinal cord ischaemic process.

The histological and immunostaining studies showed that daily low-dose EGCG (group A) and low-dose (5 mg/kg/day) EGCG (group B) had less ROS formation and more neuroregeneration. In addition, it was shown to limit progressive damage and be neuroprotective due to SSCI. Immunostaining with GFAP was performed to evaluate the model of astrocytes. The evaluation showed that there was a better perivascular organisation in the group with low-dose (5 mg/kg) EGCG (group B) than high-dose (10 mg/kg) EGCG (group C). These findings proved that the appropriate dose of EGCG was neuroprotective, but high-dose EGCG caused neurodegeneration and impairment of BSCB.

CONCLUSION

Although the exact cellular targets for polyphenol action are still uncertain, the mechanism of action seems to involve iron-chelating features and antioxidant–radical scavenging. This mechanism appears to be reasonable to clarify neuronal apoptosis experienced after SCI. Our study indicated that steady injection of green tea (group A) and 5 mg/kg intake (group B) may augment regeneration after SCI. Further studies are needed to confirm this polyphenol derivative to be recommended as a treatment of SCI.

Ethics

Ethics Committee Approval: The study protocol was approved by the ethics committee of our hospital, Ankara Training and Research Hospital, and the test procedures were performed in compliance with the study guides of the Animal Laboratory of the same hospital (decision no: 0309, date: 14.01.2009).

Informed Consent: Since this study is an experimental study, informed consent was not obtained.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.D., Concept: R.A., Ö.M.U., A.D., G.T., Design: R.A., Ö.M.U., A.D., G.T., Data Collection or Processing: R.A., Ö.M.U., A.D., G.T., Analysis or Interpretation: R.A., Ö.M.U., A.D., G.T., Literature Search: R.A., Ö.M.U., A.D., G.T., Writing: R.A., Ö.M.U., A.D., G.T.

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

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

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):176-9
DOI: 10.4274/jtss.galenos.2020.198

EFFECTIVENESS OF UNIPEDICULAR KYPHOPLASTY IN OSTEOPOROTIC THORACOLUMBAR VERTEBRAL COMPRESSION FRACTURES IN ELDERLY PATIENTS: A RETROSPECTIVE STUDY

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ABSTRACT

Objective: Discussions regarding the effectiveness of unipedicular kyphoplasty in osteoporotic thoracolumbar vertebral fractures are found in the literature. To evaluate the clinical and radiologic efficacy of percutaneous unipedicular kyphoplasty in thoracolumbar osteoporotic vertebral compression fractures (OVCFs) in elderly patients.

Materials and Methods: Our study was conducted as a retrospective analysis. We enrolled patients who underwent percutaneous unipedicular kyphoplasty due to thoracolumbar OVCFs between January 2015 and December 2018. All patients were evaluated through two-planed radiographs and computed tomography scans. The local kyphosis angle (LKA) and vertebral corpus height (VCH) of the fractured vertebrae were measured. The Visual Analogue scale (VAS) and Oswestry Disability index (ODI) were used to determine the functional outcomes of patients.

Results: We included 77 patients (28 men, 49 women) with a mean of age 76.64±5.5 years (range, 69-86 years). In this study, all patients showed better improvement in ODI scores and LKA, increased VCH and decreased VAS scores 24 months postoperatively compared with preoperative values ($p<0.05$ for all). As a local complication, cement leakage from the kyphoplasty cannula tract to the posterior of the corpus was found in six patients, and cement leakage to the anterior was found in four patients.

Conclusion: Percutaneous unipedicular kyphoplasty is a reliable method with satisfactory clinical and radiologic results in thoracolumbar OVCFs in elderly patients.

Keywords: Kyphoplasty, thoracolumbar, compression fracture, osteoporosis

INTRODUCTION

Osteoporosis is a common, chronic, progressive disease characterised by low bone quality and increased risk of fracture with a multifactorial aetiology[1,2]. Vertebral compression fractures are the most common fractures associated with osteoporosis[3]. These types of fractures are most commonly seen in the lower thoracic and upper lumbar junction[1,4]. Osteoporotic vertebral compression fractures (OVCFs) are often caused by low-energy trauma in elderly patients[3]. These fractures are associated with increased morbidity and mortality, such as progressive kyphotic deformity and persistent low back pain and severely restricting the daily life activities of patients[3,5]. The primary treatment of OVCF is conservative treatment, with bed rest, analgesic and cast-brace[1,4,6]. However, the treatment choice is surgery for persistent pain for 4 weeks and progressive kyphotic deformity[1,4,6,7]. Surgical treatment provides advantages, such as early mobilisation, recovery of vertebral corpus height (VCH) and correction of kyphotic deformity in addition to reducing pain[6,7]. The preferred methods for surgical treatment are percutaneous vertebroplasty and kyphoplasty[6], but balloon kyphoplasty applications increased in recent years because they provide better VCH (97% vs 30%) and are safer due to the decreased risk of cement leakage owing to the cavity it creates[6,7].

Traditionally, successful results have been reported in the bipedicular kyphoplasty procedure[1,7]. In the current literature, studies have recommended the unipedicular approach due to its advantages, such as a shorter operative time, low cement leakage, low radiation exposure and low cost[7,8].

In this study, we reported the clinical and radiologic efficacy of percutaneous unipedicular kyphoplasty in thoracolumbar OVCF in elderly patients.

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MATERIALS AND METHODS

Study Design and Participants

Our study was conducted as a retrospective analysis. Between January 2015 and December 2018, patients who underwent percutaneous unipedicular kyphoplasty in a tertiary hospital due to thoracolumbar OVCF at the T11-L2 levels (Table 1) (Singh index <3)[9] were enrolled. Patients with pathologic fractures (metastasis, cancer), neurologic disease, history of infection, multiple levels of kyphoplasty and multiple trauma were excluded. Our study protocol was approved by the local ethics committee (no: 56-859/05.2020).

Surgical Method

After the fracture, the patients were followed up with conservative treatment, and surgical decision was made for patients with unsuccessful results. The time between the occurrence of fracture and day of hospitalisation was <8 weeks. Surgery was performed within 48 h after hospitalisation for all patients who decided to undergo surgery. The patients were prepared by lying in the prone position under local anaesthesia and sedation. The surgical procedure was performed percutaneously and unipedicular with the same kyphoplasty system by the same surgeon, approaching the fractured vertebral segment from the left side. After the level was determined using C-arm fluoroscopy, the kyphoplasty cannula was placed in the pedicle. Two-planed (anteroposterior and lateral) images were checked to ensure proper placement of the cannula. The cavity created by inflating the balloon sent from the cannula was filled with polymethylmethacrylate cement. The patients were assessed neurologically and radiologically, and then the surgery was terminated. The patients were mobilised after 2 h on the same day and discharged after 6 h.

Table 1. Clinical and demographic features

Variables	Results
Age (years)	76.64±5.5
Gender	
Male	28 (26.4)
Female	49 (63.6)
Fracture region	
Thoracic	40 (51.9)
Lumbar	37 (48.1)
Level of fracture	
Thoracic 11	7 (9.1)
Thoracic 12	33 (42.8)
Lumbar 1	26 (33.8)
Lumbar 2	11 (14.3)
Singh index	
1	23 (29.8)
2	34 (44.1)
3	20 (25.9)

n: Number
Data are presented as mean ± standard deviation or n (%)

Data Collection and Assessment Tools

Data were obtained from the patients' records. Clinical and demographic characteristics were recorded. Two-planed graphs (anteroposterior and lateral) and computed tomography scans of all patients were examined. The local kyphosis angle (LKA) of the fractured vertebrae was measured between the upper and lower end-plates, and the VCH was measured along with the heights of the lower and upper intact adjacent vertebrae[10]. Measurements were performed independently by two experienced surgeons, and their mean values were obtained. The Visual Analogue scale (VAS)[11] and Oswestry disability index (ODI) were used for the primary functional outcomes of the patients. The ODI has been validated for the Turkish population[12].

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences software (SPSS Inc., Chicago, IL, USA). The conformity of the data to normal distribution was assessed using the Kolmogorov-Smirnov test. Descriptive data were reported as mean ± standard deviation or median (interquartile range) values. Categorical variables were compared using the chi-square test or Fischer exact test. Student t-test or Mann-Whitney U test was used for comparisons between the groups. Risk factors were determined by using the binary logistic regression analysis. Statistical significance was determined at $p<0.05$.

RESULTS

This study included 77 patients (28 men, 49 women) with a mean of age 76.64±5.5 years (range, 69-86 years) were included. The clinical and demographic properties of the patients are summarised in Table 1. All patients showed improved values 24 months postoperatively compared with preoperative values, with decreased VAS scores, ODI scores, improved LKA and increased VCH ($p<0.05$ for all) (Table 2) (Figure 1). None of the patients had any neurologic or systemic complications. One patient who underwent L2 vertebral kyphoplasty developed spinal block under the L2 spinal level during the procedure. No cement leakage was observed outside the corpus under C-arm fluoroscopy. It was concluded that the block was caused by local anaesthetic escaping into the spinal canal. The block completely resolved after 4 h. As local complications, cement leakage from the kyphoplasty cannula tract to the posterior of the corpus was found in six patients, and cement leakage to the anterior was found in four patients. However, these conditions caused no pathology or symptoms.

DISCUSSION

The main objective of this study was to evaluate the effectiveness of unipedicular kyphoplasty in thoracolumbar

OVCF in older patients by comparing pre- and postoperative radiologic and clinical values. Radiologically, LKA values were significantly decreased, and VCH values increased. ODI values along with VAS were clinically significantly decreased. Kyphoplasty can be performed with a single balloon and a single pedicle with local anaesthesia, thereby avoiding general anaesthesia complications, making it a reliable and effective, cheap method.

According to the literature, the traditional method used in percutaneous surgery of OVCF is bipedicular kyphoplasty, and good results have been reported[1,7]. However, some studies also advocate the unipedicular approach[7,8]. In their prospective study, Rebolledo et al.[13] compared both techniques and noted that radiologic and clinical outcomes were similar, but the unipedicular technique significantly reduced surgical time. In another meta-analysis, including six randomised controlled trials, Xiang et al.[14] reported that the unipedicular technique was advantageous in terms of cost, operative time and radiation exposure, although the clinical results were the same. The cost is low in unipedicular kyphoplasty where a single balloon is used. General anaesthesia is associated with increased morbidity risk in elderly patients, such as hypothermia, respiratory depression, atelectasis, pneumonia and myocardial infarction[15,16]. In terms of complications, the administration of local anaesthesia is advantageous; however, to avoid the development of nerve root anaesthesia, the needle should not enter too deeply into the junction of the pedicle and vertebral body[16]. Regarding the neurologic deficits that may occur, early detection through the ability to communicate with patients is another advantage. Therefore, the administration of local anaesthesia or sedation-assisted local anaesthesia is one of the preferred methods. Liu et al.[16] reported that extrapedicular infiltration of anaesthesia for unipedicular kyphoplasty was superior for patients' comfort. We performed the procedures in our clinic under local anaesthesia. Although patients perceive some pain during balloon inflation, this was only temporary, and they remained comfortable.

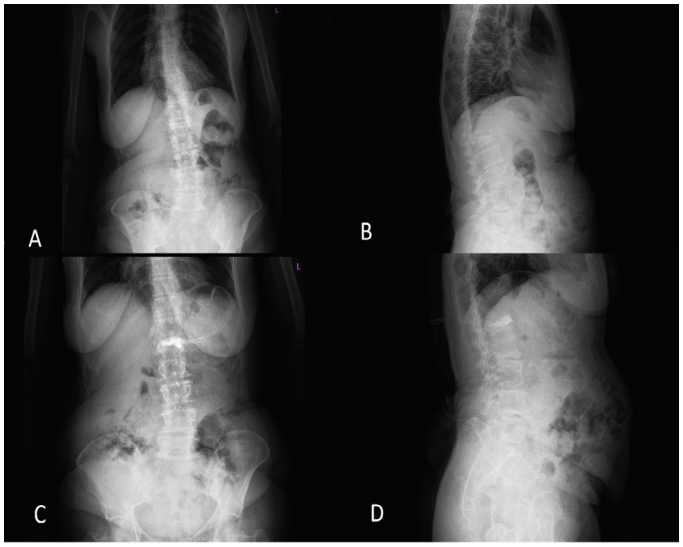

Figure 1. Radiographic images of a 74-year-old female patient
Preoperative anterior-posterior **(A)** and lateral **(B)** images show the compression fracture of the L1 vertebra. Postoperative anterior-posterior **(C)** and lateral **(D)** images illustrate the improvement in local kyphosis and vertebral height after kyphoplasty

Cement leakage and adjacent vertebral fractures are common complications[17]. The cement leakage rate in percutaneous applications was 18.4%[18], and the fracture rate in adjacent vertebrae was between 7.9% and 24%[19]. The most important risk factor for these complications was the large amount of cement used[18,20]. In the literature, the incidence of neurologic deficits due to cement leakage into the epidural space was 0.03%, and the incidence of pulmonary embolism due to cement leakage into the venous circulation was 0.01%[21]. Belkoff[22] reported that 2 cL cement volume was sufficient. However, re-fracture may occur in the zone without cement leakage as complication if the cement cannot be placed in the middle of the vertebral corpus[23]. In the literature, successful results have also been reported with unipedicular kyphoplasty in procedures other than OVCF. Papanastassiou et al.[24] compared bi- and unipedicular kyphoplasty in a patient with multiple myeloma and reported that no difference was observed between clinical and radiologic results. We have used this method in selected diseases other than OVCF and achieved successful results.

Study Limitations

The main limitation of our study is its retrospective design, as well as the small number of patients and lack of a control group.

CONCLUSION

In view of our study results, percutaneous unipedicular kyphoplasty surgery in thoracolumbar OVCF in elderly patients is a reliable method if the indication is correct. With this

Table 2. Radiologic and clinical comparison after surgery

Variables	Preoperative	Postoperative (24 months)	p value
LKA (°)	17.56±4.1	12.81±2.7	<0.05
VCH (mm)	16.45±2.3	25.50±2.7	<0.05
ODI score	14.78±2.2	6.42±1.3	<0.05
VAS score	6.25±1.8	1.70±1.1	<0.05

LKA: Local kyphosis angle, VCH: Vertebral corpus height, ODI: Oswestry Disability index, VAS: Visual Analogue scale

method, significant reduction in pain and satisfactory clinical and radiological results can be obtained.

Ethics

Ethics Committee Approval: This study was approved by the local ethics committee (no: 56-859/05.2020).

Informed Consent: This study was conducted as a retrospective analysis.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: E.K., Concept: E.K., F.S., Design: E.K., F.S., Data Collection or Processing: E.K., F.S., Analysis or Interpretation: E.K., F.S., Literature Search: E.K., F.S., Writing: E.K., F.S.

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

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

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ORIGINAL ARTICLE
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J Turk Spinal Surg 2020;31(3):180-4
DOI: 10.4274/jtss.galenos.2020.280

SURGICAL OUTCOMES OF SPINAL GUNSHOT WOUNDS

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ABSTRACT

Objective: Although gunshot injuries to the spine and spinal cord are usually not fatal, but these are associated with significant morbidities. The management of spinal gunshot wounds (SGW) is controversial. Some surgeons prefer early surgery, while others recommend late surgery, if necessary. The aim of this study was to analyse the results of patients who underwent treatment for SGW and discuss this with the current literature.

Materials and Methods: A retrospective study of SGW patients treated at a single institution was conducted. The study included a total of 32 patients over a 10-year period. Preoperative and early postoperative clinical and radiological data were analysed with the surgical technique used during the management of patients.

Results: Overall, 27 patients underwent surgical treatment and five patients underwent conservative management. The mean follow-up duration was 12±4 months. Eighteen patients were injured by bullet, while 14 patients were injured by shrapnels. Injury occurred at lumbar spine in 17 patients, thoracolumbar region in six, cervical spine in five, thoracic spine in three and lumbosacral region in one patient. Five patients underwent continuous lumbar drainage and cerebrospinal fluid (CSF) infection was seen in two patients. However, no patient died at the end of treatment period.

Conclusion: Patients with SGW should undergo comprehensive clinical and radiological assessments for surgical treatment. The main indications for early surgical intervention are CSF fistula and progressive neurological deficits. Stabilisation surgery should be the treatment option for patients with spinal instability.

Keywords: Spine, gunshot wound, surgery, morbidity

INTRODUCTION

Spinal gunshot wounds (SGW) are an important health problem in both military and civilian surroundings[1-3]. SGW account for 13% to 17% of all spinal cord injuries each year[4]. These injuries may affect both the spinal column and spinal cord[5,6]. Clinical presentation of SGW depends on the site and type of injury. Wounds that are not penetrated or involved the spinal cord usually do not cause neurological deficits. Severe neurological deficits such as paraplegia or quadriplegia occur if the spinal cord is damaged. However, SGW to the upper cervical spine, or associated with thoracic or abdominal injuries, may cause mortality[7].

Neurological examination is the first step of evaluation of SGW after the first aid. Spinal shock may occur when the spinal cord is totally damaged. The signs of a spinal cord injury are weakness and sensorial disturbances. Radiological investigation is essential for the exact diagnosis and possible indications of surgery[8].

Computed tomography (CT) and magnetic resonance imaging (MRI) are used for the evaluation of SGW[9]. Metallic and other fragments located in and around the spinal column are shown through CT scans. CT scan also reveals bony damage and gives information about the stability of spinal column. MRI should be obtained after the CT scan to rule out the presence of any metallic fragment in the body. MRI is contraindicated in patients having metallic fragments in the spine and spinal cord. MRI is also essential for the evaluation of the spinal cord damage and detection of cerebrospinal fluid (CSF) fistula or collection (pseudomeningocele). It can also be used for the detection of spinal or paraspinal abscess formation in the late period of SGW[1-4,6].

Surgical treatment is opted in SGW in case of the following: if there is CSF fistula, early and progressive neurological deficits associated with significant spinal cord compression and spinal instability[10,11]. The surgical technique involves decompression of the spinal cord and spinal roots, closure of dura mater and reconstruction of the spinal column by stabilisation surgery.

The aim of this study is to present our experience of SGW and discuss our results with the current literature.

MATERIALS AND METHODS

In this study, 32 patients with SGW, who underwent conservative and surgical treatment between 2010 and 2019, were reviewed

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retrospectively. All the patients were operated by the surgical team in a single university hospital. Ethical approval for this study was obtained from our institutional ethics committee [University of Health Sciences Gülhane Medical Research Ethics Committee Medical Research Ethics Committee (approval date: 30.06.2020, approval number: 2020/296)]. Written informed consent was obtained to publish the data.

Patients with SGW, having all clinical, radiological and surgical data, follow-up period of at least 6 months and age between 18 and 60 years were included in the study. Patients who had previous surgery done in another centre, children and patients without enough clinical and radiological data were excluded from the study.

Plain X-rays of the patients obtained just after the injury were reviewed. CT and MRI scans of the patients were evaluated carefully. Surgical data and clinical outcomes were retracted and analysed. Results of CSF cultures were recorded.

RESULTS

A total of 32 patients (one female, 31 males) with a mean age of 30.03 years (ranged between 21 and 54 years) were treated in our department. The mean follow-up period was 12 months. Clinical and radiological examinations of the patients determined the type of treatment as conservative or surgical. Plain X-rays and CT scans were obtained from all patients (Figures 1, 2 and 3). MRI was performed in 25 patients (Figure 4); seven patients did not undergo MRI because of the presence of metallic fragments within the body. Locations of spinal injuries were as follows: lumbar spine (17 patients), thoracolumbar region (six patients), cervical spine (five patients), thoracic spine (three patients) and lumbosacral region in one patient. Bullet injury was occurred in 18 patients and shrapnel injury (grenade, landmine and handmade explosive) in 14 patients (Table 1). Twenty-five patients were military persons who were

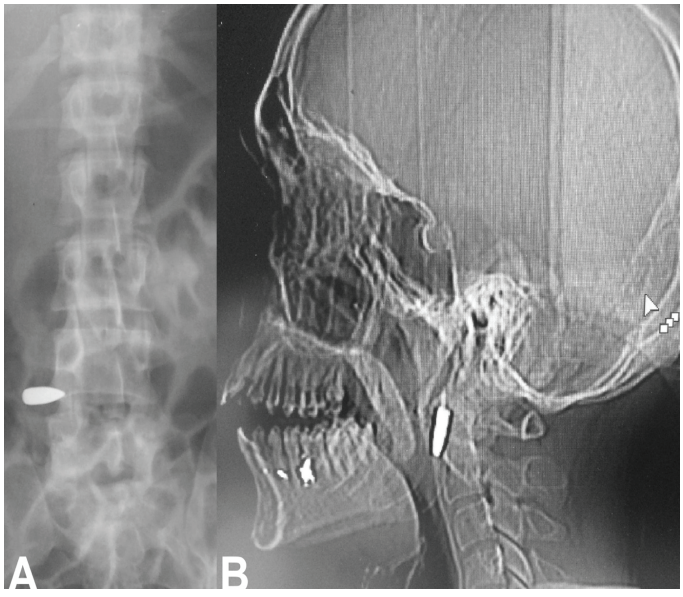

Figure 1. Radiographs of a patient with lumbosacral SGW (**A**) and cervical SGW (**B**). There was a bullet just in front of the C1 level (**B**)
SGW: Spinal gunshot wound

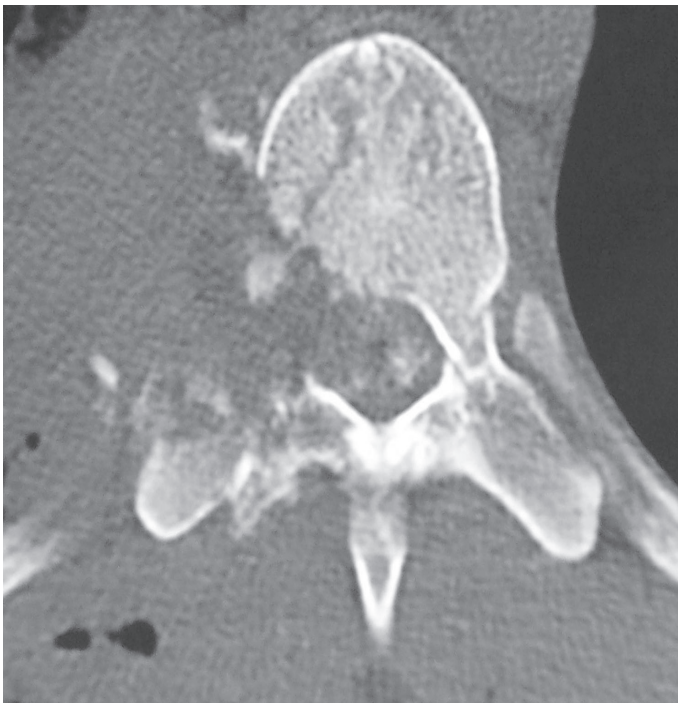

Figure 2. CT scan of a patient with SGW at thoracic level. Right side of the body and the pedicle of the vertebrae were significantly damaged
CT: Computed tomography, SGW: Spinal gunshot wound

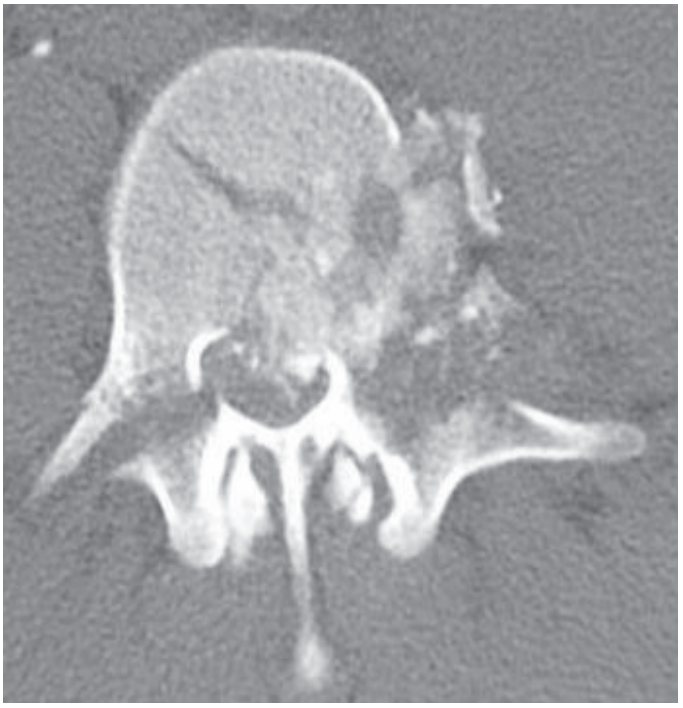

Figure 3. CT scan of a patient with SGW at lumbar level. Body and left pedicle were damaged and there were bone fragments in the spinal canal
CT: Computed tomography, SGW: Spinal gunshot wound

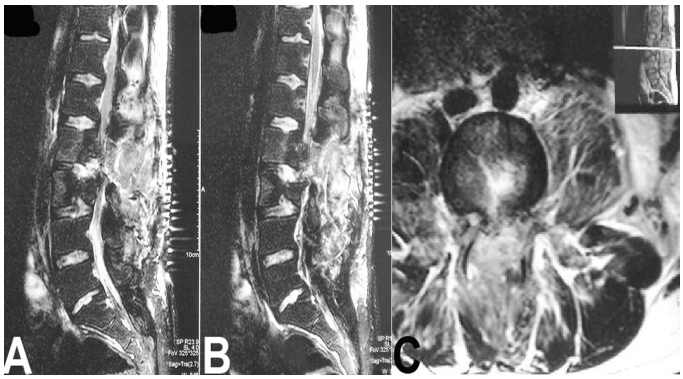

Figure 4. Postoperative sagittal (**A, B**) and axial (**C**) T2-weighed MRI scans of a patient with SGW at L3 level. Spine, spinal cord and paravertebral soft tissues were significantly damaged by a high-velocity bullet

SGW: Spinal gunshot wounds

Table 1. The demographic, radiological and surgical characteristics of patients with SGW

Variable	Number (%)
Gender	
Female	1 (3%)
Male	31 (97%)
Total	32 (100%)
Age (years)	
<30	19 (59%)
30-45	10 (32%)
>45	3 (9%)
Total	32 (100%)
Injury level	
Lumbar	17 (53%)
Thoracolumbar	6 (19%)
Cervical	5 (16%)
Thoracic	3 (9%)
Lumbosacral	1(3%)
Total	32 (100%)
Cause of injury	
Bullet	18 (56%)
Shrapnel	14 (44%)
Total	32 (100%)
Indication of surgery	
CSF fistula	11 (41%)
Spinal instability	7 (26%)
Abscess	3 (11%)
Foreign body	4 (15%)
Progressive neurological deficits	2 (7%)
Total	27 (100%)

SGW: Spinal gunshot wounds, CSF: Cerebrospinal fluid

injured in the battlefields by bullets, grenades and landmines. Seven patients were civilians who were injured by bullets and handmade explosives during the terrorist activities.

Five patients were treated conservatively and 27 (84.37%) patients underwent surgical treatment. Surgical treatment was opted for the following reasons: CSF leakage in 11 (40.74%) patients, spinal instability in seven patients, spinal abscess in three patients, foreign body in four patients and progressive neurological deficit in two patients. Decompression with duraplasty was performed in 20 patients and simple decompression was performed in seven patients. Stabilisation surgery with decompression and fusion was performed in seven patients. Continuous lumbar drainage was performed in five patients, and microorganism was isolated in two patients. The microorganisms were *Klebsiella* and *Pseudomonas* species. These patients were treated with relevant antibiotics. The mean duration of lumbar drainage was 6 days. No patient was died after surgery or in the postoperative follow-up period. Patients underwent periodical radiological follow-up using CT scans and MRI if necessary. Paraplegia was found as the common sequela of SGW in 14 patients and quadriplegia was found in two patients. Minor neurological deficits were detected in nine patients after surgery, who were existed in the preoperative period.

DISCUSSION

The results of 32 patients with SGW were presented in our study. Most of the patients were military persons younger than 30 years. Surgical treatment was performed in 84% of patients. The main indication of surgery in our series was CSF fistula and no mortality was encountered after the treatment. Stabilisation surgery was performed in seven patients with spinal instability after the injury.

SGW are common in the military practice[3,7,8,12]. Injuries are mainly caused by bullets and shrapnels in the battlefields[7,12,13]. Today, landmines and handmade explosives are frequently used in the terrorist activities. Thus, both military persons and civilians may be injured by these guns[1,2,12]. In our series, 25 patients were from the army and were injured by bullets and shrapnels. Bullet was found to be the most common injured agent.

Gunshot wounds are classified as low-velocity or high-velocity based on the speed of projectile[12]. Low-velocity wounds are caused by small-calibre handguns and thus there are less tissue damage and spinal instability than high-velocity wounds[2,3]. The damage created by a gunshot depends on the kinetic energy of the projectile[3,12]. Shrapnels are also considered as low-velocity agents. However, high-velocity wounds are secondary to missiles that are mostly used in military practice such as rifles. These wounds create severe damage and cavity in the body and the risk of infection is high because of the large injury area and damaged tissue[12,14,15]. In our series, 15 patients were injured with rifle bullet and three were injured with handgun

bullet. CSF fistula and infection in patients injured with rifle bullet were mostly observed in our study because of the large cavity created by the bullet itself.

The most vulnerable region of the human body are the spine and the spinal cord. Tumours and traumas of the spine usually result in significant morbidity[16,17]. Cervical spine is the upper part of the spinal column. Although injuries to the cervical spinal cord is relatively rare, yet it is associated with severe neurological deficits[15]. Variations of the cervical spine make the management of cervical GSW really challenging because of its complex structure[16]. Spinal nerve roots leave the spinal cord from the relevant segment. However, segments of the spinal cord do not correspond to the respective vertebral level. Spinal anatomical variations exist in terms of the segment and the level of vertebra[18]. Therefore, the neurological deficits secondary to SGW vary because of the involved segment of the spine and may confuse the surgeon. Nerve plexuses formed by the spinal nerve roots may also be involved after the injury[19,20]. Brachial and lumbar plexuses may be injured after SGW to the cervical and lumbar spine[19]. Careful radiological and neurological examinations predict the level of injury better. A good anatomical knowledge of the nervous system will help achieve better neurological outcome after injury.

Neurological examination is required for deciding the type of treatment and also for the prediction of neurological condition of the patient after the treatment[7,8,10,11]. The major signs of a spinal injury are pain and neurological deficits[3,7,8]. Back pain is the common complaint among patients with lumbar SGW[21]. American Spinal Injury Association scoring system is popularly used for the clinical assessment of SGW[3]. It is helpful for objective evaluation of patients both in preoperative and postoperative periods. Plain X-rays are mostly used for the initial evaluation of SGW. Anteroposterior and lateral X-rays can detect foreign bodies and major spinal fractures. The spinal stability can be examined by dynamic X-rays (in flexion and extension) [10,11]. CT and MRI are used for the detailed evaluation of SGW[12]. CT scan reveals the injury level and structure of wound-causing agent (metal or others). MRI is useful for the detection of the spinal cord injury and soft tissue lesions such as abscess or pseudomeningocele. However, MRI is contraindicated in the presence of metallic fragment.

Medical treatment of SGW includes tetanus prophylaxis, antibiotics and steroids. Broad-spectrum antibiotics should be initiated immediately at least 48-72 hours after SGW. High-dose corticosteroids have been advocated in patients with spinal cord injury for many years. However, many studies have questioned their use because of the risks associated with complications and side effects and lack of evidence for neurological improvement[13]. Experimental studies advocated splenectomy as a prophylactic treatment for spinal cord injury[22]. However, this technique is not useful in SGW. Some authors suggested the use of mannitol in the management of spinal cord injury, but there is no evidence in clinical practice yet[23]. Thus, there is still no definitive medical treatment method used for spinal cord injury.

Surgical treatment is the gold standard for SGW. However, the indications of surgery are important to obtain a satisfactory outcome. The main indications of surgical treatment are CSF fistula and progressive neurological deficit associated with spinal cord compression as performed in our series[4,5,7,8,11]. The main complication of SGW and CSF fistula is infection. Spinal abscesses may develop after surgery[24,25]. Continuous lumbar drainage may be performed in patients with CSF fistula who were not treated surgically. Antibiotic-impregnated catheters may be used for the prevention of CSF infection[26]. Spinal instability caused by damaged anterior and posterior elements of the spine is another indication of surgery[10,11,27].

Bilgiç et al.[10] reported their experience with 27 male patients with SGW and concluded that patients with incomplete and/or lumbar fracture had better prognosis for functional recovery when surgery was performed early. Şehirlioğlu et al.[11] presented 19 patients with spinal fracture caused by SGW and concluded that early reduction and stabilisation after unstable spinal fractures enable great utilities for mobilisation and rehabilitation of the patients. Kahraman et al.[7] analysed 106 patients with spinal missile injury from war zones and concluded that surgical treatment was not essential for SGW; however, it may be required for patients with CSF fistula, infection and spinal instability, and rapid neurological deterioration. Duz et al.[8] presented the surgical outcome of 122 patients with spinal missile injuries and pointed out that anteroposterior and oblique trajectories should be accepted as highly infective injuries in the lumbar region, but side-to-side trajectory missile injuries are usually unstable and require stabilisation surgery. Our results are similar with those of previous studies.

Study Limitations

The relatively low number of patients and lack of statistical analysis are the limitations of our study.

CONCLUSION

Surgical treatment is the gold standard for the management of SGW in cases of CSF fistula and progressive neurological deficit. Spinal instability is another indication for surgical intervention. Infection and neurological deficit are main complications. Prospective clinical studies are needed to improve the surgical outcomes of patients with SGW.

Ethics

Ethics Committee Approval: The study was performed by the ethical standards of the 1964 Declaration of Helsinki and approved by the University of Health Sciences Gülhane Medical Research Ethics Committee Medical Research Ethics Committee (Approval date: 30.06.2020, approval number: 2020/296).

Informed Consent: Written informed consent was obtained to publish the data.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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J Turk Spinal Surg 2020;31(3):185-7
DOI: 10.4274/jtss.galenos.2020.207

CASE REPORT
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ACUTE CORD REPERFUSION INJURY AFTER POSTERIOR CERVICAL DECOMPRESSION FOR CHRONIC POSTERIOR LONGITUDINAL LIGAMENT OSSIFICATION STENOSIS

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ABSTRACT

A 63-year-old male patient was referred to our outpatient clinic with complaints of upper and lower limbs weakness, which started progressively 5 years ago. Cervical X-ray and magnetic resonance imaging showed straitening of the cervical column in a fixed flexion position and fusion of the vertebral bodies, with diffuse type posterior longitudinal ligament ossification with secondary canal stenosis. The patient was operated with C2-T2 laminectomy. In the immediate post-operative period, the patient was conscious. However, he was unable to breath by himself with insufficient respiratory tidal volume and worsening of the weakness of the extremities. Emergency cervical computed tomography scan showed proper decompression of the cervical canal, no evidence of haemorrhage, and enlarged oedematous spinal cord. The patient was diagnosed of post-decompression reperfusion injury with secondary diaphragm paralysis. Ventilation and medical treatment were applied to manage the situation and the patient improved in his lower limbs motor power and in the tidal volume. The decision was to transfer the patient to another rehabilitation centre to continue treatment.

Keywords: Blood spine barrier, spinal decompression, posterior longitudinal ligament ossification, white cord syndrome

INTRODUCTION

Sudden neurological deterioration due to acute spinal cord reperfusion injury following spinal decompression is a rarely reported incident in literature. Post-operative magnetic resonance imaging (MRI) shows that cord ischaemia and oedema are characterised by a hyperintense intrinsic cord signal, which is typically addressed as the "white cord syndrome"[1]. Although documented in few cases in literature, this pathology is rarely reported after decompression for posterior longitudinal ligament ossification (PLLO)[2].

CASE REPORT

A 63-year-old male patient with a medical history of Diabetes Mellitus was referred to our outpatient clinic with complaints of upper and lower limbs weakness, which started progressively 5 years ago. Neurological examination revealed upper limb weakness (3/5) and lower limb weakness (2/5). Hyposthesia was in all extremities with hyper-reflexia in both lower limbs. Examination of the neck revealed fixed flexed position of the head with limited neck movement, especially of the flexion and extension. Cervical X-ray showed straitening of the cervical column with fixed flexion position and fusion of the vertebral bodies. Cervical MRI was done in a specialised imaging centre while the neck was in flexion position. The MRI showed the diffuse type PLLO with secondary canal stenosis (Figure 1). As a differential diagnosis diffuse idiopathic skeletal hypersoteosis was considered and accordingly dorsal and lumbosacral spine X-rays were performed and showed no calcification or ossification of soft tissues (ligaments and enthuses) and no sacroiliac joint fusion. These findings favoured the diagnosis of cervical diffuse PLLO.

A decision to perform only laminectomy from C2 to T2 without fixation as the vertebral bodies were already fused was made after discussion on the case. The patient was prepared for

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surgery and laboratory results showed no abnormalities. The patient was operated in prone position.

Wide laminectomy was performed starting from C2 level to T2 level, and the spinal cord was

decompressed (Figure 2A). The surgery was uneventful and vital signs were stable with no fluctuations or unusual recordings. After decompression, bulging of the spinal dura was noted and with gentle palpation the dura was found unusually tense.

In the immediate post-operative period, the patient gained consciousness. However, he was unable to breath by himself with a respiratory tidal volume of 50 mL. Neurologic examination revealed worsening of the weakness of all extremities (1/5), with profound hyposthesia in all extremities. The patient remained intubated and an emergency cervical computed tomography (CT) scan was performed and it showed proper decompression of the cervical canal, and no evidence of haemorrhage, however, enlarged oedematous spinal cord (Figure 2B and C). The first decision was to perform an MRI, but the MRI machine in the centre was not good enough to insert the patient with fixed flexed neck and the condition of the patient was not good for transfer to another imaging centre. So, the CT scan was performed to exclude surgically treatable possible complications, such as hematoma. The patient was diagnosed with post-decompression reperfusion injury with secondary diaphragm paralysis and was transferred to the intensive care unit. The ventilator setting was synchronized intermittent mandatory ventilation (SIMV) mode and medical treatment started with high doses of dexamethasone, citicoline, Nucleo-CMP, cyano-cobalamine injections, and intravenous vitamin C. In the early post-operative period, the patient showed improvement in lower limbs motor power (3/5) and in the tidal volume (500 mL). The patient did not show neuropathic pain. Instead, he continued to suffer from hyposthesia in all extremities. It may be was due to the extensive neural injury which might be included the sensory pathways. The patient was fully awake and felt discomfort with the endotracheal tube. For this reason, with the expectation of the long term need for the ventilator, tracheostomy was opened in the post-operative day 7. In the post-operative day 10, the tidal volume was around 700 mL and the respiratory mode was alternating between SIMV and continuous positive airway pressure therapy. The patient was later transferred to another rehabilitation centre.

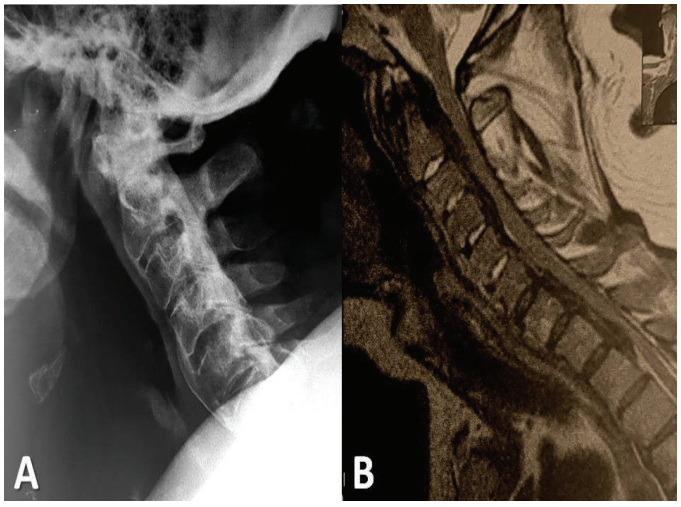

Figure 1. Pre-operative **A)** lateral cervical X-ray and **B)** T2-weighted sagittal cervical MRI demonstrating the diffuse type PLLO and secondary canal stenosis, with fusion of vertebral bodies and straitening of the cervical spine with fixed flexion position

PLLO: Posterior longitudinal ligament ossification, MRI: Magnetic resonance imaging

DISCUSSION

Posterior cervical decompression is a common surgical technique indicated for pathologies resulting in symptomatic spinal cord and/or root compression. Vascular insult such as ischaemia/reperfusion injury can develop due to rapid cord oedema after acute increased blood perfusion to the affected area[1,2]. In the case of our patient, the diffuse type PLLO with secondary chronic canal stenosis produced a large area of cord oedema. The source of the acute cord injury was likely due to the sudden decompression of the spinal cord. This led to disruption in the blood-brain and the blood-spinal cord barriers. The end result was reperfusion injury of the cord[1].

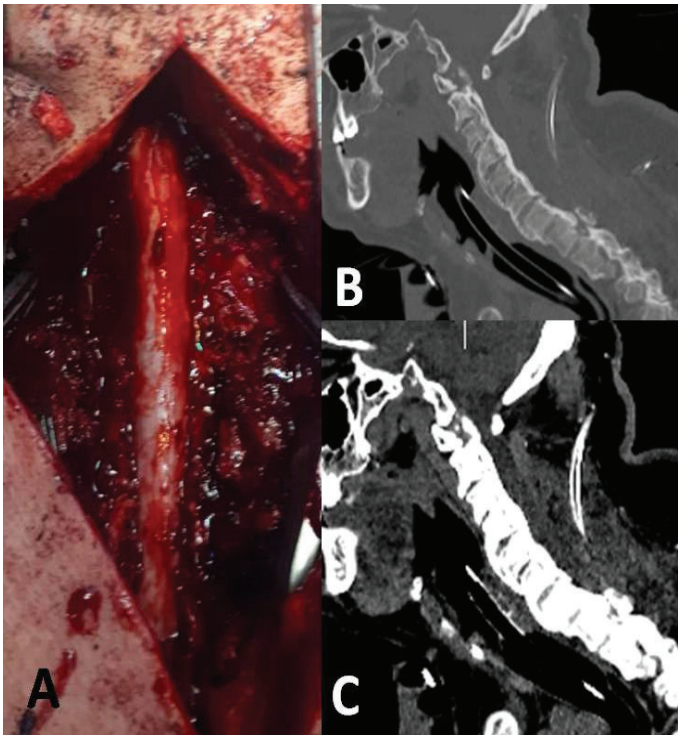

Figure 2. **A)** Intra-operative view after C2-T2 laminectomy showing the decompression of the spinal cord and bulging of the thecal sac, **B)** Bone window and **C)** soft tissue window sagittal cervical CT scan showing the decompression of the cervical spinal canal. The soft tissue window shows haemorrhage, but signs of cord oedema demonstrated increased volume and hypodensity of the spinal cord

CT: Computed tomography

Spinal cord ischaemia/reperfusion injury has also been shown to be related to free radical-related neural injury, mitochondria-dependant apoptosis, TNF-α production, and specific phospholipid signalling cascades resulting in neuronal injury in animal models and human studies[2-4]. Studies suggested that spinal cord ischaemic injury results in detachment of astrocyte foot processes from endothelial cell surfaces, thus inhibiting tight junction function in the blood-brain barrier (BBB)[3-5], leading to the disruption of transport systems and ionic buffering and enhancing the passage of blood borne or neurotrophic substances (specifically TNF- α) through the BBB past saturation point[3,4].

Experimental studies showed that post-operative acute increase in the production of cytokines within the spinal cord was independent of the time of surgical intervention[6]. Delayed surgical decompression resulted in unresolved cytokine production (up to 5 weeks following decompression), sustained astrogliosis, and systemic increase in the ratio of peripheral inflammatory/patrolling blood monocytes. This showed absence of neurological improvement. Contrarily, early decompression resulted in resolution of inflammation and astrogliosis and was associated with neurological recovery in the upper and lower extremities, and improvement of pain in the upper extremities. Post-operative abnormal expansion of the T2 high signal intensity was documented in 6.1% of the patients, which is typically labelled as the "white cord syndrome"[7]. Of these patients 43% were asymptomatic[7]. In the symptomatic patients, typical clinical finding was diffuse paresis of the upper limbs without deterioration of lower limbs, as seen in our case. However, definite radiologic diagnosis of white cord syndrome in our patient was not available due to the lack of post-operative MRI due to technical issues. Thus, it is considered as a possible diagnosis bases on the clinical picture and course.

The treatment of acute spinal cord reperfusion injury is challenging, and there are no precise guidelines described in literature for the treatment of this specific condition. There is a general direction to treat this pathology as acute spinal cord injury in spite of the aetiology. Treatment with high doses dexamethasone IV 4 mg × 4, citicoline IV 1 gr × 2, Nucleo-CMP forte tablet (Cytidine 5mg and Uridine - 5'- trisodium triphosphate 1.33 mg) 2 × 2, cyano-cobalamine 1000 mcg/mL IM 1 mL × 1 for 10 days and vitamin C IV 500 mg × 1 for 5 days were reported and clinical studies showed their efficiency in the treatment of spinal cord injury[8-10]. These medications were used in our case with observation on the improvement of our patient. Moreover, based on the National Acute Spinal Cord Injury Study II and III trials, methylprednisolone is currently recommended for the management of acute spinal cord injury[11]. These trials demonstrated the fast acting and effectiveness of methylprednisone in improving motor scores in acute spinal cord injury patients when compared to placebo[11]. However, due the medical condition of our patient with difficult controlled diabetes and metabolic disturbances, the medical and intensive care unit team preferred to avoid methylprednisolone treatment in our patient and replaced it with dexamethasone instead.

Ethics

Informed Consent: The patient signed an informed consent form.

Peer-review: Externally peer-reviewed.

Authorship Contributions:

Surgical and Medical Practices: B.A., E.K., Concept: B.A., E.K., L.R., Design: M.AQ., Data Collection or Processing: K.A., Analysis or Interpretation: M.AQ., Literature Search: K.A., L.R., Writing: B.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.

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CASE REPORT
188

J Turk Spinal Surg 2020;31(3):188-91
DOI: 10.4274/jtss.galenos.2020.215

ASYMPTOMATIC EXTRUSION OF ANTERIOR CERVICAL SPINE IMPLANT FROM HYPOPHARYNX: A CASE REPORT

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ABSTRACT

Anterior cervical spine surgery for cervical disc radiculopathy was first described by Smith and Robinson. Hardware placement in the anterior cervical spine began in the 1980s, primarily for anterior stabilisation of cervical spine trauma. Later, its use extended into the management of cervical radiculopathy in the form of discectomy and arthrodesis. Anterior cervical discectomy and fusion and anterior cervical corpectomy and fusion are now well-recognised as favourable methods of fixation for cervical spine spondylotic myelopathy, traumatic spine, ossification of posterior longitudinal ligament, neoplasia and infection. However, numerous complications have been reported following anterior cervical surgery. Immediate complications include oesophageal rupture, recurrent laryngeal nerve injury, cerebrospinal fluid leakage, vascular complications, worsening of neurological status, etc. Among late complications, they are systemic sepsis, abscess formation, mediastinitis, screw pullout, plate failure and fistula formation, etc. We present a case report of a 64-year-old male who presented with spontaneous asymptomatic dislodgement of parts of the anterior cervical plating system through the posterior wall of hypopharynx 2 years after the index surgery.

Keywords: Asymptomatic, extrusion, cervical implant

INTRODUCTION

Anterior cervical spine procedures with instrumented fusion are the procedures of choice for many cervical spine pathologies. Dislodgement of hardware is a known complication in the literature. Diagnosis of dislodgement of hardware following anterior cervical discectomy and fusion (ACDF) and anterior cervical corpectomy and fusion (ACCF) is difficult because dysphagia is common, with a prevalence ranging from 2% to 60%[1]. Around 14% of patients have reported persistent dysphagia up to 2 years after ACDF surgery[2]. However, in most patients, dysphagia resolves spontaneously without any intervention. Only 2% require further intervention[3]. Most commonly, the pulled out screw extrudes from esophagus[4]. We present a case of asymptomatic screw extrusion from the hypopharynx, which is quite rare.

CASE REPORT

A 64-year-old male presented with progressive weakness and numbness in upper and lower limbs for the last one year. He was unable to do occupational writing work and his daily routine activities. There was no involvement of bowel and bladder. After detailed investigations, he was diagnosed with cervical spine spondylotic myelopathy (Figure 1). He underwent C4 corpectomy, decompression of spinal cord and fixation from C3 to C5 using an anterior plating system and titanium mesh cage with autologous bone graft (Figure 2). Surgery was uneventful and patient got improved by 2 weeks after surgery. Three months after the surgery, the patient was again able to do occupational writing work as well as his daily routine activities. The patient was asymptomatic until 2 years after the index surgery, when one day he developed a feeling of a foreign body in his throat, which caused forceful cough reflex. A screw was expelled out from his mouth. Due to a busy festival season and asymptomatic presentation, the patient did not rush to the hospital. After a week, he presented with the dislodged screw in his hand. Plain radiograph confirmed a missing screw from the plate (Figure 3). Direct laryngoscopy and endoscopy were done to see if there was a fistula or abscess in the pharynx or oesophagus. We found a blood clot with the fistula underneath (Figure 4). Computed tomography (CT) scan confirmed a fistula track from cervical spine to hypopharynx (Figure 5). Though the fistula was present, as it was visualised by non-contrast CT scan and laryngoscopy, the patient did not have any complaint in his throat until the last follow-up. Therefore, we decided to keep him under observation.

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ORCID ID: orcid.org/0000-0003-1510-0728

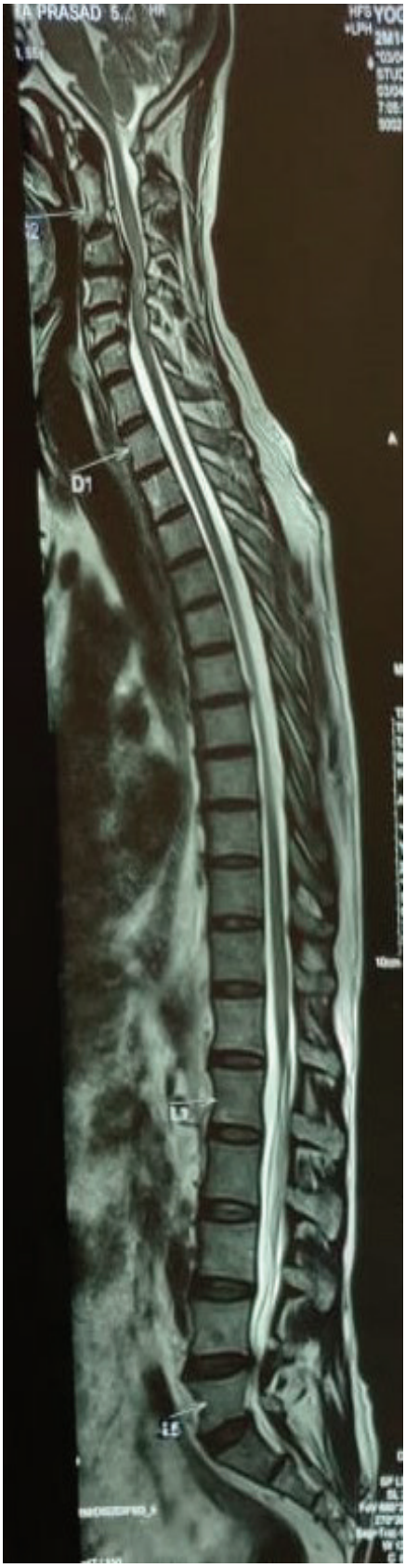

Figure 1. MRI T2 sag of C-spine with CSM
sag: Sagittal, CSM: Cervical spondylotic myelopathy, MRI: Magnetic resonance imaging

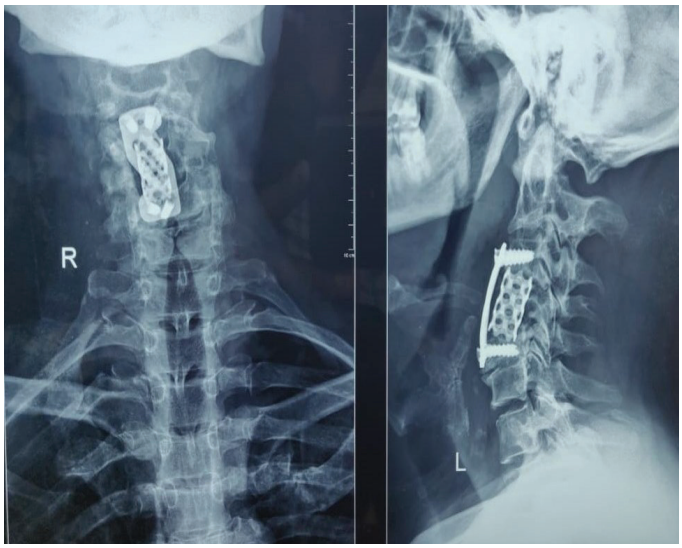

Figure 2. Post-operative X-ray with anterior plate and Harm's cage at C4

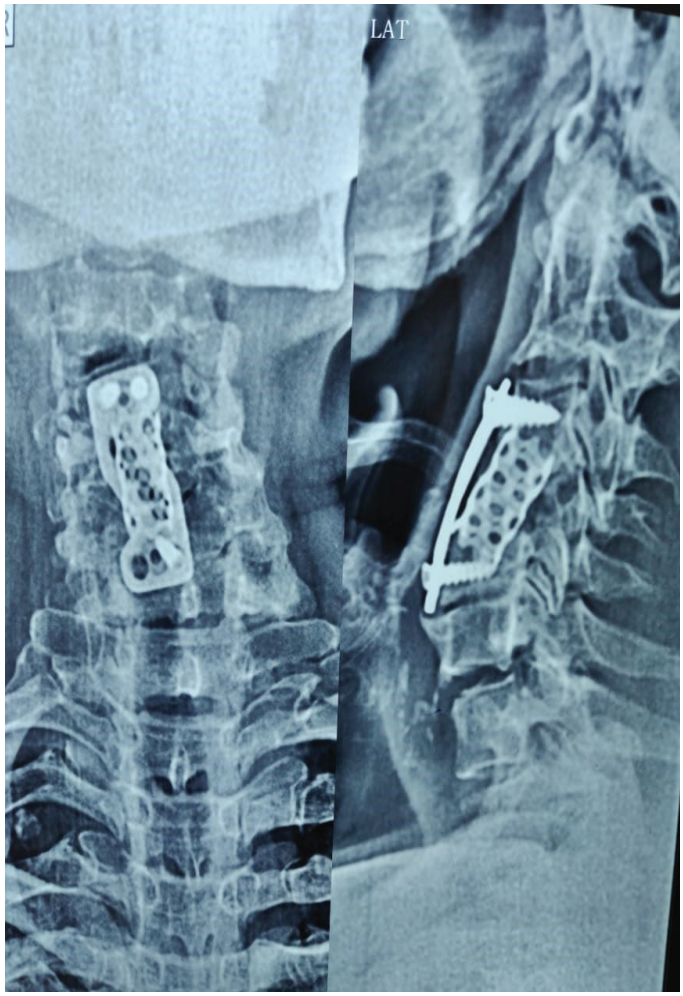

Figure 3. X-ray C-spine AP & Lat view showing missing screw
AP: Anteroposterior, Lat: Lateral

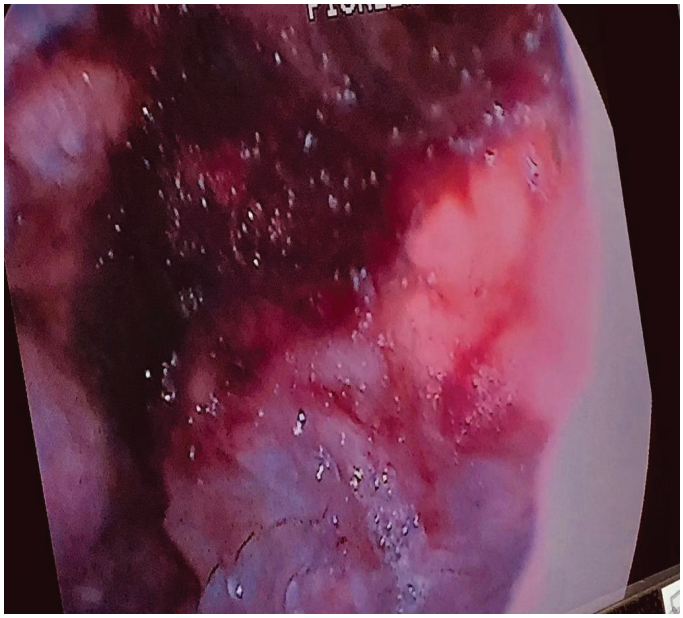

Figure 4. Laryngoscopy showing blood clot on posterior wall of hypopharynx with fistula underneath

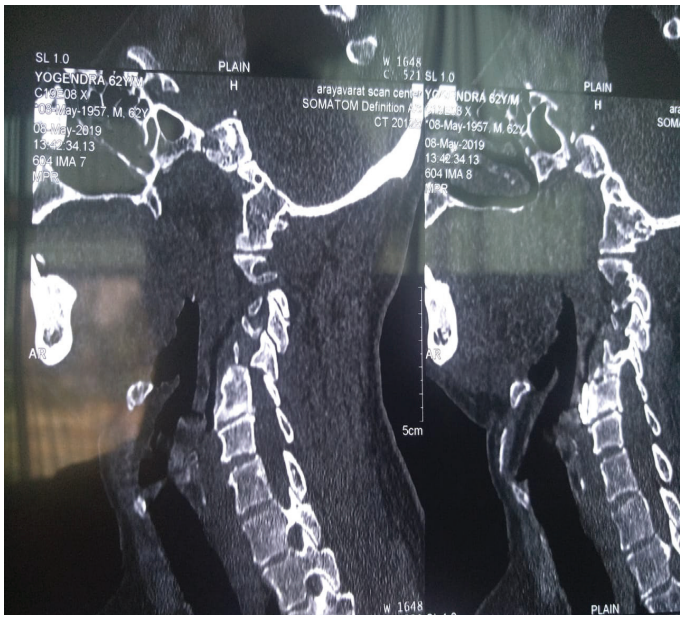

Figure 5. CT scan of C-spine, confirming fistula track communicating to hypopharynx

CT: Computed tomography

DISCUSSION

ACDF/ACCF procedures are widely used for many pathologic cervical conditions due to advanced improvement in hardware designs and widespread familiarity of surgeons with anterior cervical spine approach[3]. Similar to any other surgery, anterior cervical spine procedures with hardware placement are not free from complications. Many early complications may resolve with simple conservative management, but late complications generally need surgical intervention[5]. Ning et al.[1] found 239 complications in 2,233 patients, including screw loosening in 37 (1.7%) patients, plate loosening in 72 (3.2%) patients, broken screw in four (0.2%) patients and broken plate in two (0.1%) patients. Lowery and McDonough[6] found hardware failure in 38 (35%) patients out of 109. Sun et al.[7] observed oesophageal fistulas in five patients out of 2,348 patients. Similarly, Tasiou et al.[5] found in one (0.9%) patient with implant dislodgement. Korovessis et al.[8] reported oesophageal perforation associated with spondylodiscitis. In addition, early life-threatening complications are also reported. Li et al.[9] presented a case report of acute cervical hematoma, screw pull-out and oesophageal perforation. Sometimes, late complications of ACDF are life-threatening and should be addressed aggressively. Wong et al.[10] reported a case of acute airway obstruction by pre-vertebral abscess formation and a missing screw. Screw expulsion from oesophagus and fistula formation is well-documented in the literature but asymptomatic dislodgement from the hypopharynx is very rare presentation.

With use of a third-generation locking plate system, implant failure rate is reduced; however, higher cervical fixation gives small surgical field for optimum screw position. Two cortex purchases were a strict requisite for old non-locking plate system, but unicortical purchase is sufficient in locking plate system. Ours was a non-locking screw plate system.

Every patient with a complaint of dysphagia should be evaluated in detail to avoid life- threatening complications. Patients presenting with an extruded screw should be considered as having a fistula unless proven otherwise. Work-up should include complete blood count, erythrocyte sedimentation rate, C-reactive protein, plain radiographs, CT scan, magnetic resonance imaging, laryngoscopy and endoscopy. Vital stability, nasogastric tube placement, nutritional and fluid maintenance, intravenous broad-spectrum antibiotics and urgent surgical intervention are the mainstay treatment. Entangled implants may have to be removed urgently depending on location. A fistula can be repaired with simple suturing to a muscle flap, such as the pectoralis or sternocleidomastoid flap, in collaboration with an ear, nose and throat surgeon. Preoperative evaluation of bone quality and systemic diseases, careful scrutiny for anatomical anomalies, use of improved new generation plating system and appropriate surgical techniques may decrease the chances of screw dislodgement following instrumented anterior cervical spine fusion. We advise not underestimating a complaint of dysphagia or foreign body sensation in a patient who has previously undergone ACDF/ACCF surgery. Every patient must undergo laryngoscopy and endoscopy with plain radiographs of the spine and abdomen to rule out any dislodgement of the implant.

In conclusion, our case report is a rare presentation. Until now, oesophageal screw extrusion with fistula and abscess formation is well-documented in the literature. Immediate complications like oesophageal rupture, hematoma formation, cerebrospinal fluid leakage and very late complications like infection, plate

migration and hardware failure were recognised well in the past, but asymptomatic presentation from hypopharynx in this interval of time after surgery is still rare. Gradual or acute onset dysphagia with or without dyspnoea in a patient with anterior cervical spine surgery with implant warrants an urgent search for dislodged implant and its appropriate management.

Ethics

Informed Consent: Consent was taken from the patient himself.
Peer-review: Externally and Internally peer-reviewed.

Authorship Contributions

Concept: N.B., Design: B.S., Data Collection or Processing: B.S., Analysis or Interpretation: N.B., Literature Search: N.B., Writing: N.B., B.S.
Conflict of Interest: No conflict of interest was declared by the authors.
Financial Disclosure: The authors declared that this study received no financial support.

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REVIEW ARTICLE
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J Turk Spinal Surg 2020;31(3):192-5
DOI: 10.4274/jtss.galenos.2020.232

COVID-19 PANDEMIC AND CHANGING PRACTICES IN SPINAL SURGERY

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ABSTRACT

The novel Coronavirus disease-2019 (COVID-19), which was identified in December 2019, has quickly evolved into a pandemic, thereby forcing spine surgeons to modify their daily practice. Several articles and guidelines have been published on how to manage daily routines during the pandemic.

Neurologic deficits, spinal instability and spinal infections are generally considered as emergencies and treated immediately. Every patient who is scheduled to undergo surgery must first be screened for signs and symptoms of the disease, and diagnostic tests must be conducted on suspected and high-risk patients. In addition, precautions must be taken in the operating room to minimise the risk of disease transmission.

In regions where the disease has started to decline, a gradual return to the normal routine activities is being considered. Surgeons must be aware of the local circumstances and elective surgeries can only be resumed when the safety of patients and healthcare personnel are no longer at risk.

In this review article, we aimed to combine the data with our experience and help spine surgeons in adapting to the current situation.

Keywords: SARS-CoV-2, COVID-19, spine surgery, triaging, coronavirus, pandemic

INTRODUCTION

On December 2019, the whole world witnessed the emergence of a novel RNA betacoronavirus in Wuhan, which is the capital city of the Hubei province of China[1]. This virus was later called severe acute respiratory syndorme-Coronavirus-2(SARS-COV-2) SARS-CoV-2, and the disease caused by this microorganism is referred to as the novel coronavirus disease-2019 (COVID-19). This outbreak rapidly evolved into a global pandemic, and as of May 29th, 2020 it had spread across 216 countries with over 5,700,000 confirmed cases and 350,000 confirmed deaths[2].

Turkey's first case of COVID-19 was reported on March 11th, 2020. The country's response was swift and every health institution applied adaptive measures to prevent the virus from spreading. On March 17th,2020, all elective surgical procedures were suspended by an official directive from the Ministry of Health, and in the following days, doctors and nurses from almost every department were allocated to COVID-19 clinics and wards.

Spine surgeons remembered their duties as general practitioners of medicine and were involved in the care of COVID-19. Postponing elective procedures made it possible to relocate healthcare providers to frontline duties, but it also helps in preserving the valuable hospital resources for the care of the critically-ill, such as personal protective equipment (PPE), intensive care unit beds, ventilators and blood products. Some hospitals are strictly reserved for COVID-19 cases, but many others provide care for urgent and emergent conditions at the same time. Spinal surgeons working in these hospital's are often expected to triage the patients and perform emergent surgeries to prevent impairment. The changing practices leads to a confusion among surgeons; lack of prior experience and guidelines forced us to determine our own standards for the care of our patients; in a study on spine surgeons worldwide, 94.7% of our colleagues reported a need for international guidelines for the management of patients during this pandemic[3]. Every aspect of spinal surgery, from diagnosis to postoperative care changed during this unprecedented pandemic. The duration of this pandemic is currently unclear, and even though the number of active cases is declining worldwide, surgeons need to be prepared for upcoming outbreaks. The purpose of this article is to help guide spine surgeons on how to successfully triage patients, minimise the risk of transmission before, during and after surgery, and when to resume with elective procedures safely.

Triaging in Spinal Surgery

Spine surgeons routinely perform emergent and urgent surgical procedures for conditions such as traumatic and oncologic

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pathologies, to prevent neurologic impairment and permanent disabilities. It is common sense that emergent procedures should not be postponed if the medical institution's resources permit it. There are also certain elective procedures for conditions such as degenerative diseases and deformities, which can be postponed for a couple of months. However, the grey-zone between emergent and elective is wide, and surgeons are often faced with the difficulty of making this decision during the pandemic. In an attempt to provide a solution, different medical communities came up with guidelines, like the American College of Surgeons, the North American Spine Society (NASS) and the Rothman Institute[4-6]. Institutional experiences are also shared by spine surgeons across the world[7-10].

In our hospital, we mainly adhered to the triaging guideline recommended by the NASS (Table 1)[5]. The Rothman Institute guideline also contains valuable information, although it presumes the availability of two separate facilities as the hospital and the ambulatory surgery centre[6]. To summarise our practice, we generally considered neurologic deficits, spinal instability and spinal infections as emergencies, and surgical treatment was performed. For other cases, conservative treatment was preferred whenever possible. Certain other factors should also be considered when making the decision, such as;

- Guidelines do not apply to every patient and surgeons must be ready to take decisions on a case-by-case basis.
- Surgeons must be aware of the current situation and available resources in the hospital. Daily updates must be made considering the hospital's operative capacity.
- The period of delay for the postponed surgeries is not predetermined. It should be kept in mind that the clinical situation of the patients may change and neurologic deterioration may occur; therefore, follow-up visits can be organised accordingly. Telemedicine is currently being tried by some institutions for this purpose[11].
- For emergency surgical procedures, efforts must be made to utilise minimally-invasive approaches, if possible, in order to keep the hospitalisation period at a minimum.

Hospitalisation and Operating Room Precautions for Spinal Surgery

When a patient is triaged to undergo surgery, necessary precautions must be taken in order to minimise the risk of transmitting the disease, from the onset of hospitalisation until discharge. Patients must be kept in single rooms, and companions must not be allowed if possible. Patients must wear a surgical mask at all times, and all healthcare workers must wear the necessary PPE.

Every patient is questioned and examined for fever, respiratory symptoms and history of contact with diagnosed/suspected cases of COVID-19. Every healthcare professional must keep in mind that up to 80% of patients may be asymptomatic and still contagious[12]. Before surgery, patients are classified into one of these three risk categories[13]:

Confirmed/suspected, high-risk and low-risk. In our institution, polymerase chain reaction (PCR) screening is not routinely performed; only those who are confirmed/suspected or in the high-risk group are tested. When a risk factor is present, surgery should be delayed until the test results are release, if the surgical emergency permits.

If a patient is diagnosed positive (or if there is suspicion when the surgery cannot be delayed until the test results come out), the surgery must be performed in a room reserved for COVID-19

Table 1. Triaging guideline during the COVID-19 pandemic, adapted from the North American Spine Society

Category	Presentation	Recommendation
Emergent	• Progressive or severe neurologic deficit due to neurologic compression from any cause • Spinal instability at risk of causing neurologic deficit • Epidural abscess • Postoperative surgical site infections	Do not postpone the surgical treatment
Urgent	• Cervical or thoracic myelopathy due to spinal stenosis, with recent progression • Spinal infection that does not respond to medical treatment • Persistent significant neurologic deficit due to neurologic compression, with or without deformity • Spinal pathologies causing intractable pain that result in emergency department presentation, causing severe functional limitation and/or excessive opioid use despite non-surgical attempts at treatment	Proceed with surgery/procedure if the local situation and resources allow.
Elective	• Spinal pathologies where pain and dysfunction can be reasonably managed without surgical intervention • Spinal deformity (scoliosis/kyphosis) correction • Pseudoarthrosis • Symptomatic hardware	Postpone the surgery

COVID-19: The novel coronavirus disease

patients, preferably in the corner of the operating complex[14]. Negative pressure environment is protective against aerosol spread, and it should be kept in mind that many OR's have positive pressure setups.

SARS-CoV-2 spreads through aerosols, and known aerosol generating procedures include intubation, extubation, bag masking and electrocautery of blood and other body fluids[4]. Even the smoke produced by the electrosurgical equipment were shown to transmit certain viruses[15]; therefore, the amount of personnel in the room before, during and after the surgery of COVID-19 patients should be kept at a minimum.

Wearing full PPE during the surgery of COVID-19 patients is of utmost importance. The necessary PPE include a well-fitting N95 mask, goggles or face shield, splash resistant gown and foot covers. In our hospital, surgical hoods with powered air purifying respirators are also used for the surgery of diagnosed/suspected patients (Figure 1).

In collaboration with the department of anaesthesiology, certain rules were determined for every surgical procedure, including low-risk and negative patients:

- All the personnel in the operating room (OR) must wear the proper PPE's
- Every patient will be intubated with a video laryngoscope if possible
- During intubation, only the anaesthesiology team will be present in the room, and surgeons and other personnel will enter the room at least 10 minutes after the intubation
- Before the extubation, surgeons and other personnel should clear the room, and will re-enter at least 10 minutes after the process.

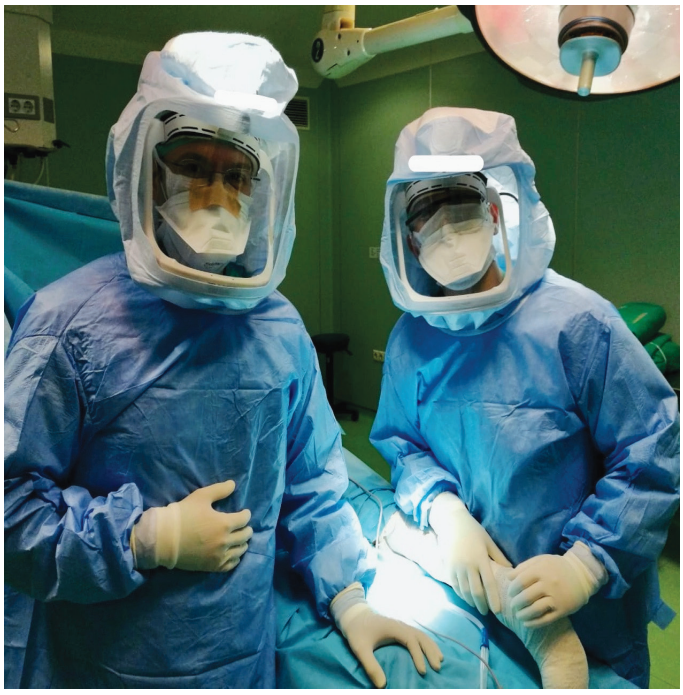

Figure 1. Surgical hoods with a powered air purifying respirator, used during the surgeries of diagnosed/suspected cases

Resuming Elective Spinal Surgery

As the COVID-19 pandemic has begun to decline in many countries, elective surgical procedures are slowly being re-introduced into our practice. Spinal surgeons must evaluate the current situation in their institutions and countries, and thus decide on the appropriate timing for this.

The Centres for Medicare and Medicaid Services has issued recommendations for a gradual return to elective surgical procedures[16], followed by other communities such as the American Academy of Orthopaedic Surgeons[17]. Generally, every surgeon must consider certain key points before resuming these surgeries:

- Safety of patients is of first priority, followed by the safety of healthcare personnel,
- Institutional rules must adhere to local government policies and regulations,
- The local COVID-19 diagnosis rate is declining, preferably for at least 14 days,
- The hospital must have adequate facilities and resources to properly screen every patient, and perform a test (PCR or antibody) whenever necessary,
- All healthcare personnel must be routinely screened,
- Non-COVID-19 patients and COVID-19 patients must be housed in separate facilities,
- The hospital must have adequate resources (personnel, PPE, facilities etc.) to quickly respond to an unexpected increase in the number of COVID-19 cases,
- Patients with comorbidities and those within the older age group may need to be postponed, until the new standards of care are established.

DISCUSSION

The current pandemic has forced us to change every aspect of our daily practice, and for an unknown period of time. Every one of us has learned different lessons and it is now more important than ever to share every bit of experience with each other and to help in adapting to the changing needs of the community.

Treating patients with emergent and urgent spinal pathologies, while preventing the disease from spreading, is a challenging task. Since the beginning of the pandemic, distinguishing these cases from the electives has been the most difficult task. Considering the lack of studies in the literature, we combined our experience with guidelines by certain institutions[4-6]. The information we shared in this review article will be a guide to help surgeons through the triaging process.

Further precautions are also necessary in the hospital and OR to maintain a safe environment. A study reported that over 15% of spine surgeons who underwent viral testing resulted positive[3], which emphasises the importance of personal protection.

Some institutions are on the brink of returning to a normal practice, but we should always keep in mind that another wave might be waiting around the corner. We do not know what the

near future will bring, but the experience we gathered so far will certainly help us through.

Ethics

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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