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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: Care must be exercised to include references that are available in indexes. Data based on personal communication should not be included in the reference list. References should be arranged in alphabetical order and be cited within the text; references that are not cited should not be included in the reference list. The abstract of the presentations made at Symposia or Congresses should be submitted together with the manuscript. The following listing method should be used.

References should derive primarily from peer-reviewed journals, standard textbooks or monographs, or well-accepted and stable electronic sources. For citations dependent on interpretation of data, authors generally should use only high quality peer-reviewed sources. Abstracts and submitted articles should not be used because many in both categories ultimately do not pass peer review.

They should be listed at the end of the paper in alphabetical order under the first author's last name and numbered accordingly. If needed, the authors may be asked to provide and send full text of any reference. If the authors refer to an unpublished data, they should state the name and institution of the study, Unpublished papers and personal communications must be cited in the text. For the abbreviations of the journal names, the authors can apply to "list of Journals" in Index Medicus or to the address "http:// www.nlm.nih.gov/tsd/serials/lji.html".

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: 61-68.

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

JOURNAL OF TURKISH SPINAL SURGERY

Degenerative disease
Destructive (Spinal Tumors)
Metabolic bone disease
Rheumatologic
Biomechanics Cervical Spine
Cervical myelopathy
Cervical reconstruction
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

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Dear Editor,

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

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

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

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JOURNAL OF TURKISH
SPINAL SURGERY

Dear Colleagues,

I feel very pleased to have the privilege of publishing 4th issue of our journal this year.

Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spine Society. Journal of Turkish Spinal Surgery was first published on January, in 1990. Journal of Turkish Spinal Surgery is published four times a year: on January, April, July, and October. Turkish Spine is currently indexed in Ulakbim, Türkiye Atıf Dizini. I am pleased to inform you that we also have a new website (www.jtss.org), and Publisher (Galenos Publishing House). We would like to remind you that, should you choose to submit a manuscript to the Turkish Journal of Spinal Surgery, it is free of charge, and the Pleksus system is being used.

In this issue, there are ten clinical research studies, one review article, and one case study. The first study is a retrospective clinical one comparing bony fusion rate of beta-tricalcium phosphate and bone marrow aspirate in posterior lumbar fusion cases. The second study is about the effect of preoperative cervical sagittal alignment on postoperative surgical results in 80 patients who were treated with anterior cervical discectomy and fusion. In the third study, the authors discuss the surgical technique and anesthesia protocol of transforaminal percutaneous endoscopic lumbar discectomy. The fourth article is a retrospective article. The authors studied the results of 282 lumbar disc herniation cases which were treated microsurgically. In the fifth study, the authors examined the correlation between spinopelvic parameters and the development of lumbar disc herniation. The sixth study discusses percutaneous vertebroplasty in vertebral compression fractures. The authors investigated whether or not a routine biopsy was necessary during vertebroplasty. In the seventh study, the authors wrote about the results of treatment of chronic coccydynia in patients who had Ganglion impar block. The eighth article is about Scheuermann's kyphosis. The authors compared spinopelvic parameters preoperatively and postoperatively. The ninth article compares the effectiveness of patient controlled analgesia, and pain pump, to patient controlled analgesia, following surgery for adolescent idiopathic scoliosis. The tenth study discusses adult spinal deformity. The authors studied sagittal and spinopelvic parameters, in a functional position, using the one step forward lateral spinal X-ray. The eleventh article is a review article about whether or not surgery is the best option to treat adult scoliosis. The twelfth article is composed of two case studies of postoperative cervical spinal epidural hematomas, and a review of the pertinent literature.

We wish all the all Turkish spinal surgeons and their families a healthy, peaceful happy new year.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

JOURNAL OF TURKISH SPINAL SURGERY

Contents

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USE OF BETA-TRICALCIUM PHOSPHATE WITH BONE MARROW ASPIRATE AS A BONE GRAFT SUBSTITUTE IN POSTEROLATERAL LUMBAR FUSION

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ABSTRACT

Objective: Retrospective clinical study. This study aimed to determine the bony fusion rate of posterior lumbar fusion (PLF) involving beta-tricalcium phosphate (ß-TCP) and bone marrow aspirate (BMA). Bone fusion remains the main component of primary surgical approach for several spinal disorders. Spine surgeons face the need to make crucial decisions regarding bone graft selection in each case.

Materials and Methods: The study included 33 patients (21 female and 12 male patients) who underwent posterior lumbar pedicle screw fixation and fusion using ß-TCP as a bone substitute. The mean patient age was 58.35 (range=35-81) years.

Results: The mean follow-up duration was 23.45 months. Solid bony fusion at the lateral side of the lumbar region between transverse processes was noted on radiography in 24 patients (72.7%), bony bridging between adjacent transverse processes in 5 patients (15.2%), and no new bone formation in the remaining 4 patients (12.1%).

Conclusion: The bony fusion rate of PLF involving ß-TCP and BMA was relatively high at 72.7%. ß-TCP is an effective and appropriate material for PLF in the lumbar area when used with BMA, and approximately 10 mL of ß-TCP per vertebral segment is sufficient.

Keywords: Bone graft substitute, fusion, lumbar, multi-segment posterolateral fusion, spine, beta-tricalcium phosphate

INTRODUCTION

Over the previous years, the number of posterior lumbar fusion (PLF) surgeries has gradually increased[11]. Spine surgeons face the need to make crucial decisions regarding bone graft selection in each case. The development of instrumentation materials and techniques has caused this expansion in the adoption of posterior lumbar surgeries, and global educational meetings and courses have helped to popularize these surgeries. In the previous decades, an autograft obtained from the iliac crest has been considered as the most desirable kind of bone substitute[10]. It provides osteogenic factors and a skeleton for healthy and strong bony fusion and is better than any other bone substitute. However, the high complication rate associated with harvesting an iliac crest graft has resulted in the development of alternative graft options. A good bone graft should exhibit strong biomechanics and should have biological properties, such as osteoinductivity and osteoconductivity. Additionally, it should be non-toxic (bioinert) and should be easy to sterilize. Ceramic carriers are derived from a process called "sintering," which uses high temperatures to extract individual crystals that are fused together at crystal grain boundaries[2]. These products are mainly synthetic and can provide an osteoconductive matrix[3,6]. Some ceramic substitutes provide scaffolds that are sufficient to protect the fusion area from loading forces, and they have all of these properties to some extent. Calcium phosphates, such as hydroxyapatite and beta-tricalcium phosphate (ß-TCP), are the most preferable options for spinal fusion. This retrospective study aimed to determine the bony fusion rate of PLF involving ß-TCP and bone marrow aspirate (BMA).

MATERIALS AND METHODS

Patients

This retrospective study included 33 consecutive adult patients (21 female and 12 male) who had undergone decompression and posterior lumbar pedicle screw fixation and fusion using (Suprabone™, BMT Calsis Co., Ankara, TURKEY) as a bone substitute. The mean patient age was 58.35 years (range=35-81

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years). Patients with metabolic bone diseases, severe uncontrolled diabetes, renal failure, and neoplastic diseases were excluded from the study. Additionally, patients who had undergone previous lumbar surgery for any reason were also excluded. A total of 72 vertebral segments were instrumented and fused in 33 patients (2.2 segments per patient).

Study Approval

This study was approved by the local ethics committee, and the need for informed consent was waived owing to the retrospective nature of the study.

Surgical Technique

Under general anesthesia and in the prone position, the target vertebral levels were identified using an image intensifier. Surgical exposure was performed for the facet joints, and the transverse processes could be seen. Decompression of the spinal canal and relevant nerve roots was performed via laminectomy and foraminotomy. After pedicle screw fixation, decortication was completed using a high-speed drill or an osteotome for all the target levels. Bony fusion was performed with ß-TCP and BMA. Approximately 10 mL of ß-TCP was used for each vertebral segment. Bone substitutes were placed laterally over the transverse processes bilaterally.

Bone Fusion Criteria

After a reasonable follow-up period, bone fusion was evaluated on plain posteroanterior lumbar radiography. Bone fusion was classified into the following three stages: stage 0, no new visible bone formation (Figure 1); stage 1, incomplete bridging across adjacent transverse processes (Figure 2); and stage 2, solid fusion (Figure 3).

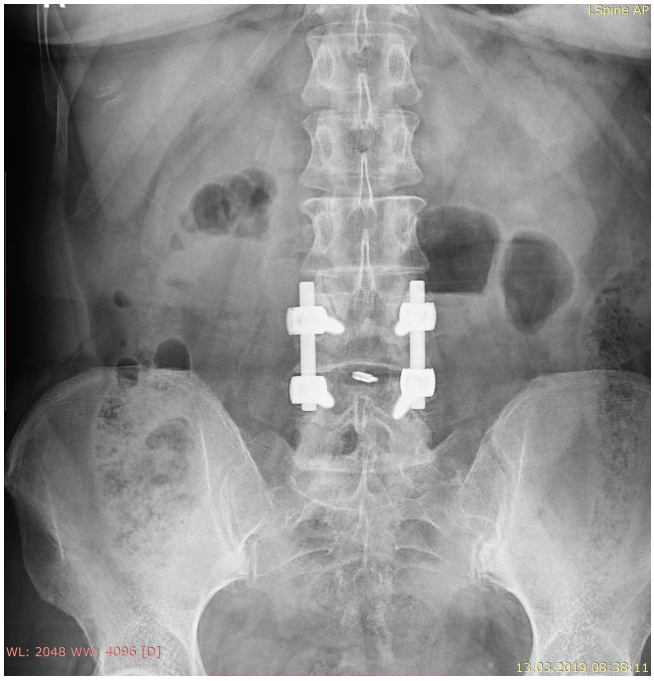

Figure 1. Stage 0 fusion. There is no new bone formation at the lateral side of the lumbar vertebrae on the posteroanterior lumbar roentgenography

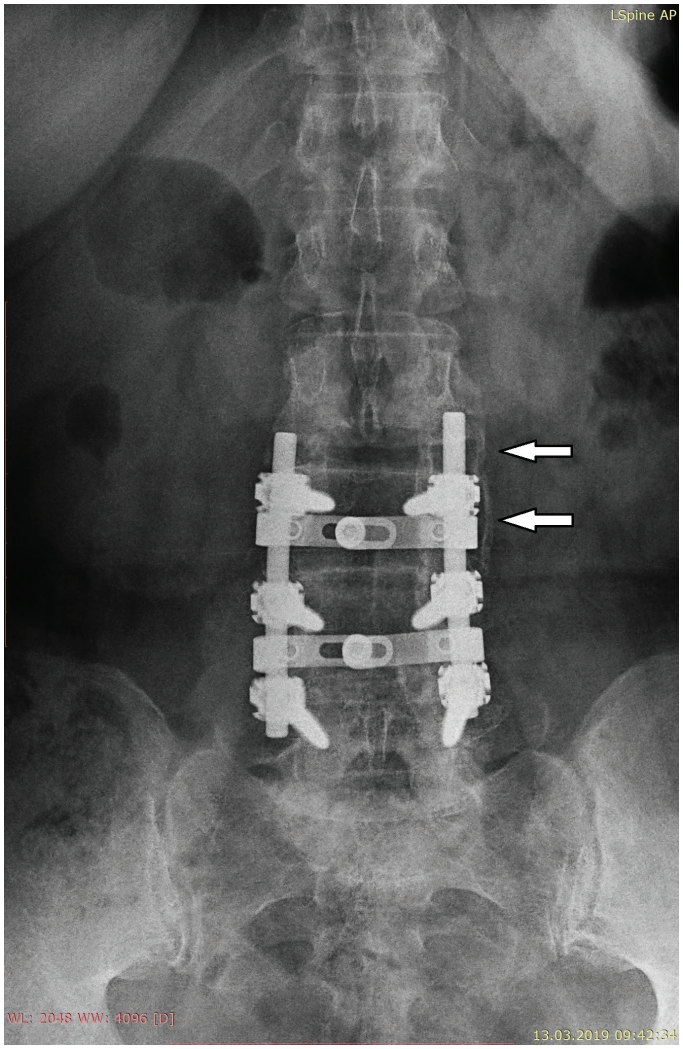

Figure 2. Stage 1 fusion. Some bony bridging is noted between transverse processes (white arrows) on the posteroanterior lumbar roentgenography, indicating incomplete fusion

RESULTS

The study included 33 patients. The fusion levels, number of fused vertebral segments, and preoperative diagnoses are presented in Table 1. The mean follow-up period was 23.45 months (range=6-86 months). Solid bony fusion at the lateral side of the lumbar region between transverse processes (stage 2 fusion) was noted on radiography in 24 patients (72.7%), bony bridging between adjacent transverse processes (stage 1 fusion) in 5 patients (15.2%), and no new bone formation (stage 0 fusion) in the remaining 4 patients (12.1%). The mean follow-up durations of stage 0, 1, and 2 patients were 8.5, 11, and 28.22 months, respectively. The follow-up duration was shorter in patients with stage 0 and 1 fusion and longer in patients with stage 2 fusion than in the overall study population. There was no difference in fusion stage between male and female patients.

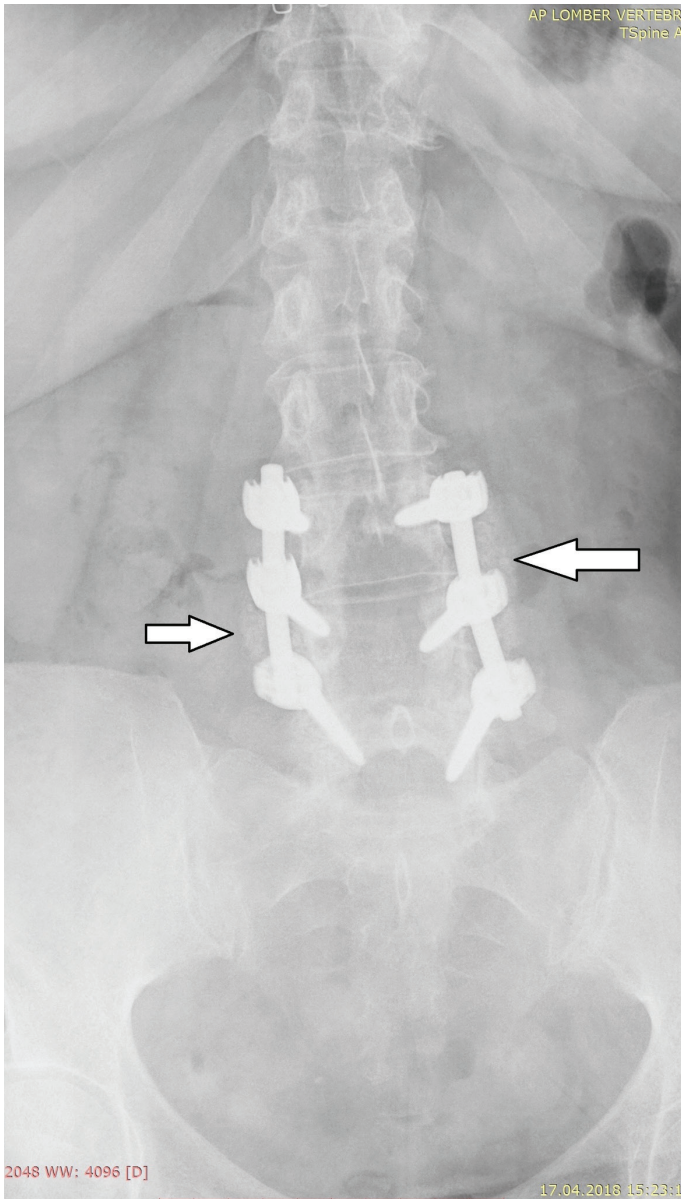

Figure 3. Stage 2 fusion. Solid fusion is noted between transverse processes (white arrows) on the posteroanterior lumbar roentgenography

Table 1. Patient demographics, preoperative diagnoses, and fusion levels

Preoperative diagnoses	M	F	T	Surgery of fused segments		
				1 segment	2 segment	3 segment
Lumbar stenosis	11	18	29		10	19
Lumbar listhesis	-	2	2	2	-	-
Lumbar instability	1	1	2	2	-	-
Total	12	21	33	4	10	19

M: Male, F: Female, T: Total

DISCUSSION

Although the optimal treatment for degenerative lumbar diseases remains controversial[1,2], bone fusion is the goal of many treatment approaches for various lumbar pathologies that especially need decompression[3,5]. Fusion may be posterolateral, anterior, or both. Posterolateral fusion can easily be performed after decompression in the same surgical step, and it is therefore the most widespread approach. Bone graft substitutes have been routinely used in spinal fusion for decades, and surgeons are faced with critical decisions regarding bone graft selection[4]. The formation of solid bone, duration of new bone formation, and stability of the lumbar region are important issues in the bone fusion process. Additionally, the physical and chemical properties of the bone substitute material and the amount of material are also important for efficient and adequate fusion. ß-TCP is a popular ceramic and an osteoconductive synthetic bone substitute with a mineral structure similar to that of bone. Additionally, it is extremely porous and has a resorption time between 12 and 24 months[9]. According to a meta-analysis, it has a fusion rate of 87% in PLF when used with an osteoinductive autologous source of cells obtained from either the vertebral body or iliac crest[4]. In the present study, the autologous cell source was BMA obtained from the vertebra. BMA provides an effective amount of osteoprogenitor cells and critical growth factors that aid in cell differentiation, leading to bone healing. *In vitro* studies have confirmed a high colony-forming unit count in BMA obtained from the vertebral body[8]. In the present study, solid posterolateral fusion was achieved in 74.1% of patients and incomplete fusion was achieved in 12.9% of patients, indicating the competence of ß-TCP for PLF. In most cases, 10 mL of ß-TCP per vertebral segment provided sufficient bone fusion. The mean follow-up duration of the present study was considered to be satisfactory. In the relevant literature, the mean follow-up duration for efficient bone formation has been reported to be 18-20 months[1,7]. With regard to ß-TCP, meta-analyses and some studies have reported fusion rates of 85%-100% in the lumbar area[1,4]. The fusion rate in the present study was lower than these rates. There are several possible reasons for this finding, including differences in the bone substitute amount, follow-up duration, and evaluation method. The follow-up duration was longer in the present study than in the previous studies. Additionally, the short follow-up duration for patients who showed no new bone formation might explain the finding. The follow-up duration of patients who showed incomplete fusion was longer than that of patients who showed no new bone formation but was shorter than that of patients who showed solid fusion, supporting this opinion. However, it should be noted that some patients showed solid fusion in 6 months. The previous studies did not mention the bone substitute amount, and thus, it was not possible to compare the bone substitute amount between our study and the previous studies.

The evaluation method is extremely important, and computed tomography might be superior to direct roentgenography for evaluating new bone formation.

Study Limitations

The study population was not large enough to reach a definitive conclusion. Additionally, the pathologies and clinical diagnoses of the patients were not homogenous. Moreover, the age range was wide. Age is an important factor for fusion, and thus, the age range should be narrow. Finally, there was no comparison with an allograft. Such a comparison is necessary to demonstrate efficacy.

CONCLUSION

The bony fusion rate of PLF involving ß-TCP and BMA was relatively high at 72.7%. Bone graft substitutes and extenders are used and developed on a daily basis in spinal surgery. Surgeons might decide to select bone substitute material for spinal fusion according to the results of independent studies. ß-TCP is an effective and appropriate material for PLF in the lumbar region when used with BMA, and approximately 10 mL of ß-TCP per vertebral segment is sufficient.

Ethics

Ethics Committee Approval: Retrospective study.
Informed Consent: The need for informed consent was waived owing to the retrospective nature of the study.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: U.E., Concept: C.T., U.E., Design: Ö.P., U.E., Data Collection or Processing: C.T., Ö.P., Analysis or Interpretation: U.E., Li terature Search: C.T., Ö.P., Writing: U.E.
Conflict of Interest: No conflict of interest was declared by the authors.
Financial Disclosure: From BMT Calsis Co., or any other third party establishments.

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THE EFFECT OF PREOPERATIVE CERVICAL SAGITTAL ALIGNMENT ON POSTOPERATIVE SURGICAL RESULTS IN PATIENTS TREATED BY ANTERIOR CERVICAL DISCECTOMY AND FUSION

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ABSTRACT

Objective: Cervical degenerative disc diseases arise in some degenerative settings. These degenerative cervical changes may be a consequence of cervical sagittal malalignment. The aim of this study is to assess preoperative profile and postoperative changes in cervical sagittal profiles; and correlation between these changes and surgical outcomes in patients undergoing anterior cervical discectomy and fusion.

Materials and Methods: Eighty consecutive men and women who underwent anterior cervical discectomy and fusion (ACDF) were enrolled in the study. Cervical alignment was classified into 4 types-lordotic, flat, sigmoid, and kyphotic. Lordosis angle was measured by the Cobb method. Segmental angle at the level of discectomy was measured. Preoperative, early postoperative, and the 1st and 3rd month visual analog scale results were recorded. Improvement of cervical sagittal alignment and visual analogue scale (VAS) changes were compared statistically.

Results: The median preoperative VAS score was 7. This score decreased to 1 as a median immediately after operation. This change was statistically significant. Sagittal alignment changes in early postoperative period were not statistically significant despite the observation of improvement in some patients. However, after 1st and 3rd months, results showed significant improvements.

Conclusion: ACDF is an effective treatment of cervical degenerative disc diseases (CDDD). Decompression is still the main issue of the degenerative cervical diseases. Sagittal alignment may be restored by using lordotic cages. Patients with F sagittal shape may tend to develop CDDD more than N sagittal profile. There is a correlation between clinical improvement and radiologic improvement.

Keywords: Cervical sagittal alignment, anterior cervical discectomy and fusion, cervical spine, surgery

Level of Evidence: Level II, Retrospective randomized study

INTRODUCTION

Normal cervical vertebral column is lordotic in shape. Many authors in the literature define normal cervical lordosis angle to be between 20° and 35°[6,7,16]. Cervical lordosis creates stimulus to normal development of Lusckha joints and this is vital for appropriate cervical integrity[12]. Normal cervical alignment is important for appropriate axial loading to the vertebrae, facet joints, discs, and ligaments. It also affects cervical range of motion and general cervical kinematic[9,15]. In the literature, there are some studies on that decrease in cervical lordosis or flat cervical alignment and cervical kyphosis can cause cervical degenerative diseases by asymmetric loading[3,10]. At the same time, there are also some authors that claim that existing kyphotic cervical deformity or even loss of some degree cervical lordosis may affect surgical outcomes after posterior cervical approaches for various cervical spine pathologies[13]. It is also widely accepted that cervical degenerative disc diseases (CDDD) arise in some degenerative settings. These degenerative cervical changes may be a consequence of cervical sagittal malalignment and vice versa[5]. The aim of this study is to assess preoperative profile and postoperative changes in cervical sagittal plane alignments and correlation between these changes and surgical outcomes in patients undergoing anterior cervical discectomy and fusion (ACDF).

MATERIALS AND METHODS

Study Population

Eighty consecutive men and women who underwent ACDF at three or less levels were enrolled in the study. Patients aged >18 years who had 1, 2 or three levels soft cervical disc hernia were included in the study. Patients who had previous cervical operations, structural bony anomaly, deformity, metabolic

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bone diseases, any other metabolic diseases such as diabetes or thyroid diseases, or any malignancy, cervical spinal canal narrowing or any other bony pathology affecting the canal or foramens and patients with spondylotic myelopathy were not included. Obese patients with body mass index >30 kg/m^2, pregnant patients, and patients with traumatic disc hernias were also not included.

All patients were evaluated for operation indications by 2 surgeons separately in a blinded fashion. Preoperative neurologic examinations of patients were performed also by two surgeons separately. All operations were performed by the senior author (U.E.).

Operation

All patients were performed standard anterior ACDF with a Poly-Ether-Ether-Ketone (PEEK) cage under the operation microscope with microinstruments. A right side anterior transvers incision was used. An image intensifier was peroperatively used for determining and checking vertebral level. The posterior longitudinal ligament was removed segmentally and anterior side of the dura was seen. Both end plates were curetted gently after the intervertebral disc was removed. PEEK cages that were used for all patients were lordotic and bladed type with different size.

Radiologic Evaluation

All lateral cervical roentgenograms must show basis cranium, all 7 cervical vertebrae and at least upper side of the first thoracic vertebra. Cervical alignment was classified into 4 types-lordotic, flat, sigmoid and kyphotic-according to the Toyama classification[14]. Lordosis angle was measured between C2 inferior end plate and C7 superior end plate by the Cobb method[4]. Segmental angle at the level of discectomy was measured.

Pain Evaluation

Preoperative, early postoperative, the 1st and 3rd month visual analogue scale (VAS) results were recorded.

Statistical Analysis

Statistical analysis was performed by using a software (SPSS vs. 22, IBM, USA). The convenience of data was evaluated by the Shapiro-Wilks test. Demographic comparison of two groups was performed by the independent Samples t-test; and VAS comparison between two groups was done by the Mann-Whitney U test. The Wilcoxon signed-rank test was used for the comparison of VAS values in each group. Sagittal alignment was compared by using the McNemar-Bowker test. Any p value <0.05 was considered as significant.

RESULTS

Thirty eight men and 42 women were enrolled the study. The mean age of the patients was 46.99±9.47 years with a range of 27-69 years. There was no significant difference between the mean ages of the men and women. The median preoperative VAS score was 7. This score decreased to 1 as a median immediately after the operation. This change was statistically significant (p<0.001). There were no differences between both genders in terms of VAS changes. Twenty patients had a normal cervical lordosis (N) according to the Toyama types[11] preoperatively, 42 patients had flat cervical (F) alignment, 11 patients had kyphotic cervical alignment (K), and 7 patients had sigmoid cervical profile (S). There was no gender differences with regard to cervical alignment types preoperatively (p=0.553). Table 1 shows changes in cervical alignments. Sagittal alignment changes in early postoperative period were not statistically significant (p=0.099) despite the observation of improvement in some patients. However, after 1st and 3rd months, results showed significant improvements with p values of 0.022 and 0.023, respectively. Overall complication rate of this series was 5%. Hoarseness was seen in 2 patients, Horner's syndrome in one patient, and temporary dysphagia in one patient.

Table 1. Changes in cervical sagittal alignment after anterior cervical discectomy and fusion

Sagittal Toyama types (n=80)	Preoperative	Early preoperative	1st month	3rd month
L	20	24	34	35
F	42	48	40	39
K	11	6	4	3
S	7	2	2	3

L: Lordotic cervical sagittal shape, F: Flat cervical sagittal shape, K: Kyphotic cervical sagittal shape, S: Sigmoid cervical sagittal shape

DISCUSSION

Cervical curve is a secondary spinal curve that provides compensation to the other spine curves which are on the sagittal plane. As the upper curve of the thoracic kyphosis, normal cervical alignment is lordotic with a range of 10°-30°[8]. In order to maintain horizontal gaze in erect position, orientation of the atlanto-occipital joints must be horizontal in direction. Cervical lordosis provides the orientation of these joints with minimum energy expenditure. If the cervical lordosis is lost, more energy would be needed to maintain horizontal gaze. Loss of cervical lordosis may be the first step of CDDD. That seventy five percent of the patients treated by ACDF in this series had loss of cervical lordosis may strengthen this opinion. In a study in the literature, it was reported that the rate of losing cervical lordosis was lower than in patients with neck pain which did not need operative treatment[5].

If the main hypothesis of this study is confirmed, cervical sagittal alignment of the patients will improve in some degree, which is demonstrated with the retrospective analysis of patients' sagittal profile changes after operation. Forty two patients had F type cervical alignment preoperatively; N sagittal alignment was seen in 21.4% in early postoperative

period. N alignment was seen in the first month in 45.2% and in the third month in 52.4% cumulatively. Eleven patients had K type cervical alignment preoperatively; F cervical alignment, 1 step improvement, was seen in 54.5% in early postoperative period. After the 1st month, 72.7% of these patients showed 1 or 2 step improvement, namely F or N sagittal alignment. After the 3rd month, this improvement reached to 81.8%. Seven patients had S type cervical alignment preoperatively; F or N type cervical alignment was seen in 85.7% in early postoperative period. After the 1st month, all of them showed F or N type sagittal profile. These results confirm that the main hypothesis of this study may be correct. At the same time, clinic results of these radiologic improvements were investigated with VAS scores. In all groups, VAS changes were significant (p<0.001) in early postoperative period (Table 2). Despite the excellent results after this operative technique, adding fusion to the simple anterior cervical discectomy brings new complications[1]. Surgical experience gained in years may decrease the complication rate. Overall complication rate of this series was low and the complications were minor. Surgical techniques and experience are two important factors for this low rate. All the posterior osteophytes and ligamentous remnants that may compress the neural tissue can be removed under surgical microscope with microinstruments. Even if PLL is intact, we advocate open and remove it. After removing the PLL, we saw some sequestrated fragments under the PLL in some cases. Some authors have claimed that folding and swelling of the PLL is the main reason of reexpolarations for morbidities in early postoperative period[2]. One of the main results of this study is that restoration of the cervical sagittal alignment may influence the result of ACDF. Lordotic cages may provide this restoration in some degree. At the same time, cages provide the preservation of intervertebral high. This may prevent secondary root compression and anterior column shortness. Another important result of the study is that the cervical degenerative changes, mainly disc diseases may develop easily in the abnormal sagittal alignment because the adjustment of horizontal gaze needs more energy and strain due to use of forces to the opposite direction of the disordered alignment. These two important results were obtained mainly in early postoperative period; and improvements of sagittal alignment continue in midterm postoperative period. This event may be considered as a supporting factor of this opinion.

A minor result of this study is that the F type cervical sagittal alignment is seen frequently in patients with CDDD who were treated operatively. This event is not considered as structural. It may be largely restored after ACDF. F type cervical alignment may arise from paravertebral muscle spasms, and this may be a worsening factor for CDDD. Regardless of the preoperative situation of the patients or their radiologies, pain perceptions of the patients were decreased significantly. Decompression is still the main issue of the degenerative cervical diseases. The low complication rate of this series shows that ACDF is an effective operation for the treatment of CDDD.

Table 2. Changes in visual analogue scale immediately after anterior cervical discectomy and fusion

Sagittal Toyama types (n=80)	Preoperative VAS mean	Early preoperative VAS mean	p
L (n=20)	6	1	<0.001
F (n=42)	7	1	<0.001
K (n=11)	7	1	<0.001
S (n=7)	6	1	<0.001

VAS: Visual analogue scale, L: Lordotic cervical sagittal shape, F: Flat cervical sagittal shape, K: Kyphotic cervical sagittal shape, S: Sigmoid cervical sagittal shape

CONCLUSION

ACDF is an effective treatment of CDDD. Decompression is still the main issue of the degenerative cervical diseases. Sagittal alignment may be restored by using lordotic cages. Patients with F sagittal shape may tend to develop CDDD more than those with N sagittal profile. There is a correlation between clinical improvement and radiologic improvement.

Ethics

Ethics Committee Approval: This study was approved by the local ethics committee of Düzce University.

Informed Consent: A written informed consent were obtained from all patients.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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EARLY RESULTS OF TRANSFORAMINAL PERCUTANEOUS ENDOSCOPIC LUMBAR DISCECTOMY UNDER LOCAL AND SEDOANALGESIA

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ABSTRACT

Objective: After the first description of percutaneous posterolateral nucleotomy by Kambin in 1973, transforaminal percutaneous endoscopic lumbar discectomy (PELD) was developed and its use has been increasing in recent years. To describe the surgical technique and anesthesia protocol of transforaminal PELD under local and sedoanelgesia in patients with lumbar disc herniations (LDH) and to report our early results.

Materials and Methods: We included 20 patients who underwent transforaminal PELD under local and sedoanalgesia within a period of two months between January 2019 and February 2019 and who had at least a three-month postoperative follow-up period. LDH was at L4-5 in 28.6% of the patients, at L5-S1 in 33.3% of the patients, at L3-4 in 14.3% of the patients, both at L4-L5 and L5-S1 levels in 14.3% of the patients, and at L2-L3 in 1 patient.

Results: The mean preoperative Visual anolog scale (VAS) score was 9.4±1.8 (range=8-10) and the mean early postoperative VAS score was 1.85±1.2 (range=0-6). During follow-up, recurrent LDH was seen in 2 patients. One patient developed epidural fibrosis. The mean VAS scores were found to be 1.8±1.69 at the third month follow-up. There was a significant difference between the preoperative VAS scores and the VAS scores in the early postoperative and third month follow-up ($p<0.001$).

Conclusion: Transforaminal PELD under local and sedoanalgesia is an alternative method to classical microdiscectomy in patients with LDH. It is a crucial advantage that it does not require general anesthesia and that patients can provide feedback during surgery.

Keywords: Percutaneous, endoscopic, lumbar, discectomy, transforaminal, percutaneous endoscopic lumbar discectomy

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

After the first description of percutaneous posterolateral nucleotomy by Kambin in 1973, transforaminal percutaneous endoscopic lumbar discectomy (PELD) was developed and its use has been increasing in recent years. The transforaminal approach has many advantages over open surgery. These have been described in the literature as the preservation of posterior ligamenteous and bone structures, lesser postoperative instability, facet arthropathy, narrowing of the disc space, and epidural scarring[4,6,13-18,23,30,31,33,34,36,38-42]. Migrated disc herniations, especially sequestrated ones, may require excessive resection of the lamina when approached by conventional posterior laminotomy. This may cause postoperative instability and low back pain. With the recent advancements in endoscopic spine surgery, the indications of PELD have expanded considerably and many transforaminal and interlaminar endoscopic methods have been described for migrated disc herniations which had been previously considered inaccessible by endoscopic methods[4,5,20,22]. The aim of this study is to describe the surgical technique and sedoanalgesia protocol of PELD under local and sedoanelgesia in patients with lumbar disc herniations (LDH) and to report our early results.

MATERIALS AND METHODS

Our study was a retrospective clinical study performed according to the principles of the World Medical Association Declaration of Helsinki, "Ethical Principles for Medical Research Involving Human Subjects" (revised in 2013). We retrospectively evaluated 20 patients who underwent PELD within a two-month period between January 2019 and February 2019 and who had an at least a three-month postoperative follow-up period. We did not include patients who underwent interlaminar PELD under general anesthesia. The mean age of the patients was 49.7±18.9 years. Of patients, 12 were female and 8 were male. LDH was at L4-5 in 28.6% of the patients, at L5-S1 in 33.3% of the patients, at L3-4 in 14.3% of the patients, both at L4-L5 and L5-S1 levels in 14.3% of the patients, and at L2-L3 in one patient. Anatomically, 61.9% of LDH's were paracentral, 19% were foraminal, 9.5% were down-migrated paracentral, and one

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was centrally located. Three patients had recurrent LDHs which had been previously treated with open microscopic discectomy. All patients underwent transforaminal PELD under local and sedoanalgesia. In 23.8% of the patients, foraminoplasty was performed by using hand reamers to reach the extruded disc material. All patients who underwent foraminoplasty had LDH at the L5-S1 level. Foraminoplasty was performed in 50% of patients with LDH at the L5-S1 level. We evaluated the clinical results using visual analog scale (VAS) for leg pain preoperatively, early postoperatively and at three-month intervals postoperatively.

Statistical Analysis

Statistical analysis was performed in Windows 22 software (IBM Corp., Armonk, NY) using the IBM SPSS package (Statistical Package for Social Sciences). We used the Paired t-test to compare preoperative and postoperative VAS scores. The value of $p<0.05$ was considered to be statistically significant.

Surgical Technique

All patients underwent surgery using the Karl Storz Endoscopy Spine TIP System (Karl Storz SE & CO Tuttlingen, Germany). All surgeries were performed under local anesthesia and conscious sedation in the prone position. Conscious sedation was achieved with midozolam and fentanyl or a combination of midozolam and remifentanyl. Because patients were under conscious sedation, a continuous feedback was obtained from the patient during surgery to prevent any possible neural injury. Midozolam was administered intravenously at a dose of 0.05 mg/kg 30 minutes before the surgery. If necessary, the same dose was repeated during surgery. Fentanyl was administered intravenously at a dose of 0.8 µg/kg 10 minutes before the surgery. During the painful sections of the procedure, such as insertion of the obturator into the disc, the same dose was administrated not to exceed 200 µg in total. Remifentayl was started at a dose of 0.1 µg/kg/min with continuous infusion and the dose was reduced to half of it after the painful sections of the procedure had been completed. The distance from the midline of the skin entry point which was specific for each patient was calculated using axial magnetic resonance (MR) images before the surgery. By giving the necessary tilts to the fluoroscopy, real anteroposterior (AP) and lateral images of the disc space were taken and straight lines were drawn to reach the disc fragment transforaminally. At the intersection of these two lines, the skin and intramuscular space were infiltrated with 1% lidocaine which coincided with the distance measured previously from axial MR images. An 18-gauge spinal needle was inserted posterolaterally through the skin under fluoroscopy guidance. According to this technique, the distance of the entry point from the middle line in Turkish patients ranged from 9 to 14 cm according to the structure of the patient and the level of LDH. The placement of the 18-gauge spinal needle in the correct place considering the placement of the disc fragment constitutes the most important step for the removal of the herniation. In endoscopic discectomy, the disc fragment can be removed only if the surgical instrument is placed in the correct place[21]. If the needle is in the medial pedicular line in the AP image and at the level of the posterior vertebra in the lateral image at the same time, it means that the needle is in the ideal position (Figure 1). The location of the nerve roots and the safe triangle of Kambin where the drug will spread in the epidural space are confirmed with the injection of the radiopaque (Figure 2). Epidural block is then made with 5 mL of 0.5% lidocaine. If the inside-out technique is used, the needle is advanced into the disc and discography is performed with 2 mL radiopaque to confirm that the needle is in the disc space. Then a 0.8 mm guidewire is passed through the needle. If the outside-in technique is to be used, foraminoplasty is performed with sequential hand reamers starting from 4 mm to 9 mm on the guidewire (Figure 3). Proper caution must be taken not to advance the tip of the hand reamers beyond the medial pedicular line in the AP image in order to prevent possible nerve

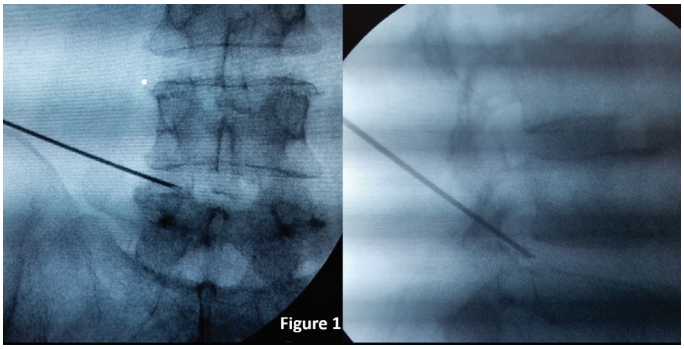

Figure 1. If the needle is in the medial pedicular line in the antero-posterior image and at the level of the posterior vertebra in the lateral image at the same time, it means that needle is in the ideal position

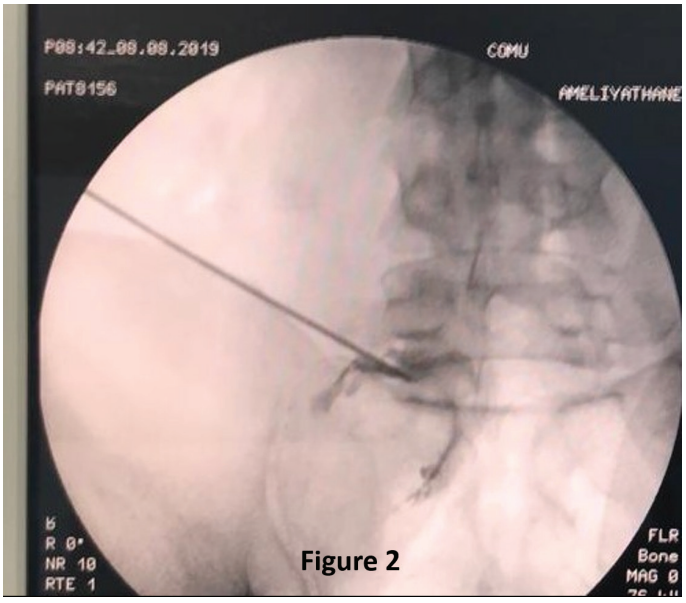

Figure 2. The location of the nerve roots and the safe triangle of Kambin where the drug will spread in the epidural space are confirmed with the injection of the radiopaque

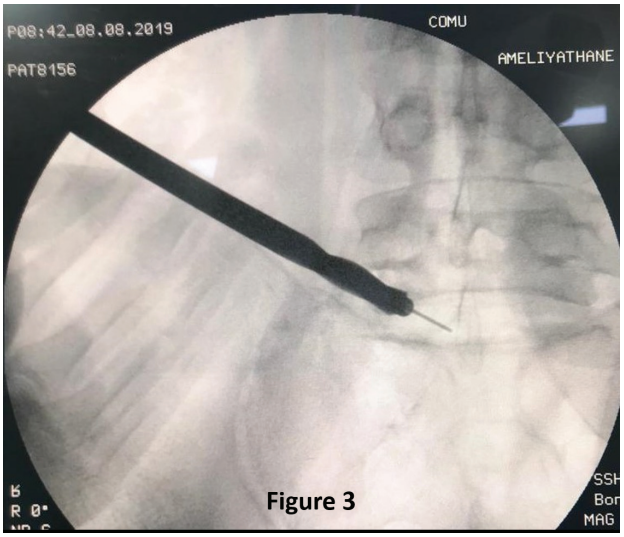

Figure 3. If outside-in technique is used, foraminoplasty is performed with sequential hand reamers starting from 4 mm to 9 mm on the guidewire

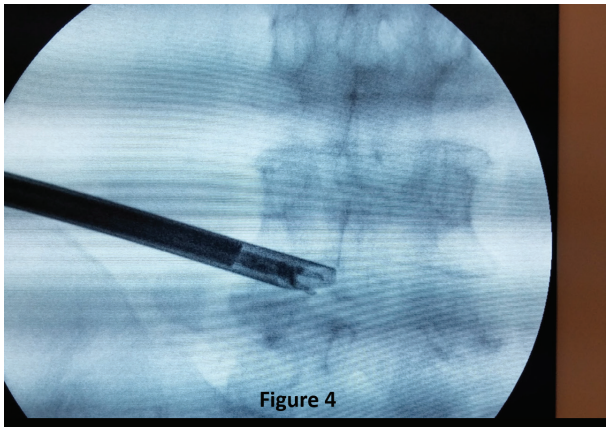

Figure 4. The obturator is removed from the working cannula and a 25° endoscope is inserted into the working cannula to perform a discectomy using endoscopic forceps and other handpieces

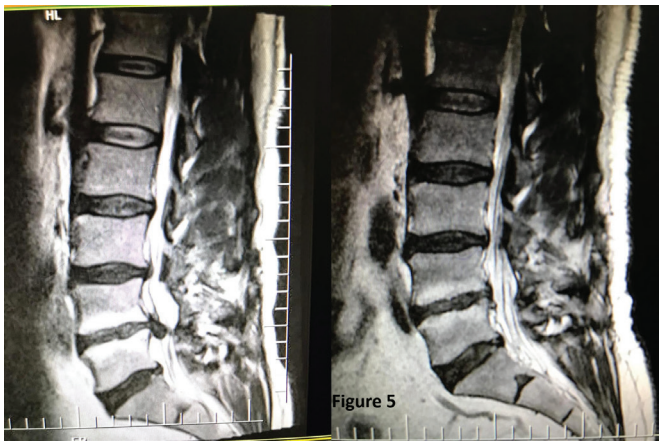

Figure 5. Preoperative and third-month follow-up magnetic resonance imaging of a 46-year-old male patient suffering from recurrent and down-migrated lumbar disc herniation at the L4-5 level, who we successfully treated with transforaminal percutaneous endoscopic lumbar discectomy

injury. The obturator is then advanced over the guidewire. If the inside-out technique is to be used, the obturator is hammered into the disc on the guidewire. If the outside-in technique is to be used, the obturator is advanced to the location of the fragment. The cannula, which is 8 mm in diameter, is placed over the obturator with rotating movements. It should be noted that the opening of the angled working cannula faces dorsally in the epidural space. The obturator is removed from the working cannula and a 25° endoscope is inserted into the working cannula to perform discectomy by using endoscopic forceps and other handpieces (Figure 4). When the inside-out technique is used, we used the half and half technique, as described by Lee et al.[20]. In this technique, half of the working cannula is placed in the ventral of the posterior line of the vertebral body (disc space), and the other half is placed dorsally in the epidural space.

RESULTS

The mean preoperative VAS score was 9.4±1.8 (range=8-10) and the mean early postoperative VAS score was 1.85±1.2 (range=0-6). In our series, there was no LDH that we could not excise with transforaminal PELD. We confirmed the early postoperative decompression using axial and sagittal T2 MR images. During follow-up, recurrent LDH was seen in two patients. One patient developed epidural fibrosis. He was treated with sacral endoscopic lumbar neurolysis. The mean VAS scores were found to be 1.8±1.69 at the third-month follow-up. At the last follow-up, 80% of the patients stated that they recovered completely and 85% stated that they could have the same surgery again. There was a significant difference between the preoperative VAS scores and the VAS scores in the early postoperative and third-month follow-up ($p<0.001$). There was no significant difference between early postoperative VAS scores and the third month follow-up VAS scores ($p=0.9$).

DISCUSSION

Percutaneous endoscopic disc surgery was modified by many innovative surgeons after the description of Kambin and Gellman[12,16]. Some of these modifications were Kambin et al.[17] arthroscopic microdiscectomy, Yeung[39-41] selective endoscopic discectomy, and Mayer and Brock[25,26] PELD. In PELD, the preservation of central disc structures is very important for preventing future disc height reduction, disc degeneration, spinal instability, and postoperative low back pain. Therefore, changing the central disc decompression concept to targeted fragmentectomy was a significant innovation in the history of PELD technique[10,11,29]. With the advancement of this technique, the skin entry point became more lateral (10-14 cm from the midline) and the diameter of the working cannulas were enlarged to 7-8 cm. As a result, complete removal of the herniated fragments became more feasible with the use of larger size endoscopic forceps and tools[12,28,29,35]. Due to these recent advancements in PELD techniques, there was no LDH that

we could not excise with transforaminal PELD in our series.

One common problem of PELD surgeries is the migration of herniated fragments. If the herniated fragment breaches the posterior longitudinal ligament (PLL) and moves into the epidural space, it migrates up or down route in 35%-72% of the cases[3,7,8,19,37]. Although there is a debate about in which direction it moves more commonly, most surgeons believe that down migration occurs more frequently[8,19,37]. Severely migrated fragments are generally placed under the pars interarticularis and medial to the pedicle. Therefore, open removal of these fragments requires extensive removal of the bone, which may result in postoperative instability[8,24,27,32]. Migrated fragments usually lie laterally away from the midline because of PLL attachments and midline septum. The peridural membrane also limits its passage to the midline. For these reasons, transforaminal access is a viable surgical option for migrated herniations[8,37]. Up-migrated herniations and sequestrations are more commonly seen in elderly patients who may likely have comorbidities such as cardiac disorders, hypertension, or diabetes. Because general anesthesia and open surgery may be risky, PELD with continuous sedation has remarkable advantages over open surgery for these patients[1,2,8]. In our series, there were only two patients with a migrated disc herniation who we treated successfully with transforaminal PELD. In one of these patients, LDH was a recurrent disc herniation which had been previously treated with an open microdiscectomy (Figure 5). One of these down migrated LDHs was at the L5-S1 level and required a foraminoplasty. Successful performance of an L5-S1 transforaminal PELD in patients with a high iliac crest can be challenging. Due to the oblique trajectory created by the iliac crest and narrow foraminal area, L5-S1 transforaminal PELD is a demanding procedure, which is hindered by the L5 transverse process, the hypertrophic L5-S1 facet joint, and the sacral ala[9]. In the study conducted by Choi et al.[4] in which they retrospectively evaluated 100 patients who underwent transforaminal PELD for the L5-S1 level, they concluded that if the height of the iliac crest was located below the mid pedicle of the L5, a conventional posterolateral approach could be performed without difficulty. However, if the height of the iliac crest was above the mid pedicle of the L5, an appropriate working channel location sometimes required foraminal widening to remove the herniated mass. Foraminoplasty was particularly required in cases where the height of the iliac crest was above the L4-5 disc space, and/or an android pelvis and/or central disc herniation was present. Due to these difficulties, half of the cases in which we performed PELD in the L5-S1 level required foraminoplasty[4,9]. A limitation of our study was the small sample size that was evaluated using transforaminal PELD. However, the validity of this approach has already been shown in the literature with larger series of patients in recent years[4,5,12,20-22,25,26,35,36,39-41]. In conclusion, the transforaminal PELD technique, which has evolved considerably in recent years, can be used to remove intra-canal, migrated, foraminal/extraforaminal, large, and recurrent disc herniations, under local and sedoanelgesia. It offers several advantages over an open surgical approach including the preservation of posterior ligamentous and bony structures, and less postoperative instability, facet arthropathy, disc space narrowing, and epidural scarring.

CONCLUSION

PELD under local and sedoanalgesia is an alternative method to classical microdiscectomy in patients with lumbar disc hernia. It is a crucial advantage that it does not require general anesthesia and that patients can provide feedback during surgery. In the early postoperative period, it is possible to evaluate whether the decompression is sufficient with the straight leg raising test before the patient leaves the operating room. Because the procedure does not require nerve manipulation and normal anatomical structures are not damaged, the patient feels less pain in the early postoperative period, can be discharged on the same day, and can return to their daily activities and work life more quickly.

Ethics

Ethics Committee Approval: Retrospective study.
Informed Consent: Retrospective study.
Peer-review: Internally peer-reviewed.
Financial Disclosure: The author declared that this study received no financial support.

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MICROSURGICAL TREATMENT OF LUMBAR DISC HERNIATION: A RETROSPECTIVE REVIEW OF 282 CASES

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ABSTRACT

Objective: Lumbar disc herniation is an important disease that causes symptoms of back pain, leg pain, and imbalances in muscle strength in patients, causing socio-economic problems due to loss of workforce in the society. In this study, which was conducted from April 2015 to April 2017, we retrospectively evaluated the patients with lumbar disc herniation, who underwent microsurgery.

Materials and Methods: Microsurgery with maximum resection principle was performed on 282 patients. Of these patients, 125 were men and 157 were women. The mean age of the patients was 44 (19-80) years. Operations were planned by using lumbar X-ray and lumbar magnetic resonance imaging techniques. Computed tomography of the lumbar spine and electromyography were used to support the diagnoses when necessary. A retrospective evaluation of the patients was performed considering their gender, age, physical examination and radiological findings, disc distances, preoperative and postoperative findings, complications, recurrences, and patient satisfaction.

Results: Of the included patients, 125 were men (44.33%) and 157 were women (55.67%). The mean age was 44 (19-80) years. Among the study patients, pathological findings were found at the intervertebral disc between the L1 and L2 levels in three (1.06%) patients, the L2 and L3 levels in eight (2.84%) patients, the L3 and L4 levels in 32 (11.35%) patients, the L4 and L5 levels in 103 (36.52%) patients, and the L5 and S1 levels in 61 (21.63%) patients. Pathological findings were present in two levels in 61 (21.63%) patients, in three levels in 13 (4.61%) patients, and in four levels in one (0.35%) patient. The dural injury was identified in nine (3.19%) patients, subcutaneous cerebrospinal fluid collection was present in one (0.35%) patient, and a mislabeled laminotomy was found in one (0.35%) patient. Spondylodiscitis developed in one (0.35%) patient, superficial skin infections developed in two (0.71%) patients, and postoperative spondylolisthesis occurred in one (0.35%) patient to whom stabilization was applied. Recurrences developed in eight (2.84%) patients and these patients underwent repeat surgery. According to the Prolo follow-up scale, the results of the surgery were excellent in 137 (48.58%) patients, good in 124 (43.97%) patients, moderate in 20 (7.09%) patients, and poor in one (0.35%) patient.

Conclusion: Our study results demonstrate that the microsurgical technique and maximal disc resection in selected cases of surgery are effective and reliable methods in the surgical treatment of lumbar disc herniation.

Keywords: Lumbar disc herniation, microdiscectomy, maximal resection

INTRODUCTION

The intervertebral disc was anatomically defined by Valsalius in 1555 for the first time. The link between low back pain and sciatica was revealed by Laseque in the 1800s. In 1925, Walter Dandy reported that the free disc material was the cause of the compression in two patients who he had operated. Intervertebral disc herniation treatment was introduced after the disease was first defined in the early 1930s[9,20]. The intervertebral disc consists of three parts: the annulus fibrosus, the nucleus pulposus, and the cartilaginous plaque. In children, the nucleus pulposus is liquid; however, it is subject to dehydration and shrinkage over the years. Throughout this aging process, the content of the nucleus pulposus changes, too. Trauma, occurring either in the form of a single accident or being exerted constantly in the form of minor stress (for example, due to professional obligations), either leads directly to herniation or accelerates the development of further herniation[17,19,24].

As it is known, lumbar disc herniation (LDH) is currently one of the major burdens in the society and economic settings due to a variety of symptoms including low back pain, leg pain, impaired muscle strength, and hypoesthesia. Although most patients are in the range from 30 to 50 years of age, LDH is diagnosed in children and adolescents, too[20,24]. Approximately 90% of all disc herniations in the spine are observed in the lumbar region. Only 5% of the painful cases are diagnosed with disc herniation. Up to 95% of LDH occur in the intervertebral disc areas between the L4 and L5 and L5 and S1 levels[2,12,18]. In our study, which was conducted from April 2015 to April 2017, we retrospectively evaluated the patients with LDH, who underwent microsurgery.

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MATERIALS AND METHODS

A total of 282 patients with LDH, who were operated in our clinic from April 2015 to April 2017, were retrospectively analyzed. All patients were evaluated with direct lumbosacral radiographs, lumbar magnetic resonance imaging (MRI) (Figure 1), and if necessary, with lumbar computed tomography (CT). Furthermore, some patients underwent electromyography (EMG) to support the diagnosis. The patients who were previously operated were retrospectively evaluated for the parameters including the gender, age, physical examination, intervertebral disc distances, radiological findings, preoperative and postoperative findings, complications, and recurrence.

RESULTS

Maximal disc resection was performed by the microsurgical technique in all patients. Of the patients, 125 were men (44.33%) and 157 were women (55.67%) (Table 1). The mean age was 44 (19-80) years. The distribution of patients according to age ranges is shown in Table 2. All patients complained of low back pain and unilateral or bilateral sciatica. The patients having only low back pain were not operated. On the physical examination, the Laseque test was significant (<60°) in 273 (96.8%) patients. Of the study patients, 65 (23.04%) patients had motor deficits at various levels, 144 (51.06%) patients had changes in reflexes, and 178 patients (63.1%) had dermatomal sensory changes (Table 3). The patient distribution according to the intervertebral disc level pathology was as follows: L1-2 level in 3 (1.06%) patients, L2-3 level in 8 (2.84%) patients, L3-4 level in 32 (11.35%) patients, and L4-5 level in 103 (36.52%) patients. There were 61 (21.63%) patients with LDH at the L5-S1 level. Also, the disc herniation was two levels in 61 patients (21.63%), three levels in 13 patients (4.61%) and four levels in one patient (0.35%). All of these patients were operated. Among all patients, 8 patients (2.84%) underwent repeat operations (Table 4). All patients received one dose of preoperative and 2 doses of postoperative prophylactic antibiotic therapy. The skin of all patients was brushed with antiseptic solutions for 5 minutes before the operation. The intervertebral distance was determined by perioperative scopy. A 2-3 cm skin incision was performed in the lumbar area on the midline (Figure 2). All of the patients were operated with the microsurgical technique with maximal disc resection (Figure 3). There was dura injury in

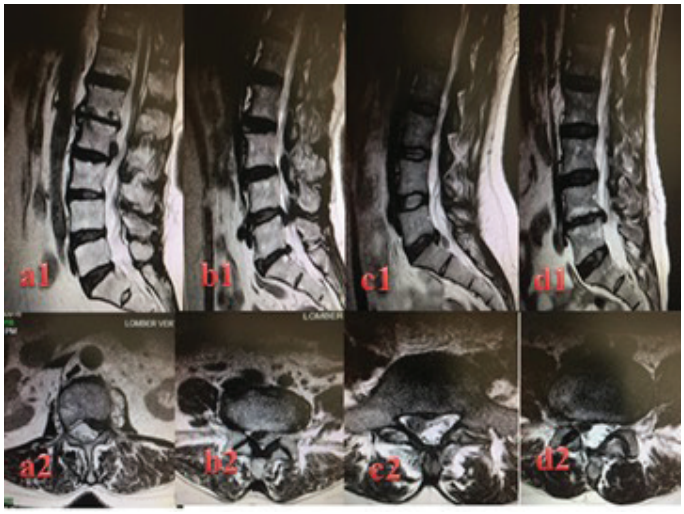

Figure 1. Magnetic resonance imaging of selected patients before the operation. a1-2: Left centrolateral disc herniation at the L2-3 level, b1-2: right centrolateral disc herniation at the L4-5 level, c1-2: right centrolateral disc herniation at the L5-S1 level, d1-2: and right centrolateral recurrent disc herniation at the L4-5 level

Table 1. Gender distribution in the study population

	Number of patients	%
Male	125	44.33
Female	157	55.67

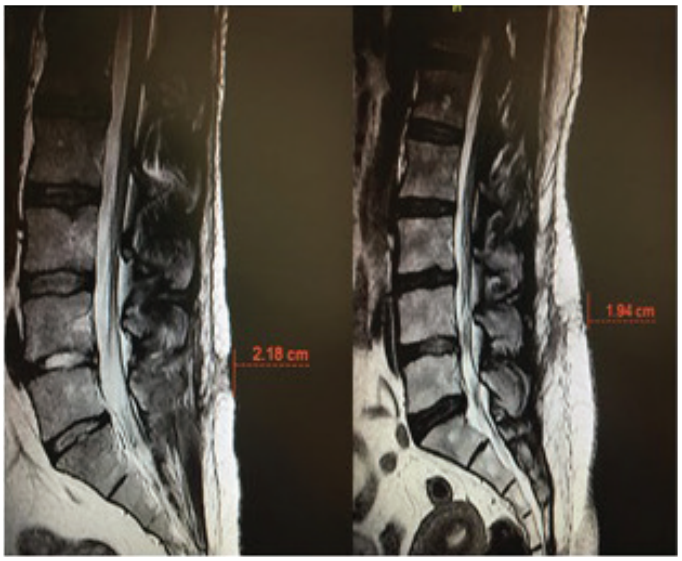

Figure 2. Postoperative magnetic resonance imaging of a skin incision

Table 2. Distribution of patients by the age groups

	Number of patients	%
10-29 years	23	8.16
30-49 years	173	61.35
50 years and older	86	30.49

Table 3. Physical examination findings of the study patients before surgery

	Number of patients	%
Motor deficits	65	23.04
Reflex changes	144	51.06
Sensory changes	178	63.1
Laseque test	273	96.8
Femoral tensile test	55	19.5

9 (3.19%) patients. Two of these patients had previously been operated in external clinics. Cerebrospinal fluid (CSF) collection developed in one (0.35%) patient and this patient was treated with ultrasound-guided needle aspiration intermittently. Accidentally, one (0.35%) patient underwent laminotomy at an erroneous intervertebral disc level. Spondylodiscitis developed in one (0.35%) patient but this patient recovered totally after medical treatment. In two (0.71%) patients, superficial infections developed in the incision site. These infections recovered after medical treatment and wound debridement. Post-traumatic spondylolisthesis developed in one (0.35%) patient in the postoperative period. Recurrences occurred in eight (2.84%) patients (Table 5). Patients were evaluated postoperatively in the first week. The Prolo scale was administered to the patients in the third month. It was found out that our surgical results were excellent (48.58%) in 137 patients, good (43.97%) in 124 patients, moderate (7.09%) in 20 patients, and poor in one (0.35%) patient (Table 6). Excellent results indicated that the complaints of the patient were resolved completely and the patient returned to daily functioning. Good results indicated that the patient returned to work and daily activities but with mild complaints occurring at some times. Moderate results indicated that the patient was unable to perform in the previous work and the patient had to work in a less strenuous job. A comparison of the preoperative and postoperative radicular pain levels revealed a significant reduction in postoperative radicular pain ($p<0.001$). The patients reporting that they did not benefit from the operation and that their complaints remained were considered to be in the "poor results" group. Overall, 93% of our patients reported that they benefited from the surgery.

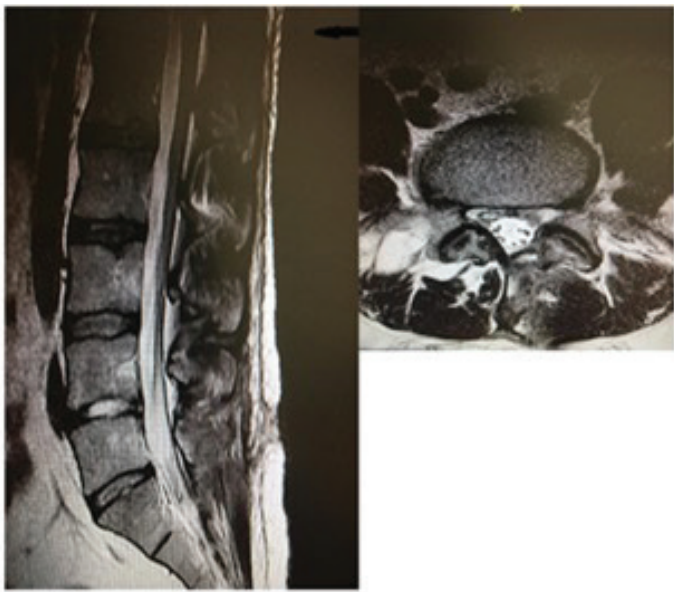

Figure 3. Postoperative magnetic resonance imaging of a left disc herniation at the L4-5 level

Table 4. Levels of discectomy

	Number of patients	%
L1-2	3	1.06
L2-3	8	2.84
L3-4	32	11.35
L4-5	103	36.52
L5-S1	61	21.63
Two levels	61	21.63
Three levels	13	4.61
Four levels	1	0.35

Table 5. Complications

	Number of patients	%
Dura injury	9	3.19
BOS subcutaneous collection	1	0.35
Incorrect distance	1	0.35
Spondylodiscitis	1	0.35
Superficial skin infection	2	0.71
Recurrence	8	2.84

DISCUSSION

It is established that 70-80% of people suffer from low back pain at some time in their lives[2,18,24,25]. However, only 1-2% of the patients presenting to the outpatient clinics with low back pain require surgical treatment at the end of a series of examinations and treatments. LDH usually occurs in men more frequently and this frequency varies from 65 to 80%[7,16,26]. In our study, 44.33% of our patients were men. Compared to the literature, the number of female patients in our study was higher.

LDH is frequently seen in the 3rd, 4th, and 5th decades of the lifespan. As the underlying reason, it is suggested that the individuals are more active in these decades compared to the other ages in the lifespan[13,22,29]. In our patient series, LDH was most commonly observed in the age group of 30-49 years (61.35%). Our results were in alignment with the findings reported in the literature.

The examination findings of the operated patients showed that the Laseque sign was significantly positive in 273 patients (96.8%). In the literature, it has been reported that the Laseque

Table 6. Clinical results according to the Prolo follow-up criteria

	Number of patients	%
Excellent	137	48.58
Good	124	43.97
Moderate	20	7.09
Poor	1	0.35

sign is positive in 83% of cases suffering from nerve root compression[3]. Furthermore, our patients suffered from various levels of strength loss (23.04%), dermatomal sensory changes (63.1%), and reflex changes (51.06%). It was found out that these rates were compatible with the literature[1,14]. On the same day, 11 (3.9%) patients were treated due to advanced neurological deficits (drop foot, paraparesis or urinary-stool incontinence) under emergency conditions. In 8 (72.7%) of these patients, complete neurological recovery occurred; however, the recovery was partial in one (9.1%) patient and no neurological improvements were observed in two (18.2%) patients. LDH is mostly seen at the intervertebral disc levels of L4-5 or L5-S1 due to the impact of biomechanical effects on the lumbar spinal column with a frequency of 80-90% in the literature[15,26]. This rate was found to be 84.75% in our study in line with the literature. Lumbosacral radiographs, lumbar intrathecal contrast-enhanced and non-contrast CT images, myelography and EMG findings, and MRI can be used in making the diagnosis of LDH[11,15]. Besides showing the herniated lumbar disc pressing on the nerve root or dural sac outside the disc distance, MRI also reveals signal changes within the suspected disc degeneration distance[4]. In our series, direct lumbosacral radiographs and lumbar MRI were used in making the diagnosis in all patients. The diagnoses were supported by EMG and CT findings in some patients.

Perioperative and early postoperative complications may be encountered in LDH operations. These complications include superficial or deep infections of the wound site, infection in the intervertebral distance, dural tears and neural tissue injuries, major vascular injury, and ureter damage[5,6,8,23,26-28,30]. In our series, 9 (3.19%) patients had dural injury. Two of these patients had been operated previously. CSF collection developed in one (0.35%) patient, who was treated with ultrasound-guided needle aspiration intermittently. It was found out that one (0.35%) patient underwent laminotomy accidentally at an incorrect intervertebral disc distance. Spondylodiscitis developed in one (0.35%) patient and improved after medical treatment. In two (0.71%) patients, a superficial infection developed in the skin incision and improved after medical treatment combined with wound debridement. Spondylolisthesis was observed in one (0.35%) patient in the postoperative 8th month. The patient had a history of trauma in the postoperative period. Spondylolisthesis was thought to be secondary to trauma. We considered that compliance with microsurgical principles and maximum disc resection enabled to achieve the low rates of complications and recurrent disc herniation.

Williams argued that removing only free disc fragments was sufficient to avoid creating injury in the healthy disc, reporting a recurrence rate of 9%[27]. Similarly, Rogers[23] reported a recurrence rate of 11% in cases, where only the disc fragment was removed. Yaşargil[28] and Caspar et al.[6] reported a recurrence rate of 4% in the patients undergoing maximum resection[8]. In our series, maximum resection was performed and 8 (2.84%) patients had a recurrence during the follow-up period. This rate corresponds to the series that advocate maximum resection. When we compared the symptoms of the patients before and after the surgery, we observed a statistically significant reduction in the symptoms compared to the preoperative values ($p<0.001$). The Prolo scale is widely used in evaluating postoperative improvement in patients[10,21]. Various patient series in the literature report that the achieved results are "good" with rates from 74 to 93%[10].

CONCLUSION

In our series, excellent results were obtained in 137 patients (48.58%) and good results were obtained in 43 patients (43.97%) as determined in the postoperative follow-up visits (Table 6). Our results were considered to be in alignment with the literature. In this study, 282 patients with LDH underwent surgical treatment with microsurgical technique and maximum resection principle. The outcomes of surgery were evaluated in the patients. Our study results were in line with the results reported in the literature. Our results showed that in selected cases requiring surgery, the microsurgical technique with maximum disc resection was an effective and reliable method for the surgical treatment of LDH.

Ethics

Ethics Committee Approval: All procedures performed in this study were conducted in compliance with the ethical standards of the institutional ethics committee of Medipol University and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Retrospective study.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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CORRELATION BETWEEN SPINOPELVIC PARAMETERS AND THE DEVELOPMENT OF LUMBAR DISC HERNIATION

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ABSTRACT

Objective: The present study aimed to identify the correlation between spinopelvic parameters and the development of lumbar disc herniation, which is a condition usually surgically treated.

Materials and Methods: A total of 147 consecutive patients with low back pain were divided into two groups according to treatment with microdiscectomy or treatment with some medications. In all patients, pelvic incidence (PI), lumbar lordosis (LL), sacral slope (SS), and pelvic tilt (PT) angles were measured on standing profile roentgenograms of the lumbar spine and pelvis. Statistical differences were investigated between the two groups.

Results: The PI, LL, and SS values were significantly different between the two groups. However, the difference in terms of PT was not significant.

Conclusion: Some spinopelvic parameters, such as PI, LL, SS, and PT, may be considered as predictive factors in the development of degenerative spinal diseases, and the restoration of sagittal balance may provide better results when these factors are considered.

Keywords: Lumbar disc herniation, lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope

INTRODUCTION

Non-specific low back pain (LBP) affects people of all ages, and it is a significant cause of sick leaves worldwide[7], with a lifetime incidence rate of approximately 30%[4]. Lumbar disc herniation (LDH) is one of the leading causes of LBP[5]. However, lumbar microdiscectomy, which is a gold standard for surgical treatment of LDH, is preferred in <10% of patients with LDH[3]. Although the surgical indications of LDH are strictly defined, the development of LDH requiring surgery may be identified using some different low back parameters. The structure of the spinopelvic complex may cause different degenerative spinal diseases, such as LDH[10]. The correlation between lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT), which are the most remarkable spinopelvic parameters, and LDH should be investigated. Thus, this retrospective study aimsto identify whether there is a correlation between these parameters and LDH, which needs surgery for treatment.

MATERIALS AND METHODS

Patients

This study included 147 consecutive patients with LBP who were admitted to our neurosurgery outpatient clinic. Informed consent was obtained from all participants. The inclusion criteria included being male or female patients with LBP who were aged between 25 and 65 years. After undergoing neurological examination and magnetic resonance imaging, some patients were diagnosed with LDH at only one level. Patients with diabetes mellitus or other types of metabolic disorders, such as hypo- or hyperthyroidism and metabolic bone disorders; those with uncontrolled hypertension, malignant diseases, osteoporosis, and previous spinal trauma/fracture; and those who previously underwent surgery in the lumbar region were excluded from the study. In addition, patients with a narrow spinal canal, spondylolisthesis, and any deformity in the spinal column were also excluded. Moreover, patients with a body mass index greater than 30.0 kg/m^2 were not included. Patients were divided into two groups as group I and group II. Patients with signs and symptoms that were indications for lumbar microdiscectomy (patients with neurologic deficit, difficulty in walking or urinary incontinence, or intractable pain after adequate physical therapy and medication) were included in group I. Meanwhile, those who did not meet the criteria for surgery (patients without neurologic deficit, difficulty in walking or urinary incontinence, but with herniation findings according to imaging studies) were included in group II. The PI, LL, SS, and PT angles of all the patients were measured on standing profile

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roentgenograms of the lumbar spine and pelvis. Measurements were performed as follows:

Pelvic Incidence

This parameter is used to characterize pelvic morphology and function[2]. PI is defined as the angle generated by the intersection of the line drawn from the center of the femoral heads to the middle of the sacral plate and the line passing perpendicular to the middle of the sacral plate[10]. PI is generally accepted as the angle that describes the relationship between the sacral plate and femoral heads. It is a stable morphologic parameter for each individual.

Lumbar Lordosis

LL is defined as the angle between the lines passing the L1 superior plate and sacral plate and is measured using the Cobb method on lateral lumbosacral roentgenogram. The present study compared the two groups in terms of PI and LL angles[9].

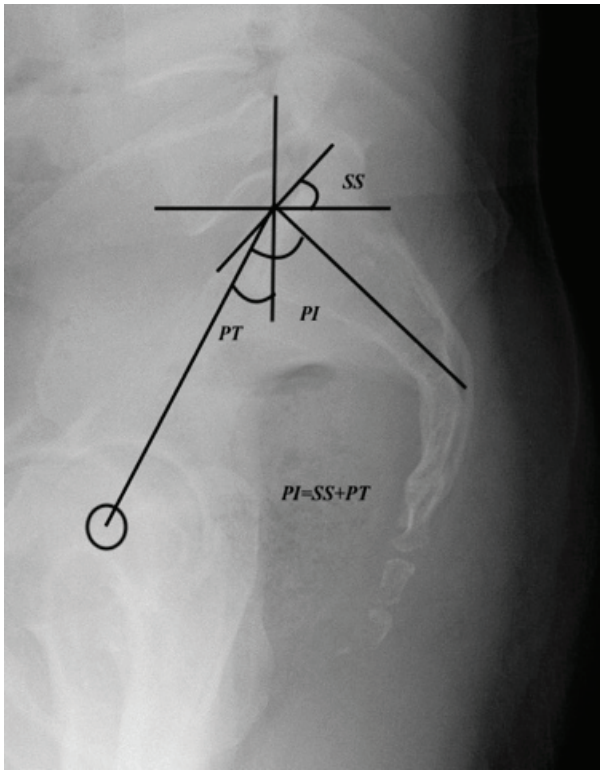

Figure 1. Spinopelvic parameters. The values obtained using the equation pelvic incidence=sacral slope+pelvic tilt can easily be proven on the figure geometrically
PI: Pelvic incidence, SS: Sacral slope, PT: Pelvic tilt

Sacral Slope

SS is one of the two spinopelvic parameters that define the orientation of the pelvis. The other parameter is PT. These two parameters are positional parameters. SS is defined as the angle between the sacral plate and horizontal line on standing lateral roentgenogram. A vertical sacrum is characterized by a low SS value, and a horizontal sacrum is characterized by a high SS value.

Pelvic Tilt

PT is defined as the angle between the line connecting the midpoint of the sacral plate to the bi-coxo-femoral axis and the vertical plane. The arithmetic equation between these parameters is as follows: PI=SS+PT (Figure 1)[1]. Thus, if there is a significant difference between the two groups in terms of these parameters, it may be assessed via forward-looking estimations particularly in individuals who take part in the tail of the Gaussian distribution.

Ethical Consideration

All procedures involving human participants performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Statistical Analysis

The Statistical Package for the Social Sciences software for Windows version 16.0 (IBM Corp., the USA) was used for statistical analyses. Intergroup comparisons of the data were performed using the independent t-test. Data were presented as mean ± standard deviation. Any p value less than 0.05 was considered as statistically significant.

RESULTS

The current study included 147 patients aged between 25 and 65 years with a mean age of 44.41±8.95 years. Group I comprised 101 patients aged between 25 and 65 years with a mean age of 44.73±9.03 years. Group II consisted of 46 patients aged between 25 and 65 years with a mean age of 43.70±8.81 years. In terms of age, no significant difference was observed between the two groups (p>0.05). The male-to-female (M/F) ratio of the study population was 1.2. The ratios in groups I and II were 1 and 1.9, respectively. A significant difference was observed between the two groups in terms of

Table 1. Pelvic incidence, lumbar lordosis, sacral slope and pelvic tilt values of groups I and II

Spinopelvic parameters	Group I (n=101)	Group II (n=46)	Study population	p
PI	54.63±8.24	64.88±7.98	57.84±9.43	<0.005
LL	44.11±12.26	50.56±10.62	46.13±12.11	<0.005
SS	30.22±7.52	39.00±5.04	33.00±7.98	<0.005
PT	24.51±7.06	25.80±6.30	24.91±6.03	<0.005

PI: Pelvic incidence, LL: Lumbar lordosis, SS: Sacral slope, PT: Pelvic tilt, numbers are mean ± standard deviation

gender distribution (p<0.05). The mean PI value of the study population was 57.84°±9.43°, ranging from 36° to 77°. The mean PI value of group I was 54.63°±8.24°, and that of group II was 64.88°±7.98°. A significant difference was observed between the two groups in terms of PI value (p<0.05).

The mean LL value of the study population was 46.13°±12.11°, ranging from 6° to 68°. The mean LL value of group I was 44.11°±12.26°, and that of group II was 50.56°±10.62°. A significant difference was observed between the two groups in terms of LL value (p<0.05). The mean SS value of the study population was 33.00°±7.98°, ranging from 14° to 49°. The mean SS value of group I was 30.22°±7.52°, and that of group II was 39.00°±5.04°. A significant difference was also revealed between the two groups in terms of SS value (p<0.05). The mean PT value of the study population was 24.91°±6.03°, ranging from 5° to 42°. The mean PT value of group I was 24.51°±7.06°, and that of group II was 25.80°±6.30°. No significant difference was found between the two groups in terms of PT value (p>0.05), (Table 1). In conclusion, statistically significant differences were observed in PI, LL, and SS values, but not in PT value.

DISCUSSION

Standing in erect position is a basic human attribute. As bipedal locomotion has developed in the history of transformation from Hominidae to erect human species[10], it causes some spine problems in humans. LDH develops as a result of degenerative process[8]. Degenerative diseases are more likely to occur in an unbalanced loading and under asymmetric force vectors. Spinopelvic parameters may be helpful in identifying the risk factors for lumbar degenerative disc disease, and such parameters can be used to explain why asymmetric loading causes LDH. PI and LL are the most important spinopelvic parameters that form the lumbo-pelvic shape. The International Spine Study Group has recently reported about PI-LL mismatch[11]. According to their interpretation, PI-LL mismatch is correlated to disability. In relation to this reason, these two parameters were used in this study to identify the correlation between the development of LDH and spinopelvic morphology. By contrast, two other parameters defining the orientation of the pelvis, SS, and PT were also investigated for their possible correlation with the development of LDH. PI is a morphologic constant parameter and is not affected by posture or pelvic position[1]. Therefore, degenerative lumbar lesions are expected not to influence PI value. LL is another important parameter that forms the lumbar sagittal shape and even affects the global sagittal balance. LL angle is of clinical interest in assessing lumbar alignment[6]. Thus, the influences of these two parameters in developing degenerative disc pathologies is worth investigating. At the same time, a weak correlation was observed between PI and LL, which strengthens this thought. This study showed a negative correlation between PI value and the development of LDH. The same negative correlation was observed between LL and SS values and the development of LDH. However, these statistical results are applicable in patients with LBP. These correlations may only show the severity of the situation. In this study, we cannot conclude that individuals with high PI, LL, or SS values do not develop LDH. However, we can say that individuals with existing or previously diagnosed LDH who have low PI, LL, and SS values are more likely to undergo surgery. Based on gender differences, men with LBP were less likely to undergo surgery compared to women with standard indications of LDH. However, the M/F ratio of group I was 1, which makes this result challenging to interpret. LL is the important parameter that may explain this result. However, no significant differences were observed between men and women in terms of LL values. The influences of pelvic shape and orientation may help to identify individuals who are at risk of developing LDH at some degree. At the same time, the restoration of these parameters, except PI, may help surgeons establish a preoperative plan. The sagittal balance of the spine should be considered during the evaluation of each patient with degenerative spine diseases. The restoration of sagittal balance with the main treatment of any pathology of the spine is crucial in obtaining good outcome.

Study Limitations

The current study had some limitations. First, the use of the LL angle alone may not be sufficient. There are different types of LL and each type representing a corresponding PI value may have different clinic outcomes[10,12]. Second, this is a retrospective study performed on patients with LBP. Thus, orthopedic spine surgeons must conduct prospective studies about this subject in real-life settings.

CONCLUSION

Some spinopelvic parameters, such as PI, LL, SS, and PT, may be considered as predictive factors for the development of degenerative spinal diseases, and the restoration of sagittal balance with consideration of these parameters may provide better results. Moreover, PI is a constant structural parameter; thus, an individual with low PI who presents with LBP must be monitored to prevent the development of LDH.

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Ethics

Ethics Committee Approval: Retrospective analysis in patients' savings. It doesn't need Ethics Committee approval.

Informed Consent: Written informed consent was obtained from all participants.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: U.E., C.T., Ö.P., Concept: C.T., Design: U.E., Data Collection or Processing: Ö.P., C.T., Analysis or Interpretation: U.E., Literature Search: Ö.P., C.T., Writing: U.E.

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SHOULD WE PERFORM ROUTINE BIOPSY DURING PERCUTANEOUS VERTEBROPLASTY IN VERTEBRAL COMPRESSION FRACTURES?

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ABSTRACT

Objective: Percutaneous vertebroplasty (PVP) is widely used all over the world, especially in elderly patients for osteoporotic, traumatic, and pathological vertebral compression fractures (VCFs). Previous studies have reported incidental tumors in vertebral biopsy. However, whether a routine biopsy should be performed during PVP is controversial. The aim of this study was to evaluate the importance of routine biopsy during PVP in the treatment of VCF.

Materials and Methods: The patients who underwent PVP under sedo-analgesia for single or multi-level thoracolumbar vertebrae fracture were reviewed retrospectively between March 2015 and June 2019. The study included 87 patients with VCF. A hundred eleven vertebral levels were treated with PVP. Vertebral bone biopsy was performed in 67 (77.01%) patients. These biopsy specimens were examined pathologically. The mean age of the patients was 74.18±9.08 years (91-48 years), and 12 of them (17.91%) were male and 55 (82.09%) were female.

Results: Malignancy was detected in 3 patients (4.48%). Two of them were multiple myeloma and the other one was renal cell carcinoma metastasis.

Conclusion: Bone biopsy during PVP procedures does not cause significant time loss or complications. Therefore, revealing the underlying pathology provides a great advantage to the patient and the surgeon. We recommend routine vertebral bone biopsy using a biopsy needle during the PVP procedure.

Keywords: Percutaneous vertebroplasty, vertebral bone biopsy, vertebral compression fractures

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Percutaneous vertebroplasty (PVP) procedures are used to alleviate pain in patients with osteoporosis and stable fractures. Vertebroplasty is also recommended for traumatic fractures, hemangiomas, and primary or metastatic tumors in the vertebral body[1]. Secondary osteoporosis may also occur after systemic lupus erythematosus, Cooley's disease, Paget's disease, metastatic lesions or corticosteroid use. Vertebral compression fractures (VCFs) may also develop due to these conditions. Most vertebral augmentation procedures are thought to result from osteoporosis. Therefore, bone biopsy is not performed[11]. The etiology of VCFs may change the treatment decision and method. The diagnosis of osteoporotic VCF before vertebral augmentation procedure is based on clinical findings and imaging methods but they sometimes cannot determine the true etiology of VCF. Previous studies of the vertebral augmentation procedure revealed incidental malignancies as a result of bone biopsy. Routine biopsy was not used in some of these studies[6,15]. The aim of this study was to analyze the results of routine vertebral bone biopsies obtained from all PVPs performed by a single surgeon in a single center.

MATERIALS AND METHODS

The records of 87 patients (73 females, 14 males) hospitalized for VCFs in the Neurosurgery Clinic of Çanakkale Anadolu Hospital between March 2015 and June 2019 were retrospectively reviewed. A hundred eleven PVP levels included T6 (2), T7 (3), T8 (3), T9 (2), T10 (3), T11 (10), T12 (25), L1 (25), L2 (15), L3 (11), L4 (6), and L5 (6). Vertebral bone biopsy was taken from 77.01% (n=67) patients (55 females, 12 males) and referred to the department of pathology. Adequate biopsy was not obtained from 22.99% (n=20) patients. Therefore, the study was evaluated for 67 patients. The mean age of the patients was 74.18±9.08 years (91-48 years) and 12 of them (17.91%) were male and 55 (82.09%) were female. All patients underwent one level vertebral body biopsy. Biopsy specimens sent to

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the department of pathology from VCFs were histologically evaluated. These evaluations were noted retrospectively. The demographic characteristics of the patients are shown in Table 1. Patients with one or more VCFs had severe pain in the lumbar or thoracic region despite medical treatment or rest. Preoperative and postoperative thoracolumbar steel underwire corsets were given to all patients. PVP was applied to the patients with VCFs, whose fracture age was 10 weeks. PVP was not performed in patients with motor and sensory loss, incontinence, and unstable vertebral fractures.

All patients were preoperatively evaluated through vertebral magnetic resonance imaging (MRI), X-ray or computed tomography (CT). These procedures were performed in the operating room under sedo-anesthesia. All patients were placed in prone position with scopy guidance. Antibioprophylaxis (1 gm cefazolin sodium intravenously) was given before the procedure. The 11-gauge Jamshidi biopsy needle was percutaneously inserted into the fractured vertebral body via the transpedicular approach. A cannula was placed in the back half of the spine body with the help of Kirschner wires. A bone biopsy was obtained by inserting and twisting an obturator. An attempt was made for bone biopsy from the vertebral corpus in all patients. However, adequate biopsy was obtained from 67 of 87 patients. Bone cement was injected into the vertebra through the pedicle. Follow-up for complications after PVP was performed through postoperative vertebral radiography or vertebral CT.

Table 1. Demographic and clinical characteristics of patients undergoing routine biopsy during percutaneous vertebroplasty

Study population	Patients (n=67)
Age (years, mean ± SD)	74.18±9.08
Gender (n, %)	Male 12 (17.91%) Female 55 (82.09%)
Vertebral tumors (n, %)	
Multiple myeloma	2 (2.99%)
Renal cell carcinoma metastasis	1 (1.49%)

SD: Standard deviation

RESULTS

Tumor pathology was detected in 3 patients except osteoporosis. This means that 4.48% of patients undergoing bone biopsy were pathological. They were multiple myeloma (MM) and renal cell carcinoma (RCC) metastasis. Other specimens showed necrotic bone areas, hematopoietic areas, acute or chronic inflammation foci. Our first patient with MM was a 61-year-old man. He had previously had suspected tumors but could not be diagnosed. Pathological fractures were present in the T6/T11/L3 vertebrae. Diagnosis was made by vertebral bone biopsy. The second patient with MM was a 62-year-old woman. Previously, another surgeon had done T12 and L4 pvp. However, biopsy was not taken in the previous surgery. The L2/L5 had new VCFs. PVP was applied to both spine. Biopsy was performed and diagnosis was made. Figure 1 shows L2 and L5 VCFs on preoperative sagittal MRI sections of a 62-year-old woman with MM (Figure 1). The other patient was a 64-year-old female patient. He underwent surgery for RCC years ago. No metastasis was detected during follow-up. However, she was admitted to our clinic because of severe low back pain. Lumbar MRI showed many metastases, especially L4 vertebrae. This patient underwent bone biopsy during PVP. The diagnosis was made through a biopsy. In male patient with MM, the lesions were suspected because of the history of previous tumor investigations. However, there was no doubt in the female patient before PVP. The female patient was diagnosed incidentally. The patient with other RCC metastasis had suspected tumor due to his history. Therefore, the incidence of incidental tumors was 1.49% in routine vertebral biopsy performed during PVP.

DISCUSSION

Minimally invasive spine augmentation methods such as PVP are frequently used in the treatment of VCFs, especially in the thoracolumbar region. PVP and percutaneous kyphoplasty (PKP) are often used to treat osteoporotic vertebral compression fractures[3,13]. It has been applied successfully even in burst fractures without neurological deficit[9]. However, the cause of low back and back pain may not be caused solely by osteoporosis. Differential diagnosis should include benign or

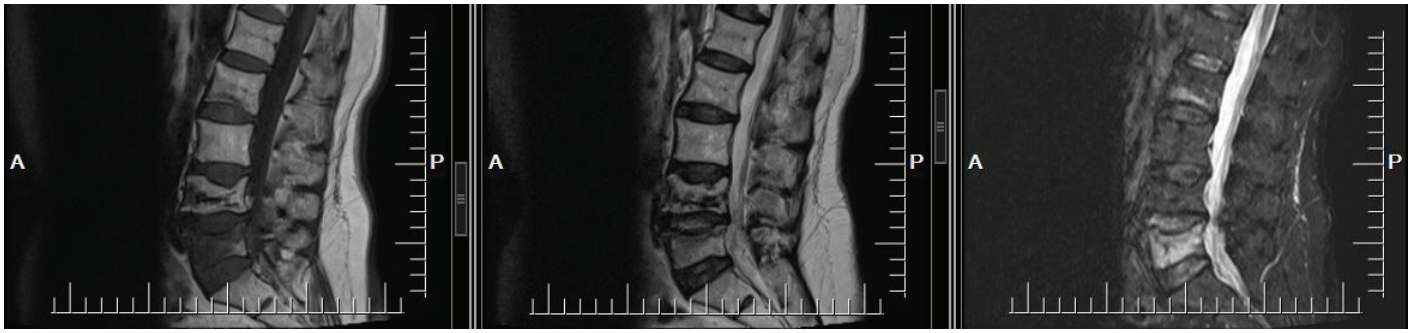

Figure 1. T1-weighted, T2-weighted, and fat suppression sagittal magnetic resonance imaging show the involvement, compression, and edema of the vertebral body at L2/L5 levels

malignant tumors, traumas, infections, tumor endocrinopathy, blood dyscrasias, and autoimmune diseases[4,11].

MM is a hematologic malignancy with lytic bone lesions. Vertebral involvement is present in approximately 60% of MM patients. PVP has been safely administered and recommended for the treatment of pain in these patients [8]. RCC is the most common malignancy of the kidney. Recurrence postoperatively occurs in 40% of patients[14]. Treatment options for vertebral metastases of RCC are limited. If metastasis is detected, the average life expectancy is 12-24 months. PVP is used to relieve pain and support the vertebral body[5]. In the literature, vertebral metastasis of RCC has been reported less than vertebral involvement of MM. Diagnosis of spinal metastasis requires a good clinical evaluation (patient age, single and multiple involvement, history), CT, MRI, and nuclear medicine[2]. Nuclear medicine methods, such as bone scintigraphy, show all vertebral fractures. Bone scans are insufficient to reveal the underlying pathology in fractures. MRI is the most appropriate method to show whether the vertebral fracture is old or new and the probability of tumor. It is also guiding for the choice of treatment. However, despite all these investigations and findings, bone biopsy is needed if the suspicion continues[11]. In a study published in 2005, biopsy was taken from 142 patients and plasma cell dyscrasia was detected in 4 (2.82%) patients. Therefore, the authors recommended biopsy during vertebral augmentation procedure. In this study, the majority of patients were women and the mean age of all patients was 72 years (range 40-90 years)[12]. In this study, age, gender and MM rates coincide with the results of our study. In 2010, a research was carried out at a public hospital in Greece. It was thought to increase the cost in patients without suspected malignancy. Therefore, biopsy should be performed only in patients with suspected malignancy. Routine vertebral bone biopsy was not recommended due to cost[11]. In another article published in the UK in 2014, malignancy was detected in 4 (4.7%) of 86 patients who had no previous history of cancer. Malignancy was seen in 2 (10%) of 20 patients with cancer history. When both groups were combined, the diagnosis of malignancy reached the rate of 5.5%. The authors recommended vertebral bone biopsy with or without cancer in both groups[7,10]. The results of this study conducted at Royal London Hospital are consistent with the results of the research conducted in our hospital.

Procedures were performed by a surgeon who believed that a routine biopsy was required during vertebroplasty. This made our work easier. Therefore, the study was retrospectively reviewed. When we look at the literature, we see that there are similar studies but they are limited. We did this study to contribute to the literature and to guide surgeons dealing with the spine[10].

CONCLUSION

In conclusion, we recommend routine bone biopsy during percutaneous vertebral augmentation. If the cost is low, it should be done to all patients. If the cost is high, it should be done to patients with a history of cancer and suspected cancer. It is an advantage that it does not extend working time and can be applied easily.

Ethics

Ethics Committee Approval: Permission from Chief Physicsian to use data (approval number: 20.08.2019/348)

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Ö.Ö., Concept: Ö.Ö., N.K., Design: Ö.Ö., N.K., Data Collection or Processing: Ö.Ö., N.K., Analysis or Interpretation: Ö.Ö., N.K.,Literature Search: Ö.Ö., N.K., Writing: Ö.Ö., N.K.

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

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GANGLION IMPAR BLOCK IN PATIENTS WITH CHRONIC COCCYDYNIA

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ABSTRACT

Objective: Coccydynia refers to pain in the terminal segment of the spine caused by abnormal sitting and standing posture. Coccydynia is usually managed conservatively; however, in nonresponsive patients, ganglion impar block is used as a good alternate modality for pain relief. This article studied the effect of ganglion impar block in coccydynia patients who were not relieved by conservative management.

Materials and Methods: We retrospectively reviewed 39 patients who underwent fluoroscopy-guided trans-sacro-coccygeal ganglion impar block between April 2014 and April 2016. We included four patients with coccygeal fractures. General demographics and parameters including operative time, length of hospital stay, mean time to return to work, complications, and recurrences were recorded. Clinical outcomes were evaluated using Visual Analog Scale (VAS) for pain.

Results: The study included 25 (64.1%) female and 14 (35.9%) male patients. The mean age of the patients was 48.6 years (range, 14 to 81 years). Coccydynia was the leading symptom in this series. The mean duration of symptoms was 16 months (between 1 and 36 months). All patients were followed up for a 12-month period. A significant decrease was found in the mean VAS scores. The mean preoperative VAS score was found to be 8 whereas the mean postoperative VAS score at the 12th month was found to be 0.3.

Conclusion: This study recommends the trans-sacro-coccygeal "needle inside needle" technique for local anesthetic block of the ganglion impar for pain relief in patients with chronic coccydynia. This should be integrated with rehabilitative measures including ergonomic modification for prolonging pain-free period.

Keywords: Coccydynia, ganglion impar block, trans-sacro-coccygeal approach, VAS score

INTRODUCTION

The success rate of the treatment of coccydynia varies widely. It is not well understood whether treatment outcome is related to any predictable patient factors[7]. There are no standard treatment guidelines despite the existence of many modalities, including physical therapy, local infiltration of local steroids and anesthetics, caudal epidural block and neurolysis of the sacral nerve root. Furthermore, coccygectomy is not recommended due to problems, such as high rate of infection[8]. The ganglion impar (GI) is a solitary retroperitoneal structure that is located at the level of the sacro-coccygeal junction with a variable position in pre-coccygeal space which marks the end of the two sympathetic chains[5]. A trans-sacrococcygeal approach to a GI block, described by Wemm and Saberski[13] in 1995, was developed to improve the technical feasibility and overcome the associated risk for visceral injuries with a conventional technique; this approach is easy to perform and considered extremely quick[5,12]. It occurs when the pain is caused by a fracture of the tailbone changing from a dull to a severe sharp pain. Patients with coccydynia generally have complaints of pain while sitting on a hard chair and during defecation. The force to the coccyx seriously affects their daily lives[4,12]. Coccydynia has many causes. This may occur after a trauma, following a fracture or contusion or after difficult vaginal delivery. Chronic microdamage to the coccyx from an incorrect posture or bursitis on the coccydynia periosteum is also a part of the pathogenesis. Moreover, coccydynia is related to the body mass index, and the etiology is usually unknown[11,12].

MATERIALS AND METHODS

We identified all patients who presented with primary diagnosis of coccydynia from April 2014 and April 2016. Data were obtained by retrospective review of the hospital clinical files. We reviewed all the case notes and clinic letters for patients identified with a primary diagnosis of coccydynia and excluded those with other primary spinal pathologies. We confirmed the diagnosis in the clinic through a combination of clinical presentation and typical local tenderness over the coccyx on clinical examination, plain radiographs or magnetic resonance imaging.

The patient is in a prone position, and the C-arm is pushed in

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from the patient's side. The shape of the sacral hiatus is an inverted "U". The two ends of the "U" are called the sacral cornu. Identifying sacral cornu on a lateral fluoroscopic image of the sacrum may aid in performing the caudal epidural steroid injection (Figure 1).

Trans-sacrococcygeal approach was reported by Wemm and Saberski[13] in 1995. The patient was placed in the prone position with a support under the lower abdomen. The site of the needle insertion was located by palpating the sacral cornu and by using a fluoroscope after sterilization of the skin overlying the interspace. Following localization, the area was infiltrated with 2-3 mL of local anesthetic (lidocaine 2%). Under the guidance of a fluoroscope C-arm in a lateral position, a 22-gauge type B beveled, 5 cm needle was inserted through the skin piercing the dorsal sacrococcygeal ligament at the midline. The needle was then inserted into the vertebral disc until the tip was placed anteriorly to the ventral sacrococcygeal ligament, following an absence of resistance. The position of the needle tip was confirmed by injecting 1 mL of radio-opaque dye into the retroperitoneal space. The shape of the spreading dye resembles a "reverse comma" in a lateral view. Once the position of the needle tip was confirmed, 4-6 mL of 7% phenol in saline was injected followed by 1 mL of saline to avoid the deposition of phenol within the intervertebral disc material (Figure 2A, 2B).

We assessed the pain using the Visual Analogue Scale (VAS) (0 = "no pain" and 10 = "worst imaginable pain"), measured in pre-procedural 30 minutes; 10 days and 6, 12 months after the procedure. A failed block was defined as failure to lower the VAS by 50% of the preprocedural measured VAS. The hemodynamic parameters (blood pressure, heart rate, SpO_2) before, during, and after the procedure were assessed during hospitalization in the daily inpatient clinic. The patient was discharged after 1-3 hours, to be followed up for the next 10 days at the first, sixth, and twelfth months.

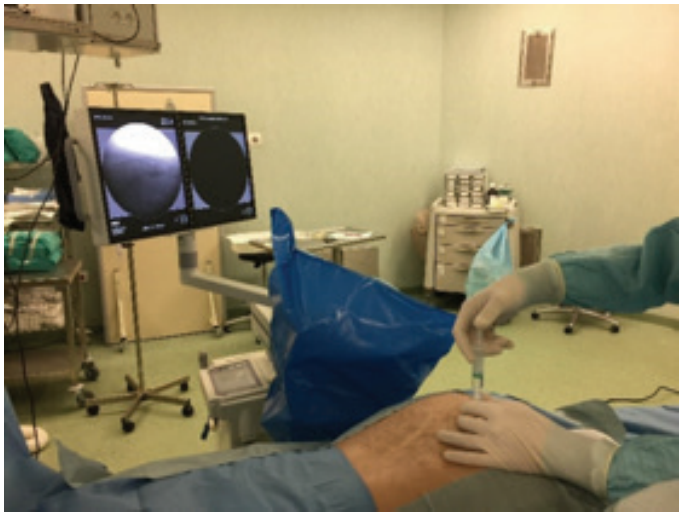


Figure 1. Surgical positioning of the patient and c-arm position can be seen in figure

Statistical Analysis

Data were analyzed by using Statistical Package for Social Science (SPSS version 21). Descriptive statistics including mean, standard deviation, median, and minimum-maximum values of the numerical variables of the study population were

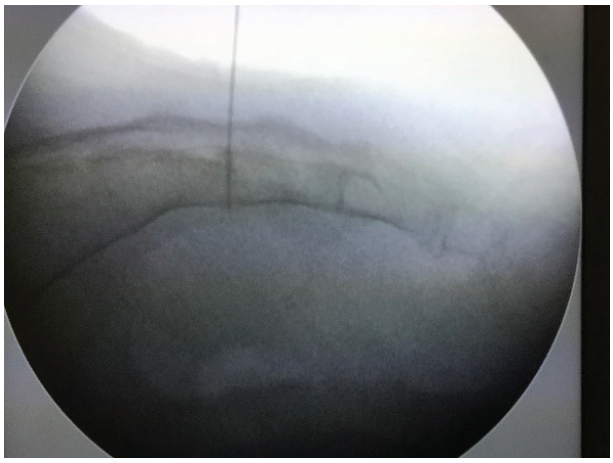


Figure 2A. Needle insertion to ganglion impar with trans-sacro-coccygeal approach seen in lateral fluoroscopy view

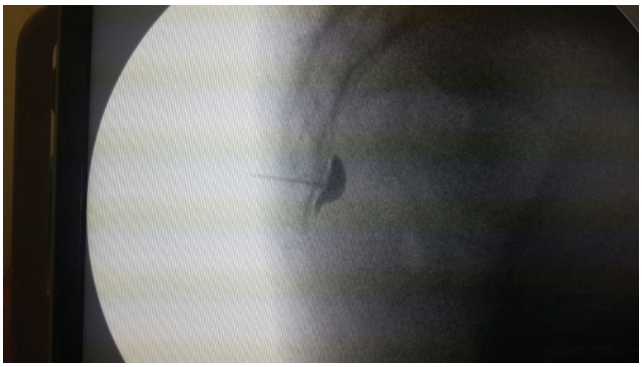


Figure 2B. Contrast medium has been delivered through needle for the confirmation of ganglion impar puncture

Table 1. The patient characteristics were summarized

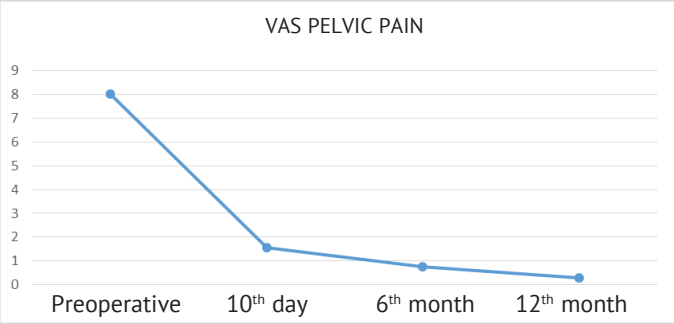
	Mean	Standard deviation	Median	Maximum	Minimum
Age	48.64	13.47	48.00	81.00	14.00
Mean duration of symptom (month)	16.05	10.73	12.00	36.00	1.00
Mean operative time (min)	35.18	4.41	35.00	47.00	25.00
Number of C-arm-fluoroscopy	4.36	0.87	4.00	7.00	3.00
Mean length of hospital stay (hour)	2.13	0.59	2.00	3.00	1.00

analyzed. Also, frequency and percentage values were used for categorical variables.

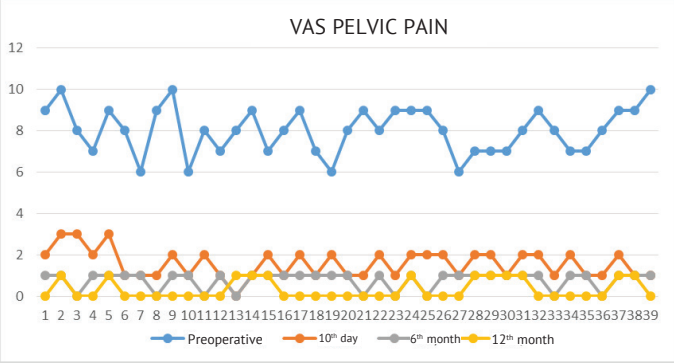
RESULTS

A total of 39 patients, following up in the pain, underwent GI block. General demographics and parameters including operative time, length of hospital stay, mean time to return to work, complications, and recurrences were recorded (Table 1). The mean age of the patients was 48.6 years (range, 14 to 81 years). The study included 25 (64.1%) female and 14 (35.9%) male patients. Coccydynia was the leading symptom in this series. Four patients were presented with coccygeal fractures (10.2%). There was no other significant causes for pain in the rest of the patients.

The mean duration of symptoms was 16 months (between 1 and 36 months). GI block through a trans-sacrococcygeal approach took a mean duration time (± standard deviation) of 35.18±4.41 minutes with a minimum and maximum duration of 25 and 47 minutes, respectively (Graphic 1, 2). The mean number of intraoperative radiographs obtained with c-arm fluoroscopy was 4.36 (range, 3 and 7). The mean hospital stay was found to be 2.13 hours following the intervention (range one hour and 3 hours).



Graphic 1. Graphic shows the decrease in Visual Analog Scale (VAS) scores for coccydynia in time. Note that there was a sharp drop in VAS scores at the 10th day postoperative visit. The decrease moderately continued until the end of the follow-up time
VAS: Visual Analog Scale



Graphic 2. Graphic shows Visual Analog Scale scores of each individual according to the pre- and postoperative examinations
VAS: Visual Analog Scale

All patients were followed up for a 12-month period. A significant decrease was found in the mean VAS scores as seen in Graphic 1 and 2. The mean preoperative VAS score was found to be 8 whereas the mean postoperative VAS score at the 12th month was found to be 0.3.

During the follow-up time, a transient paresthesia occurred in 3 patients (7.7%) in early postoperative period. It was completely resolved in all these three patients within 1 month after surgery. Another issue was the persistent postoperative local pain in 4 patients (10.3%) and it was successfully managed with medical treatment and resolved completely within 6 months. Recurrence of coccydynia was present in 4 patients (10.3%). No further surgical intervention was performed for these patients and despite medical treatment, coccydynia was persistent. No other complications were encountered during the follow-up period.

DISCUSSION

Coccydynia is a pain radiating to the sacral and perineal area, located around the coccyx. The cause of the pain is often unknown. Coccydynia is encountered five times more frequently in female gender than male gender. Women have more posteriorly located sacrum and coccyx, so they may be more exposed to this phenomenon[4,12]. The occurrence of a sacrococcygeal ligament injury during vaginal delivery can also cause pain. The coccyx is mobile and supported by the sacrococcygeal ligament; therefore, sprains are more commonly seen compared to the fractures. Microtraumas resulting from inadequate body positioning while seating can also cause chronic sprain of the coccyx[11]. However, careful differential diagnosis is needed as the cause of the pain can often be idiopathic[1,6].

The trans-sacro-coccygeal "needle inside needle" approach adopted in this study is better than the classical and paramedian approach to the ganglion, and is a technically feasible method which is easy to learn and perform. There is minimal risk involved in this technique compared to surgical treatment. The complications of this technique are neuritis and inadvertent injection of the neurolytic agent into the rectum, which can be avoided by meticulous care. All the patients required only one attempt without any difficulty. The technique was originally described by Wemm and Saberski[13] and then modified by Nebab and Flonehce[9].

First, irrespective of approach, the injectate usually flows cephalad rather than caudal. Thus, the first intracoccygeal approach results in an excellent coverage with smaller volumes of neurolytic agents compared to sacrococcygeal approach (injectate flowing too far superior to the ganglion impar)[3]. Second, in the lateral view of fluoroscopy, the bilateral cornua from the first coccygeal bone often obstruct and cause difficulty with visualizing and traversing the sacrococcygeal junction. At the first intracoccygeal junction, fluoroscopic visualization is better as these cornua are angled cephalad

and the other coccygeal segments lack any cornu. The second intracoccygeal (between the second and third coccygeal bones) approach again requires a higher volume of injectate[2]. Third, the sacrococcygeal junction is obstructed by joint fusion in 51% of patients with coccyx pain, compared with only 12% fusion at the first intercoccygeal joint[10].

CONCLUSION

Our study shows the long-term effectiveness of GI block for patients with coccydynia in providing pain relief by the trans-sacro-coccygeal "needle inside needle" technique. Fluoroscopically guided trans-sacro-coccygeal ganglion impar block may offer a safe and effective treatment option for chronic coccydynia. The integration of ganglion impar block with other rehabilitative measures including ergonomic modification may be needed for prolonging pain free period. The systematic review of the literature revealed a lack of evidence supporting conservative interventions for coccydynia.

Ethics

Ethic Committee Approval: Retrospective study.
Informed Consent: Retrospective study.
Peer-review: Internally peer-reviewed.
Financial Disclosure: The author declared that this study received no financial support.

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HOW SPINOPELVIC PARAMETERS ARE AFFECTED AFTER SURGICAL TREATMENT FOR SCHEUERMANN'S KYPHOSIS

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ABSTRACT

Objective: The relationship between the pelvis and spine is critical in global spinal alignment and sagittal imbalance and its associated compensatory mechanisms have been reported to correlate with negatively influenced quality of life. There are several studies evaluating the sagittal spinopelvic parameters (SSPs) in many areas of spinal disorders but studies evaluating the SSPs in Scheuermann's kyphosis (SK) are limited. To evaluate the effect of surgical treatment on SSPs in patients affected by SK.

Materials and Methods: The database of the institution was retrospectively reviewed to identify patients who underwent surgery for SK between the years of 2012 and 2015. Twenty-nine patients were included, and records of these patients were reviewed. Changes in pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), cervical lordosis (CL), thoracic kyphosis (TK), lumbar lordosis (LL), and the sagittal vertical axis (SVA) measurements were compared.

Results: There were no significant changes in PI, PT, SVA, and SS compared to preoperative values. There were decreases in TK and LL measurements, which were statistically significant.

Conclusion: Surgical treatment for SK seems to have little or no influence on changing SSPs.

Keywords: Kyphosis, pelvic tilt, pelvic incidence, sacral slope, sagittal vertical axis

INTRODUCTION

Scheuermann's kyphosis (SK) is a structural hyperkyphosis of the thoracic or thoracolumbar spine[21]. It is the most common cause of rigid hyperkyphosis and develops during adolescence with equal prevalence in both sexes and the incidence rate ranging from 0.4% to 8%[4,16]. The diagnosis is based on the presence of thoracic kyphosis (TK) of >40° or thoracolumbar kyphosis of >60° and at least three consecutive vertebrae wedged at a minimum of 5°, as indicated on lateral spine imaging[23]. The etiology of the disease is unknown, but it is considered as multifactorial, with a strong genetic predisposition[15]. Although the first-line treatment of SK is usually conservative, surgical management is indicated in patients with progressive deformity exceeding 70°, progressive neurological deficit, severe back pain, or significant cosmetic deformity[16]. Although some authors have suggested the use of combined anterior and posterior approaches to maximize initial deformity correction, Ponte has reported that posterior fusion alone is sufficient to achieve satisfactory outcomes with lower complication rates than those of combined approaches[2,19]. The radiographic parameters include pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), cervical lordosis (CL), TK, lumbar lordosis (LL), and the sagittal vertical axis (SVA), collectively known as sagittal spinopelvic parameters (SSPs). The relationship between the pelvis and spine is critical in global spinal alignment and sagittal imbalance and its associated compensatory mechanisms have been reported to correlate with negatively influenced quality of life[12,22]. There are several studies evaluating the SSPs in many areas of spinal and as well as hip disorders[5,6,11,24]. However, studies evaluating the SSPs in SK are limited. We tried to study the effect of surgical treatment on SSPs in patients affected by SK.

MATERIALS AND METHODS

The database of the institution was retrospectively reviewed to identify patients who underwent surgery for thoracic SK between the years of 2012 and 2015. The records of these patients were reviewed and the patients with postural kyphosis, congenital spine deformity, neuromuscular disease, associated

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spondylolisthesis or spondylolysis, the presence of scoliosis, patients who underwent previous spinal surgeries, and patients with lack of X-ray controls were excluded. Finally, 29 patients with SK were included in the study. The diagnosis of SK was based on the radiological criteria reported by Sorensen[23]. The indications for surgery were kyphosis with a curve greater than 70°, conservative treatment resistant back pain or an unacceptable cosmetic appearance. All the patients had normal neurological examination records. Following parameters evaluated on preoperative and postoperative radiographs are SVA, TK, LL, PI, SS, CL and PT (Figure 1). SVA is the horizontal distance from the posterosuperior corner of the sacrum to the C7 plumb line; TK is the Cobb angle between superior endplate of T1 vertebra and the inferior endplate of T12 vertebra; LL is the Cobb angle between the superior endplate of S1 vertebra and the superior endplate of L1 vertebra; PI is the angle between a line perpendicular to the upper sacral plate at its midpoint and the line connecting this midpoint to the middle axis of the femoral heads; SS is the angle between the sacral plate and the horizontal line; CL is the angle determined by measuring the angle between the straight lines that connect the posterior edges of the C2 and C7 vertebrae; PT is the angle between the vertical line and the line joining the middle of the sacral plate and the axis of the femoral heads[3,7,13,20]. Matched-pair analysis was used to compare radiological measurements before and after surgery. A p value threshold of <0.05 was chosen to define statistical significance. Analysis of changes in postsurgical SSPs compared to preoperative values was performed, and encountered complications were described. The measured values were compared with those reported in literature.

RESULTS

Twenty-nine patients were included in the study, of which 25 were male and 4 were female. The mean age was 20.75±5.38 years (range=14-36 years). There were 3 patients that had complications after surgical treatment: two proximal junctional kyphosis managed by revision surgery and one hemothorax that needed intervention by thoracic surgery. There were no significant changes in PI, PT, SVA, and SS compared to preoperative values (p>0.05) (Table 1). TK passed from an average 61.34±15.55 preoperatively to an average 38.27±13.49 (p<0.05). LL passed from an average 66.37±11.22 preoperatively to an average 50.93±15.66 (p<0.05), and SL passed from an average 24.32±19.87 preoperatively to an average 25.75±15.74 (p>0.05).

DISCUSSION

The sagittal spinal alignment analysis has become popular and correlation between SSPs and various spinal and pelvic diseases has been searched in the last decades[14,18,19]. Afterward, SK is the most common cause of sagittal spinal deformity in adolescence, but unexpectedly very few studies evaluating the

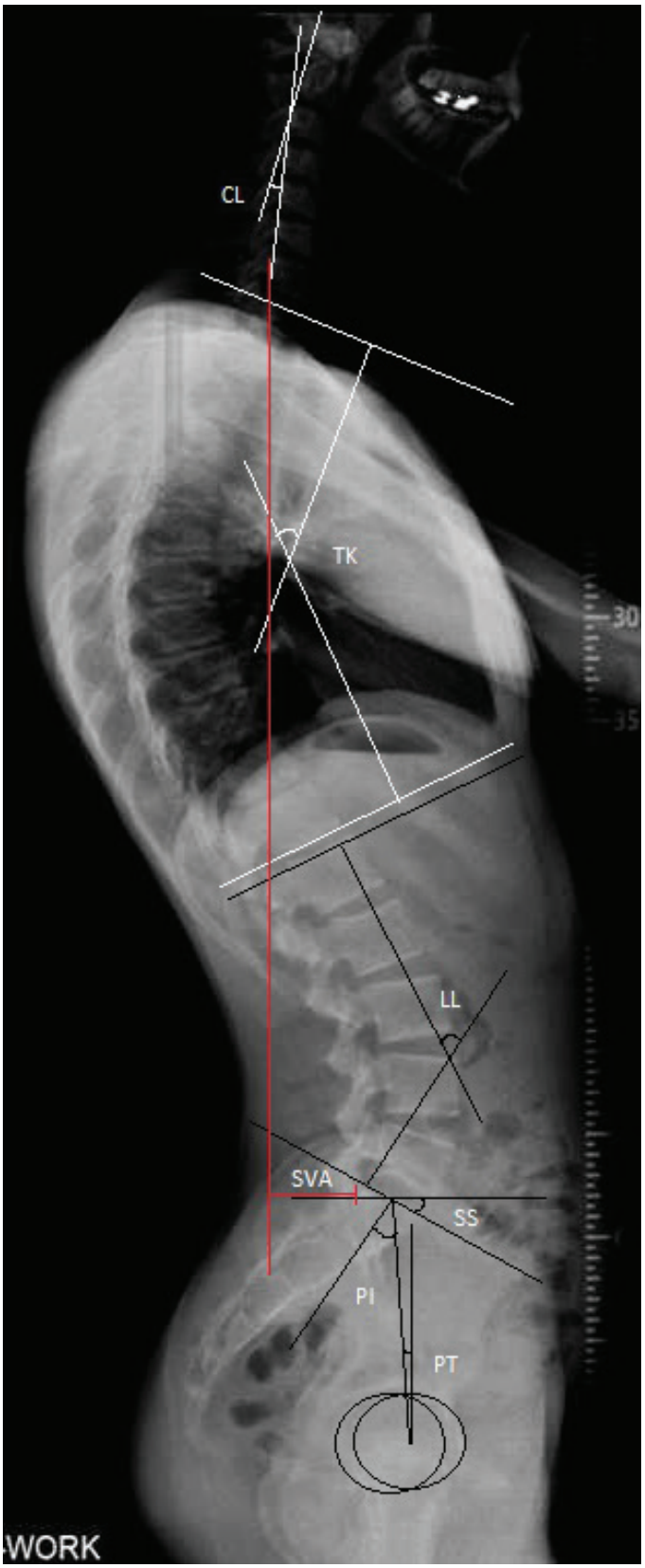

Figure 1. Measurement techniques for assessment of sagittal balance and spinopelvic parameters
CL: Cervical lordosis, TK: Thoracic kyphosis, LL: Lumbar lordosis, PI: Pelvic incidence, SS: Sacral slope, PT: Pelvic tilt, SVA: Sagittal vertical axis

Table 1. Changes in spinopelvic parameters

	Preoperative	Postoperative	p value
CL	24.32±19.87	25.75±15.74	>0.05
TK	61.34±15.55	38.27±13.49	**<0.05**
LL	66.37±11.22	50.93±15.66	**<0.05**
PI	41.93±13.18	42.37±14.38	>0.05
SS	33.10±10.57	31.31±10.82	>0.05
PT	8.82±8.31	11.06±13.64	>0.05
SVA	-20.21±40.53	-19.24±32.08	>0.05

CL: Cervical lordosis, TK: Thoracic kyphosis, LL: Lumbar lordosis, PI: Pelvic incidence, SS: Sacral slope, PT: Pelvic tilt, SVA: Sagittal vertical axis

effect of surgical treatment on SSPs in SK patients exist in literature[10,17]. The aim of the surgical treatment for SK is not only the reduction of the deformity but also to obtain a balanced spine. Therefore, the aim of this study was to evaluate SSPs and their changes after surgical treatment of SK. We did not find significant differences between pre- and post-operative SVA, PI, SS, and PT values. Ashraf et al.[1] also evaluated the changes in sagittal spinal and pelvic parameters after surgical treatment in 18 patients with SK. They had similar results to our study. There were no significant changes in PT and SS after surgery as in our study. They reported a direct correlation between LL and TK with significant LL reduction after surgery. There was also a significant change in TK and LL values in our study, as expected. Hosman et al.[10] compared two surgical techniques (combined and posterior-only procedures) for surgical treatment in 33 SK patients. They found no statistically significant differences on SVA between the preoperative and follow-up values in both groups. But they did not evaluate the other SPPs. Different from Hosman et al.[10] we performed surgery by using posterior-only approach which allowed to obtain adequate surgical correction with the advent of modern multisegmental vertebral stabilization systems with pedicle screws[8,18]. We had similar results in terms of SVA values with Hosman et al.[10] There were no statistically significant differences between preoperative and follow-up values. Lonner et al.[14] also found no statistically significant differences between anteroposterior and posterior-only surgery in terms of correction magnitude. They also found a correlation between PI an LL, but not between PI and TK. However, we did not evaluate the correlation between SSPs within themselves. On the other hand, in the study of Guler et al.[9] they evaluated the angular and SK patients in terms of SPPs changes after surgical treatment. Although there were no significant differences between preoperative and postoperative values in angular kyphosis group, different from the above-mentioned studies there were statistically significant differences in terms of SS and PT but not in PI. When they compared their study with the literature (studies with the result of no change in SPPs after surgery), they suggested that non-assessment of the impact of kyphotic angle on sacropelvic junction might be the reason for the insignificant effect of surgery on sacropelvic parameters. We also did not evaluate the correlation between SSPs. That may seem as a limitation of current study but we think that it may be a subject of another study. Retrospective study design and short follow-up time may be the limitations of our study.

CONCLUSION

In conclusion, despite the widespread use of SSPs as a key factor in the good clinical results in the majority of spinal and pelvic disorders, surgical treatment for SK seems to have little or no influence on changing SSPs toward normal values according to the current study and most of the studies in the literature. Surgical correction of SK by Ponte osteotomy and posterior spinal fusion with pedicle screw systems results in the reduction of the kyphosis and of its compensative LL.

Ethics

Ethics Committee Approval: Retrospective study.
Informed Consent: Written informed consent was obtained from all patients.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Y.A., Concept: S.D., Y.A., Design: B.P., Y.A., Data Collection or Processing: E.Ç., S.E., Y.A., Analysis or Interpretation: S.E., B.P., Literature Search: S.E., Writing: S.E.
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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COMPARISON OF EFFECTIVENESS OF PATIENT CONTROLLED ANALGESIA AND PAIN PUMP VERSUS PATIENT CONTROLLED ANALGESIA FOLLOWING SURGERY FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: The pain control is a difficult and tedious process following a surgery for adolescent idiopathic scoliosis (AIS). Although there are many treatment methods used to relieve pain, the pain is not completely controlled yet. This study was aimed to compare the effectiveness of intravenous patient controlled analgesia (PCA) and a combination of PCA and pain pump (PP) (PP + PCA) used after surgery for AIS.

Materials and Methods: In the present study, the results of patients at the age of 12 to 22 years, who had an AIS surgery between 2016 and 2019 at our clinic, were retrospectively reviewed. The patients' postoperative pain scores, need for opioids, time to walk, and discharge time were compared.

Results: The results of 83 patients (Group PCA, n=34; Group PP + PCA, n=49) that met the study criteria were compared. The visual analogue scale (VAS) scores at the postoperative 6th and 12th hours were lower in the group PP + PCA ($p<0.001$), but there were no differences in pain scores at 24th and 48th hours between the groups ($p>0.05$). The time to walk for the group PP + PCA was significantly earlier than for the group PCA (2.67±0.99 vs. 3.68±0.94, $p<0.0001$). As for discharge time, the group PP + PCA was discharged earlier than the group PCA (8.00±2.03 vs. 10.00±4.56, $p=0.045$). With regard to the postoperative use of opioids, the use by the group PP + PCA was less than the group PCA at the end of both 24th hour and 48th hour ($p<0.001$).

Conclusion: Following surgery for AIS, PP + PCA is a good choice for postoperative analgesia in the early postoperative period (the first 12 hours), reducing postoperative use of opioids and allowing patients to walk and to be discharged earlier.

Keywords: Adolescent idiopathic scoliosis, local anesthetic infusion, postoperative analgesia, catheter, pain

INTRODUCTION

Due to recent advances in regional anesthesia options, the pain can be readily controlled following many orthopedic surgeries. However, pain control is still difficult in spinal surgery and the pain cannot be completely controlled yet. The pain control by the use of paracetamol or non-steroidal anti-inflammatory drugs is not sufficient; therefore, there are many pain control systems that have been developed. The methods commonly used for pain control include patient controlled analgesia (PCA), intrathecal opioids, epidural analgesia, wound site infiltration, and catheters inserted into the incision site for continuous release of local anesthetics. The use of intravenous PCA following a scoliosis surgery is a routine procedure that is carried out by many clinics. Many studies showed that the use of PCA with intrathecal or epidural analgesics achieved better pain control as compared to the use of PCA alone[4,9,10]. However, as these analgesia options result in postoperative urinary retention[7], delay ambulation and prolong the hospital stay[1], lead to postoperative leakage of cerebrospinal fluid[9,10], and mask the postoperative neurological examination of patients[5], they are not often chosen by the surgical teams. Although continuous release of local anesthetics through catheter, which has been widely used in recent years, provides pain control following many surgical procedures[3,13,14], only one study has indicated the use of this method for pain control following an adolescent idiopathic scoliosis (AIS) surgery[11]. The objective of this study was to compare the postoperative pain results of patients using PCA alone and patients using PCA + pain pump (PP) following an AIS surgery. Our hypothesis was that the use of intravenous PCA with incisional PP following an AIS surgery would reduce the patient's pain score, use of opioids, and hospital stay due to early mobilization.

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MATERIALS AND METHODS

The approval of faculty's ethics committee was obtained for this study, and 83 patients who underwent a posterior instrumentation and fusion surgery for elective AIS between 2016 and 2019, were at the age of 11 to 22 years, had no known story of cardiac, renal, hepatic or hematologic disorders, peptic ulcer, gastrointestinal hemorrhage, and chronic pain, and did not use analgesics routinely or within the last 24 hours were included in the study. The patients who underwent a procedure other than the planned surgical intervention, were operated by a different surgical team, had a revision surgery, had missing data in the PCA follow-up form and postoperative study data, had no pain scores recorded, had a PCA connected for less than 48 hours, had a drug dependency, were using chronic analgesics, had a central and peripheral neurological disorder, had coagulopathy or were using an anti-coagulant drug, were not cooperative, and had an allergy to any of the drugs used in the study were excluded from the study. To collect the patient data, the PCA follow-up records kept by the department of anesthesiology and reanimation, which were periodically reviewed and stored, and the patient records maintained in our orthopedics clinics during the postoperative period of patients were used.

For all the patients, the postoperative pain score, time to walk, discharge time, and number of opioids used were recorded, and the values of the two groups were compared.

Surgical Technique

All the patients were operated by the same surgical team; the same incision opening and closure techniques were used; and all the patients were instrumented by pedicle screws. The facet joints of all the patients were removed during the operation and all the patients underwent a fusion with an animal-derived bone graft. During the closure procedure, the end of a drain was inserted into the left side, to proximal, and the other end of the drain was inserted into the right side, to distal. The PP was placed to the right along the incision between the paraspinal muscles (Figure 1).

Anesthesia Technique

The anesthesia was induced with propofol (2 mg kg^{-1}), fentanyl (1-2 µg kg^{-1}), and rocuronium (0.6 mg kg^{-1}) and maintained by 1-2% sevoflurane, and the mixture of 50% O_2 and 50% N_2O. 2.5 mg of neostigmine and 1 mg of atropine were used after the operation to antagonize the effect of muscle relaxation. The patients were then extubated and transferred to the post-anesthetic care unit.

Postoperative Analgesia

The patients of both groups received 50 mg of dexketoprofen and 1000 mg of paracetamol 30 minutes before the completion of surgery. Dexketoprofen was postoperatively re-administered every 12 hours and paracetamol was postoperatively re-administered every 6 hours. A PCA device was connected to the patients after the surgery in the recovery room. The PCA device was prepared with fentanyl and programmed at the concentration of 10 µg/mL, with a loading dose of 50 µg, locked time of 15 minutes, 25 µg bolus, and 25 µg basal infusion. The PCA was maintained for 48 hours. The patients with VAS score equal to or over 4 were given 25 mg of meperidine and were recorded in the recovery room. The same multimodal analgesia protocol was used for the postoperative analgesia in both groups. The patients with Modified score equal to or over 9 were transferred to the service. The postoperative follow-up and assessment of patients were performed by a researcher

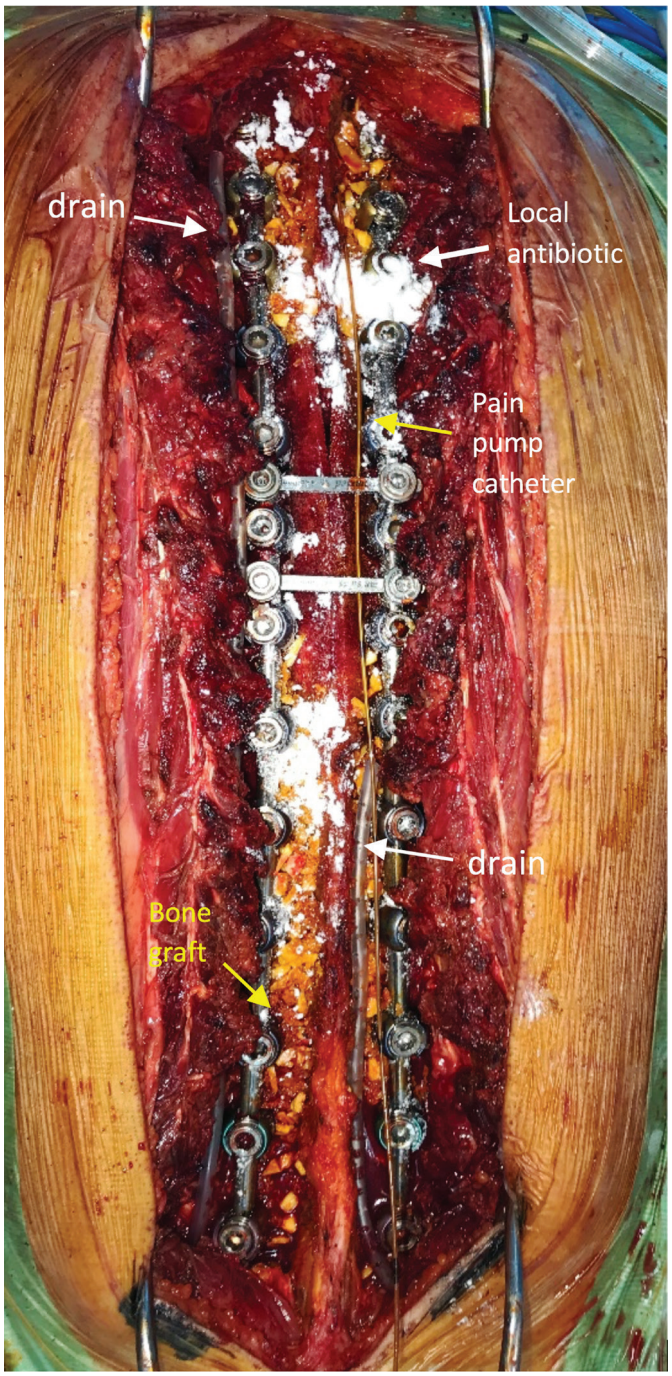

Figure 1. Pain pump and drain placement

who was unaware of the study group. The postoperative pain was assessed by the visual analogue scale (VAS) score (VAS 0=no pain, VAS 10=worst possible, unbearable pain). The pain scores were assessed at the postoperative 6th, 12th, 24th, and 48th hours. The postoperative consumption of opioids was recorded at the end of 24th and 48th hours.

Use of Pain Pump

ON-Q PainBuster Post-Op Pain Relief System was used as a PP. A balloon contained in the system that retained fluid up to 400 mL was filled with 0.5% bupivacaine (Figure 2). 10 mL of bupivacaine was infused into the incision site through a 1 mm catheter per hour. The fluid in this pump was consumed at the end of approximately 40 hours. The drain was kept at positive pressure to avoid the increase in the postoperative hemorrhage and suction of anesthetic agents. The PP was removed at the end of 40 hours as it completed the release at the end of 40 hours.

Statistical Analysis

IBM SPSS 20.0 (SPSS Inc., Chicago, Illinois, USA) was used for statistical assessment. The Histogram and Kolmogorov-Smirnov tests were used to determine the normal distribution of data. The descriptive data were provided as mean ± standard deviation. The categorical variables were assessed by the chi-square test. The Student's t-test was used for normally distributed data whereas the Mann-Whitney U test was used for the assessment of data that did not show normal distribution. The value of p<0.05 was considered as statistically significant.

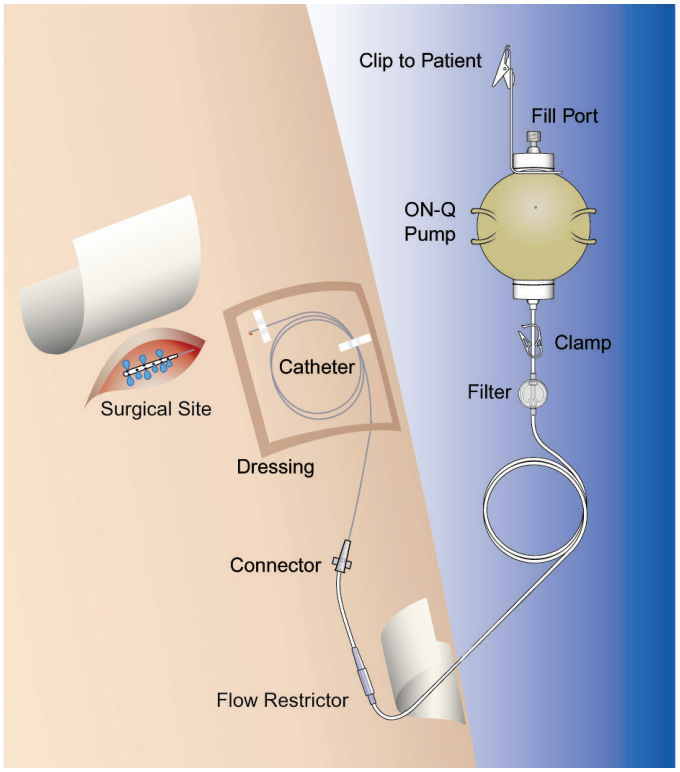

Figure 2. The schematic depiction of the placement of the pain pump

RESULTS

The results of 122 patients with AIS in the age range of study were reviewed retrospectively. Of 83 patients that met the study criteria, 49 patients received PP + PCA, and 34 patients received PCA alone. There were no differences in preoperative ages, gender, weight, Cobb angle, and fusion level between the two groups (Table 1). The VAS scores at the postoperative 6th hour [7.54 (7-10) vs. 9.53 (8-10)] and 12th hour [6.21 (5-8) vs. 8.34 (6-9)] were lower in the group PP + PCA than that in the group PCA (p<0.001). There were no differences in the pain

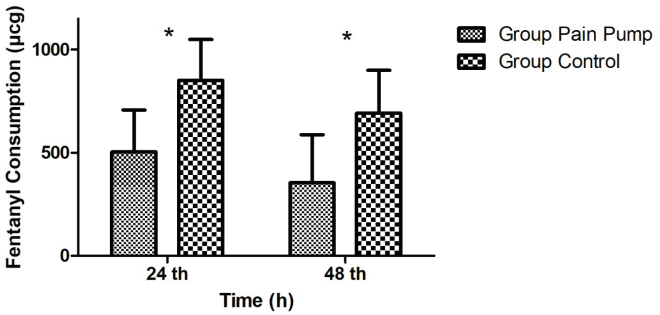

Figure 3. Opioid consumptionat postoperative 24th and 48th hours

Table 1. Demographic data of patients

	Group pain pump (n=49)	Group control (n=34)	p
Age (year)	17.31±3.20	16.76±3.03	0.326[a]
Gender (M/F)	16/33	7/27	0.319[b]
Weight (kg)	59.98±8.13	58.62±8.86	0.472[c]
ASA (I/II)	44/5	29/5	0.733[b]
Cobb angle	64.12±15.64	64.79±15.44	0.847[c]
Fusion level	12.82±1.70	12.76±2.49	0.285[a]
Walking time (day)	2.67±0.99	3.68±0.94	**<0.0001**[a]
Discharge time (day)	8.00±2.03	10.00±4.56	**0.045**[a]

Values are presented as mean ± standart deviation or number, ASA: American Society of Anesthesiologists, F: Female, M: Male, [a]Mann-Whitney U test, [b]Fisher's exact test, [c]Independent Sample t-test

Table 2. Pain scores visual analogue pain scale and wong-baker faces scale

	Group pain pump (n=49)	Group control (n=34)	p[a]
VAS 6th hour	8 (7-10)	9.5 (8-10)	**0.001**
VAS 12th hour	6 (5-8)	8 (6-9)	**0.003**
VAS 24th hour	4 (4-6)	4 (3-6)	**0.692**
VAS 48th hour	3 (2-5)	3 (2-4)	**0.925**

Values are presented as median (percentage 25-75) or number, VAS: Visual analogue scale
[a] Mann-Whitney U test

scores at 24th hour [4.22 (4-6) vs. 4.45 (3-6)] and 48th hour [3.12 (2-5) vs. 3.17 (2-4)] between the groups (p>0.05) (Table 2).

The time to walk for the group PP + PCA was significantly earlier than the group PCA (2.67±0.99 vs. 3.68±0.94, p<0.0001). As for the discharge time, the group PP + PCA was discharged earlier than the group PCA (8.00±2.03 vs. 10.00±4.56, p=0.045), (Table 3). The number of opioids used was less in the group PP + PCA than in the group PCA at the end of postoperative 24 hours (503.27±203.65 vs. 850.88±198.44) and 48 hours (354.08±233.36 vs. 691.47±207.92) (p<0.001), (Table 4, Figure 3).

Two patients in the group PP + PCA and one patient in the group PCA had a prolonged wound site leakage which was improved without intervention. The superficial wound site infection was treated with oral antibiotics in two patients, each in two groups.

DISCUSSION

Although epidural analgesia or peripheral nerve blocks help to achieve a good pain control following many orthopedic operations, the pain control following posterior spinal fusion (PSF) is still difficult in the patients with AIS. Although the use of PCA for pain control following PSF is now an indispensable procedure, different methods have been included in the administration of PCA to relieve the patient's pain as its efficacy is insufficient. The PCA is widely used with intrathecal morphine injection (IMI) and epidural catheter infusion (EPI) as an analgesic method. There are many studies that compared these methods with each other or with PCA alone. Some of these studies suggested that IMI + PCA and EPI + PCA were superior to PCA[4,6,8,10]. However, as this is an invasive procedure and several complications such as the higher rate of failure to insert a catheter into the epidural space[4,15], causing postoperative leakage of dura mater fluid[4,9,15], leading to respiratory depression[10], and masking the postoperative neurological examination [2,12], may occur, it is not chosen by some clinicians. Another method that can be used in addition to PCA is a PP that is placed in the incision site and capable of continuous release. This method allows continuous release of local anesthetics into the incision site without invasive intervention and it is unlikely to cause side effects that may occur with epidural anesthesia. The most important disadvantages include that a second foreign object is inserted into the wound site in addition to the drain in the postoperative period and a proper fixing cannot be achieved because the catheter is removed from the incision site; therefore it can easily come away during walking and transfer. In the literature, there are limited studies that used a PP following a scoliosis surgery although it was used for different surgeries[11]. In a study assessing 244 patients following AIS surgery, there were no differences in pain scores of patients that used and did not use PP at the 6th, 12th and 24th hours; however, the group using PP had a lower pain level at the 18th hour. The consumption of opioids in the patients using the PP was reported to be less than that in the patients that did not use the PP at the end of postoperative day 1. The requirement for anti-emetic drugs and blood transfusion by the patients using the PP was lower. Some data obtained during this study support our study. What was different in our study was that the group using PP had lower pain scores in the early postoperative period, and the pain scores at the 24th and 48th hours were similar in both groups. This may be explained by effective relief of pain by us through a multimodal analgesia protocol after the 12th hour in both of the groups. In addition, the use of opioids at the end of 24th and 48th hours was less in the PP + PCA group, which was similar to the other study. Different from that study, we also compared the patients' time to walk and discharge time. The time to walk and discharge time in the group PA + PCA were earlier. The mean of discharge times was higher as compared to other studies, which might be due to sociodemographic characteristics of patients as a major reason. Many patients were from a rural area; therefore, they waited for a complete healing before they departed, and those patients that would use a corset waited for one. Our study had several limitations; for example, we could not compare the complications such as nausea, vomitting, and fever, which are common in the postoperative period, as this was a retrospective study. We also consider that preoperative pain threshold and postoperative pain scores of patients would be effective in assessment; however, we did not carry out such an assessment.

Table 3. Mobilization and discharge time

	Group pain pump (n=49)	Group control (n=34)	p
Walking time (day)	2.67±0.99	3.68±0.94	**<0.0001**[a]
Discharge time (day)	8.00±2.03	10.00±4.56	**0.045**[a]

Table 4. Opioid consumption

	Group pain pump (n=49)	Group control (n=34)	p[a]
Opioid consumption 24th hour (microgram)	503.27±203.65	850.88±198.44	**<0.001**
Opioid consumption 48th hour (microgram)	354.08±233.36	691.47±207.92	**<0.001**

Values are presented as mean ± standart deviation, [a]Independent Sample t-test

CONCLUSION

As a result, we observed that the use of PCA in combination with a continuous release PP that was inserted into the incision site helped early postoperative pain control in the patients with AIS and enabled patients to walk earlier and to be discharged earlier. We also demonstrated that the PP reduced postoperative consumption of opioids. We believe that this study would help patients with AIS in pain control through further prospective randomized studies including more patients.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of Atatürk University (approval number: 27.12.2018.08/11).

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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THE ONE STEP FORWARD LATERAL SPINAL X-RAY: MEASUREMENT OF SAGITTAL AND SPINOPELVIC PARAMETERS IN A FUNCTIONAL POSITION

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ABSTRACT

Objective: Previous studies demonstrated an association between health related quality of life and sagittal balance for the adult spinal deformity (ASD) population, rendering an accurate evaluation of sagittal balance very important. Patients develop compensatory extension of hips, retroversion of pelvis and flexion of knees, identification and elimination of which may be useful. One step forward (OSF) is a lateral X-ray taken with the patient in the "starting to walk" position, taking the first step forward. To compare the sagittal balance and spinopelvic parameters between regular lateral and OSF X-rays in an ASD population and in those with increased pelvic retroversion [pelvic tilt (PT) >25].

Materials and Methods: Forty seven patients with ASD enrolled had their standing lateral X-rays in regular and OSF positions. OSF was defined as that with the patient taking one full step forward with the self-preferred side. Sagittal spinal and spinopelvic parameters were measured. Comparisons were made for the entire population and for patients with PT >25 degrees.

Results: Of 47 patients, 17 had PT >25 degrees. OSF did not create any effect in the general population but did so in PT >25 patients for spinopelvic angle, spinosacral angle and global tilt and for sacral slope, PT and pelvic incidence.

Conclusion: As evidenced by a decrease in the PT values, OSF eliminates the compensatory pelvic retroversion. It would be reasonable to accept the measurements in OSF as the more "functional" measurements. It is also probable that using OSF in surgical planning may decrease the possibility of imbalance.

Keywords: Sagittal balance, adult, radiography

INTRODUCTION

Adult spinal deformity is getting to be recognized as a real health and social problem as our population ages. The standard initial radiodiagnostic test for this population is the standing antero-posterior (AP) and lateral radiographs of the entire spine. Although the "normal" coronal plane of the spine is almost similar for every person, sagittal plane does not have a single normal alignment and nor is necessarily static during the life span. A better understanding the importance and impact of sagittal balance on functional outcomes and patient satisfaction as well as the results of treatment in later years have prompted the definition of several sagittal plane spinopelvic parameters to be taken on standing lateral whole spine radiographs from occiput to hip joints[11]. It is now well know that inappropriate evaluation of sagittal balance before the surgery may result in flatback, accelerated adjacent segment degeneration, pain and inferior outcomes in terms of health related quality of life (HRQL) instruments[1,2,11,15]. To achieve optimum results after surgery, maximum awareness of the potential problems of preoperative and postoperative sagittal balance appears to be essential. With regard to the global sagittal spinal alignment, C7 positioning is accepted for its stability over the sacrum in asymptomatic population. Of note, most people as well as patients with spinal deformity tend to acquire a positive sagittal balance (that is, the gravity line shifting forward) as a result of aging and/or spinal deformity. Several studies have shown that this change in balance is one of the most important parameters affecting the HRQL especially in people with adult spinal deformity[5,7,11,15]. It is also evident that every person affected by such a change in the sagittal spinal balance would recruit several compensatory mechanisms, the most frequent being the flexion of the pelvis by extending the hip joints followed by flexion of the knee joints. In radiographical evaluation of the sagittal balance, flexion of the knees is usually (supposedly) eliminated by the X-ray technicians whereas the flexion of the pelvis is not eliminated and can be evidenced by an increased pelvic tilt (PT)[10,11]. These standard X-rays used to evaluate deformity and balance are static and

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can only show the position of the patient in a standing upright position at best. This compensated position however, may not necessarily be maintaned when the patient starts to walk, as one of the hips (the opposite side of the hip taking the step) has to be over-extended in due process[3,6,11,12]. Therefore, especially in patients who had been compensating for their positive sagittal balance by hip hyperextension (to the limit) or in those with pathologies of the hip (i.e. osteoarthritis) the actual walking position may be (has to be) that of more positive sagittal balance than reflected by standard standing X-rays. This indeed is a common observation for those dealing with elderly; they can stand somewhat upright, but can not maintain this position while walking[5,6,8,10]. We hypothesized that this walking position (reflecting the real sagittal alignment) may be mimicked by having the patient take a step forward at the time X-rays are taken. To the best of the author's knowledge, there is no study that has evaluated the effect of walking position on the segmental, regional, and global sagittal spinal alignment. The aim of the present study was to compare sagittal balance and parameters used commonly to determine sagittal balance between two different techniques of lateral whole spine radiographs [standard technique and one step forward (OSF) technique], in adult patients with spinal deformity.

MATERIALS AND METHODS

This study was based on a prospective spinal centre database of 47 adult spinal deformity patients (39 female, 8 male) who were scheduled to undergo full lenght AP and lateral spine radiographs for either surgical or conservative treatment. The inclusion criteria were: 1) Adult patients with deformity of the spinal column with or without spinal stenosis in which spinal deformity is defined as the presence of any of the following a) Coronal plane deformity >25 degrees, b) thoracic kyphosis (TK) >60 degrees, c) PT >25 degrees and d) Spinal vertical axis (SVA) >50 mm; 2) Patients who are willing to sign an informed consent to participate the study. On the other hand, patients who had previous servical, thoracal or lumbar surgeries (fusion and/or instrumentation) and patients who have documented severe hip and knee problems such as previous surgery or being scheduled for surgery were excluded from the study. Digital lateral whole spine radiographs were obtained from each patient in two different positions preoperatively. In the standard technique, patients stand in front of the X-ray sensor holding bars in front of them with the shoulders in 30 degrees of flexion. Legs are paralel in the position of patients own preference when standing. In the OSF technique, patient will take a step forward of up to 25 cm (ideally should be larger than the foot size), with the leg she/he prefers or the side of hip pain if any, in order to fix the hip joints and will stand in front of the sensor also holding the bars in front (Figure 1, 2)[3,4,9,11]. SVA, TK, lumbar lordosis (LL), sacral slope (SS), PT, pelvic incidence (PI), spinopelvic angle (SPA), spinosacral angle (SSA), kyphosis tilt angle, spinal tilt angle (STA), T1 spinopelvic inclination (T1-SPI) and T9-SPI were measured for all patients in both positions using a specific digital X-ray analysis software (Surgimap, Beta 1.2.1.56, USA)[2,5,7,10,12]. Numerical variables were reported as mean + standard error of the mean, minimum to maximum range. Student's t-test with repeated measures and two tails was used for the statistical comparisons of standing versus OSF measurements in two different age groups of younger or older than 40 years. A p value of <0.05 was considered to be significant.

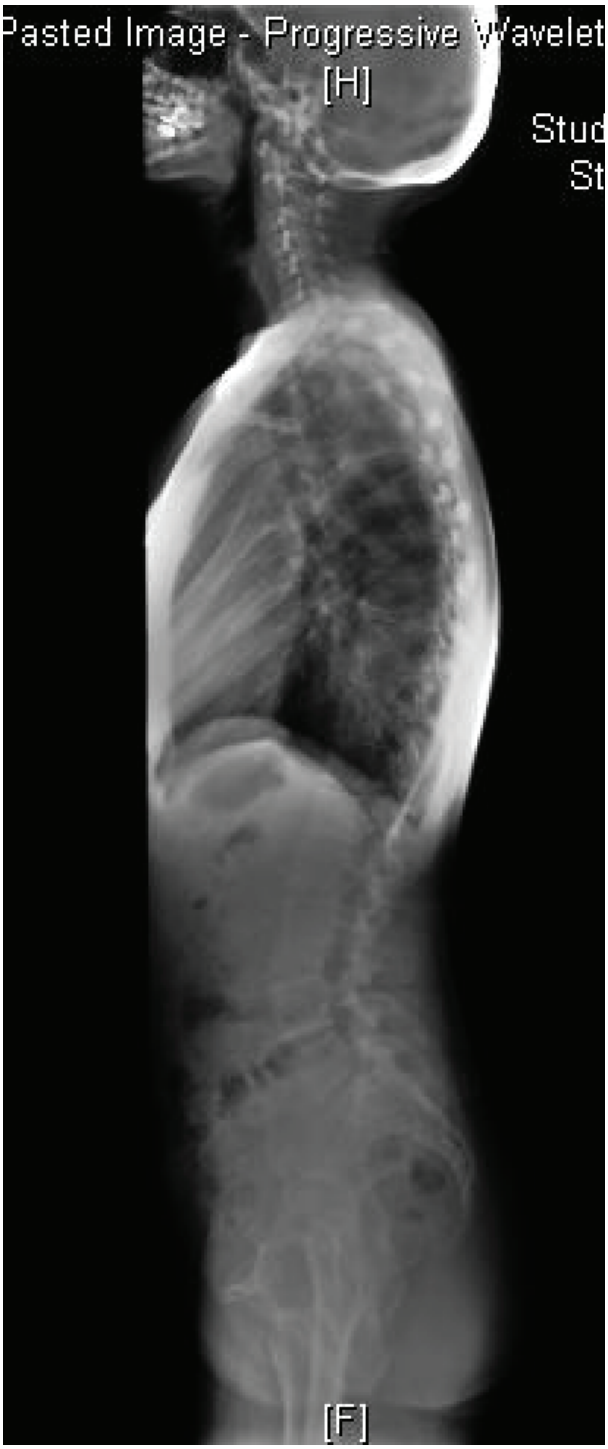

Figure 1. Whole spine lateral X-ray

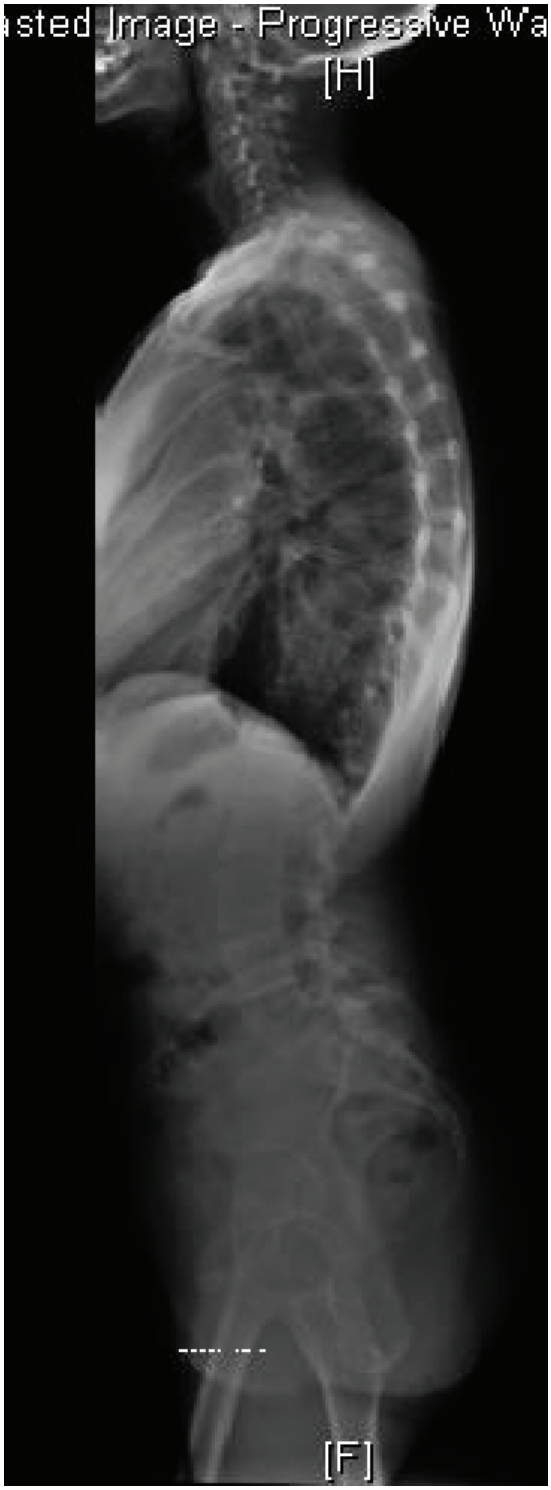

Figure 2. Whole spine one step forward lateral X-ray of same patient

RESULTS

The results are summarized in table 1. In this study, we retrospectively evaluated 47 patients of both genders (8 male, 39 female). Ten patients were under 40 years old and 37 patients were over 40 years. Average age was 54.4. Evaluated standard standing lateral X-ray and OSF lateral X-ray sagittal balance and spinopelvic parameters did not show any statistically significant difference in whole study group (47 patients); but in subgroup of patients with increased PT (17 patients with PT >25) we found significant differences in SPA, SSA, global tilt (GT) and SS, PT and PI parameters. In increased PT subgroup, PT values mean 34.1 degrees with standard X-rays, showed a decrease to 18.5 degrees with OSF X-rays ($p<0.001$) which was the most statistically significant difference in our study. SS values average increased from 26.8 to 34.2 degrees ($p<0.002$), while PI average decreasing from 61.2 to 53 degrees ($p<0.05$). Also as seen in table 1, decreased mean values of SPA, SSA and GT parameters with OSF lateral X-ray were statistically significant. However changes in SVA, TK, LL, STA mean values were found as insignificant.

DISCUSSION

This study aimed to analyze the differences in sagittal balance parametrs in two different positions for an adult deformity population[8,10,14]. Our hypothesis was that by having the patients take OSF during the sagittal plane X-rays, the hip extension/pelvic rotation compensation of patients may be eliminated and results closer to the real life extent of the imbalance may be obtained[11]. Our results appear to support our hypothesis in general. It is demonstrated that SVA, PT parameters do significantly worsen as the patients takes OSF, especially in the population older that 40 years of age. In line with our hypothesis, our result confirm that OSF lateral radiographs are effective in eliminating the compensation mechanisms used by the patient to stand upright thus giving a more realistic picture of the sagittal balance problem. These X-rays are closer to the clinical picture of the patient and may as well be closer to the end balance of the patient after surgery (given that surgery is not planned based on them). Having thus established the efficacy in reflecting the pre-treatment pathology more accurately than standard lateral X-rays, further studies focusing on the predictive value of the sagittal balance following surgery will be needed[4,9,13,14]. The major shortcoming of this study is the limited number of patients who had consented to have an additional X-ray for research purposes. On the other hand, as significant differences could be demonstrated, potential problems with sample size (i.e. limited statistical power) appear not to be particularly relevant. On the other hand, further studies comparing pre-treatment to post-treatment results may have to be done with larger sample sizes.

CONCLUSION

In this study; it has shown that lateral standing X-rays taken with the patients taking OSF demonstrate significantly higher levels of imbalance in adult deformity patients. The mechanism behind this is most probably the elimination of compensatory hip extension and pelvic flexion by that step. In this respect, OSF lateral X-rays may be closer to the actual clinical picture

Table 1. Analysis of sagittal balance and spinopelvic parameter changes between standard lateral and one step forward lateral X-rays in adult spinal deformity patients and in increased pelvic tilt subgroup

	Lateral	OSF lateral	p value	Lateral (PT >25)	OSF (PT >25)	p value (PT >25)
SVA	51.8 (50.9)	63.6 (54.2)	0.29	66.3 (58.5)	46.6 (42.7)	0.30
TK	39.0 (31.0)	34.8 (29.7)	0.40	29.2 (16.8)	29.7 (12.2)	0.93
LL	48.9 (27.8)	45 (22.7)	0.49	37.4 (28.7)	51.7 (25.5)	0.16
SPA	25.8 (16.4)	26.6 (17.1)	0.74	40.2 (13.2)	20.9 (14.3)	**0.003***
SSA	59.9 (14.2)	58.9 (14.9)	0.74	65.3 (14.6)	53 (15.2)	**0.04***
STA	5.8 (5.6)	8.3 (6.5)	0.23	7.9 (6.4)	5.5 (3.9)	0.24
GT	27.6 (15.8)	29.5 (15.1)	0.91	42 (12.9)	22.8 (12.6)	**0.003***
SS	31.8 (9.1)	32.8 (10.8)	0.51	26.8 (8.6)	34.2 (9.7)	**0.002***
PT	20.8 (12.3)	20.1 (12)	0.81	34.1 (7.5)	18.5 (10.9)	**0.001***
PI	52.5 (13.4)	53.1 (13.5)	0.83	61.2 (11.3)	53 (15.3)	**0.047***

OSF: One step forward, SVA: Spinal vertical axis, TK: Thoracic kyphosis, LL: Lumbar lordosis, SPA: Spinopelvic angle, STA: Spinal tilt angle, GT: Global tilt, SS: Sacral slope, PT: Pelvic tilt, PI: Pelvic incidence
Values are mean values (range), *Statistically significant changes, SSA: Spinosacral angle

of patients and demonstrate the real extent of the balance problems compared to standard lateral X-rays.

Ethics

Ethics Committee Approval: Approved.
Informed Consent: Was taken.
Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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CASE REPORT
270

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POSTOPERATIVE CERVICAL SPINAL EPIDURAL HEMATOMAS; TWO CASE REPORTS AND LITERATURE REVIEW

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ABSTRACT

Postoperative spinal epidural hematomas are rarely seen and mostly asymptomatic. Urgent surgery is advised in case of the occurrence of neurologic deterioration. Here, we presented two cervical spinal surgery case reports and literature review. In the first case, after anterior cervical microdiscectomy and cage fusion operation, a 35-year-old male patient had paresis because of the cervical epidural hematoma. In the second case, an 85-year-old male patient had multilevel surgery of cervical posterior screw stabilization and posterior laminectomy. In early period, tetraparesis occurred because of large cervicothoracic epidural hemorrhage. The patients' neurologic deficits were improved without surgery.

Keywords: Cervical spinal surgery, postoperative epidural hematoma, paresis

INTRODUCTION

Acute spinal epidural hematoma can occur as spontaneous, secondary or traumatic[4]. The incidence of spontaneous spinal epidural hematoma is rare (1 case per 1.000.000)[6]. Postoperative cervical spinal epidural hematomas are rarely encountered entities (0.1% of all spine cases). Of postoperative spinal epidural hematomas (PSEH) after surgery, asymptomatic ones are extremely common[10], symptomatic ones range from 0.10% to 0.24% in all spine surgery group. After spinal surgery, if there is an extra acute neurologic deficit, new computed tomography (CT) and magnetic resonance imaging (MRI) scans should be performed immediately in order to establish a diagnosis and to start treatment. MRI scans can diagnose acute epidural hematoma quickly (89%)[10]. Rich venous plexus of epidural space may be the origin of the hemorrhage. The area on which epidural hematoma is mostly seen is the thoracic spine[11]. After the occurrence of a new neurologic deficit, surgery is suggested. Surgery can solve neurologic deficits in 60% of patients[10].

CASE REPORTS

Case 1

A 35-year-old male patient was admitted to our outpatient clinic with the complaints of left side arm pain and hand numbness. There was no previous history of using anticoagulant, antiaggregant therapy or coagulopathy. No recent trauma was noted. The patient had a previous history of an anterior cervical 5-6 microdiscectomy 3 years ago. He had a new adjacent cervical disc herniation at the cervical 6-7 level. MRI scans revealed cervical 6-7 disc herniation (Figure 1). Anterior microdiscectomy with cage fusion operation was done. Minivac drain was used. In half an hour after the surgery, the patient had mild motor and sensory deficits in his lower and upper extremities. His symptoms progressed quickly and he was soon completely quadriparetic. In the neurological examination, his motor power was reduced (2/5) in both lower and upper extremities, deep tendon reflexes in both lower limbs were increased, the Babinski sign responses were positive, there was hypoesthesia for light touch, and there was hypoesthesia below the cervical 6-7 dermatome.

The complete blood count (hemoglobin, hematocrit, and platelet count), biochemistry profile (kidney function, liver function, proteins, and glucose), prothrombin time, and international normalized ratio (INR) were normal, and he did not have additional comorbidities (hypertension, diabetes mellitus, etc.). His blood was Rh (+). He was a social smoker, smoked approximately 10 boxes per year.

CT scan showed a large cervical epidural bleeding in the anterior region of the spinal cord. The CT scans were not really diagnostically helpful at the operated level. Because of cage fusion, there were metal streak artifacts (Figure 2, 3). MRI revealed anteriorly epidural hematoma compression to the spinal cord extramedullary from C1 to T1 vertebrae levels with isointense or increased signal intensity on T1-weighted image, heterogeneous hyperintense on T2-weighted images (Figure 4-6).

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High-dose steroid treatment was started (bolus 30 mg/kg administered over 15 minutes with maintenance infusion of 5.4 mg/kg per hour infused for 23 hours). We planned decompressive surgery and started the preparation of operation theatre. Surprisingly, at the third hour of follow-up, improvement of paresis in his first lower extremities than upper ones was detected, he recovered and his sensorimotor function was normal. We decided not to operate on the patient, his functions were recovered well after 6 hour. The day after of the operation, his neurologic examination was normal. The patient was discharged three days after the operation.

Case 2

An 85-year-old male patient had the complaints of pain and numbness on his both arms and hands. The patient had

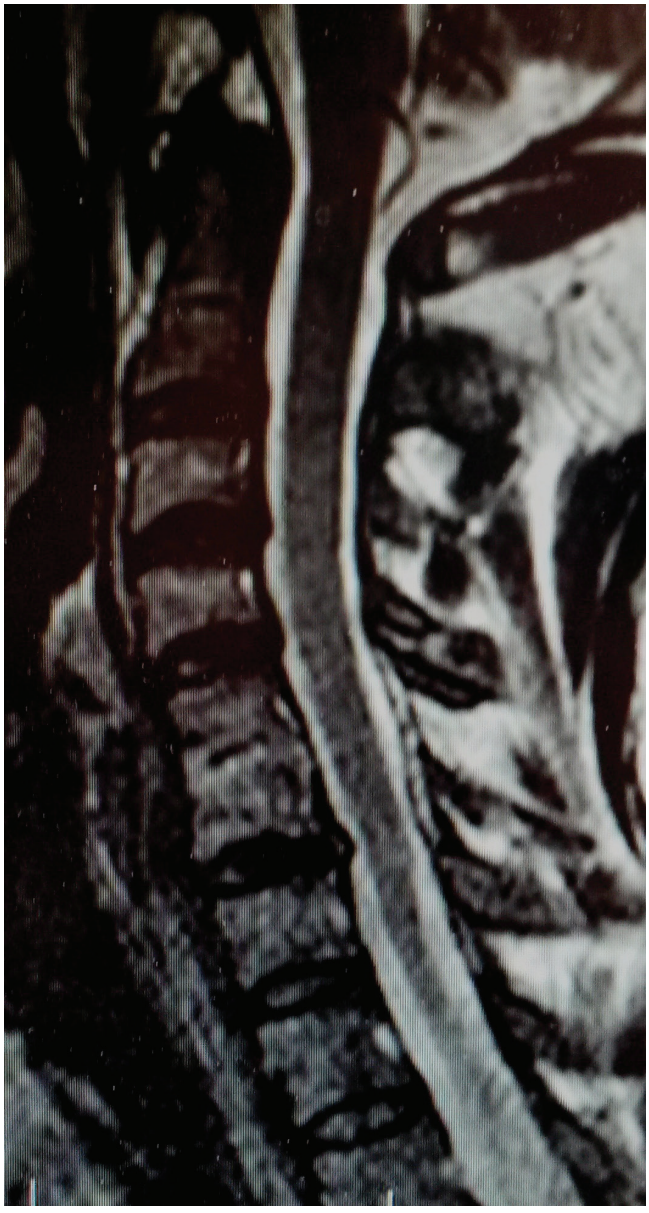

Figure 1. Preoperative sagittal T2-weighted magnetic resonance imaging (cervical 6-7 hernia nucleolus pulposus, cervical 5-6 fusion)

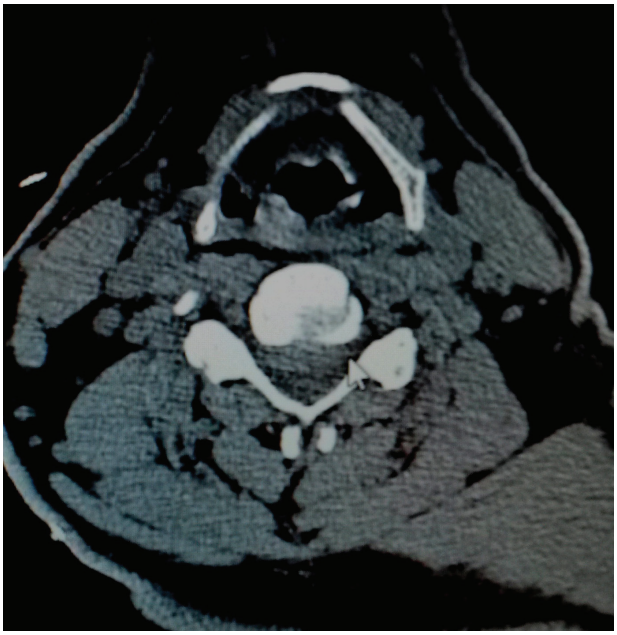

Figure 3. Postoperative axial computed tomography shows the epidural hemorrhage and cord

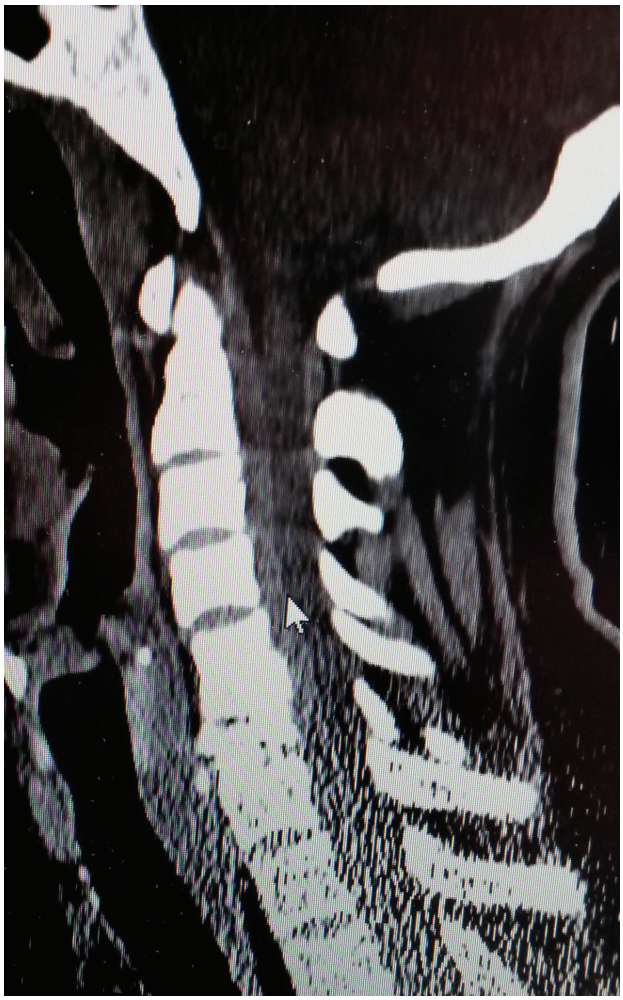

Figure 2. Postoperative sagittal cervical computed tomography (arrow show the epidural hemorrhage and cord line)

cervical stenosis. The patient underwent anterior cervical 5-6-7 microdiscectomy and plate, screw operation in an external center one year ago. The patient had a previous history of coronary artery disease, hypertension and by-pass surgery. His blood group was Rh (+) and he was a smoker, smoked 40 boxes/year. He was using acetylsalicylic acid. We stopped acetylsalicylic acid and started low molecular weight heparin during hospitalization. The patient had multilevel surgery of Cervical 2-3-4-5 posterior screw stabilization and cervical 3-4-5 laminectomy posteriorly. The day after the surgery, neurologic deficit was deteriorated and tetraparesis occurred. Motor and sensory deficits in his lower and upper extremities

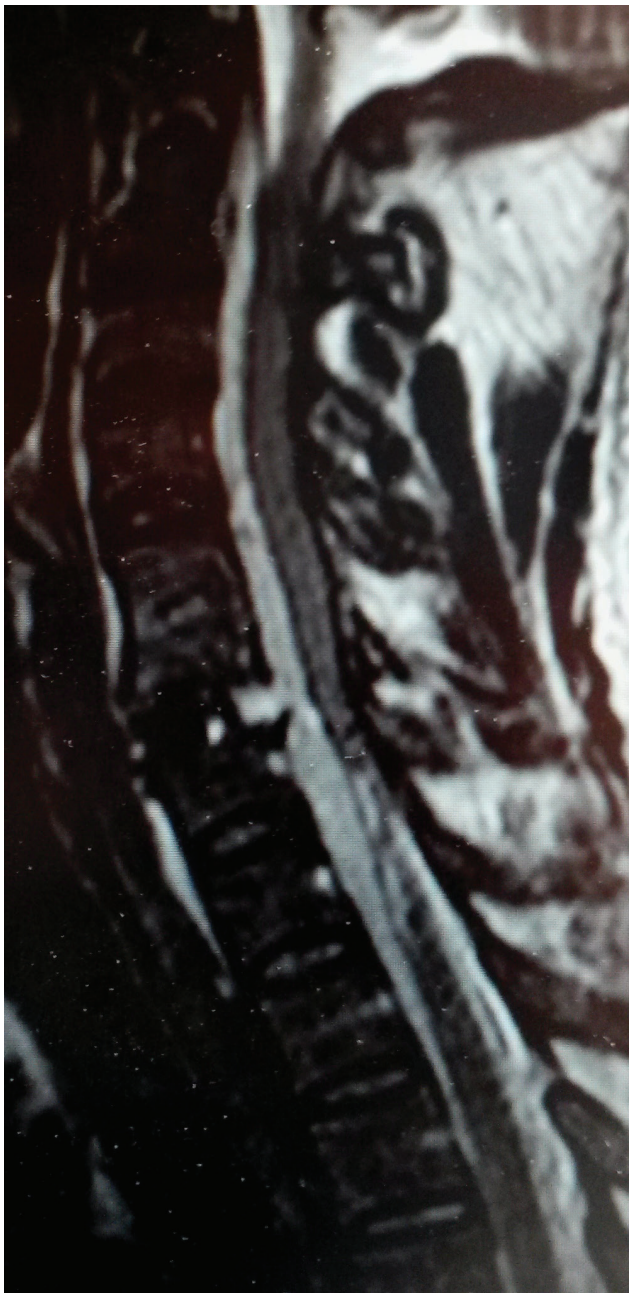

Figure 4. Postoperative sagittal T2-weighted cervical magnetic resonance imaging image shows epidural hemorrhage

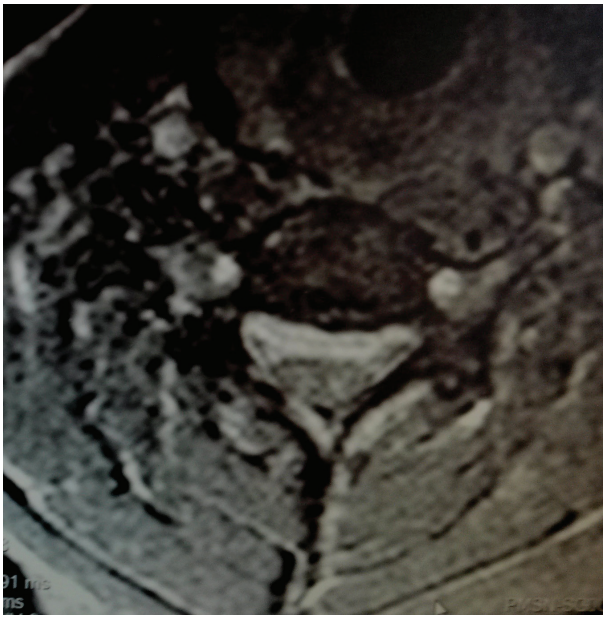

Figure 5. Postoperative axial T2-weighted magnetic resonance imaging

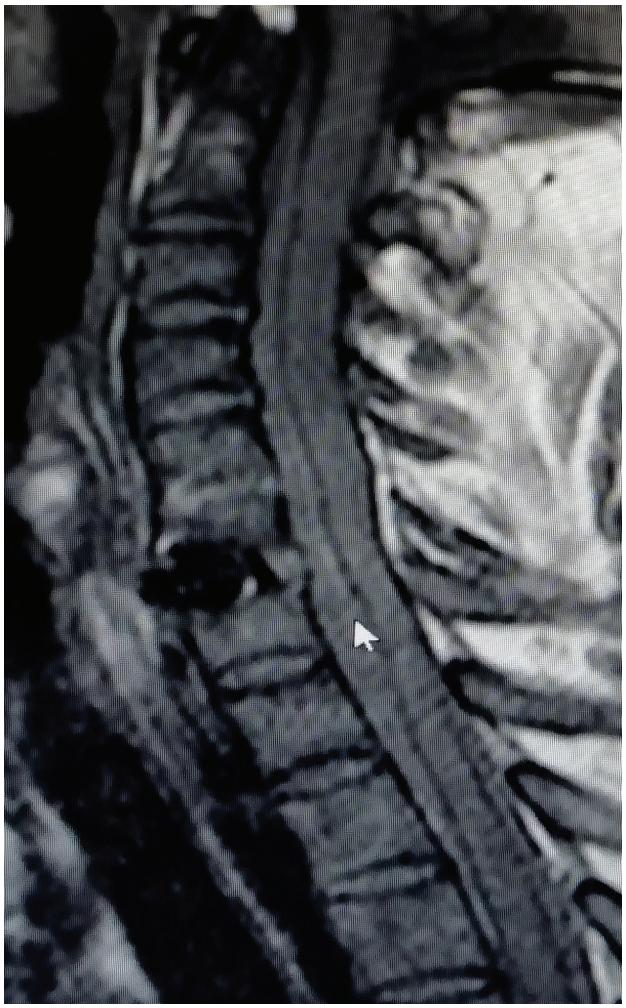

Figure 6. Postoperative sagittal magnetic resonance imaging T1-weighted hem sequence

could not resist gravity. In the neurological examination of his motor power, (2/5) in both lower and upper extremities, he had ataxia, deep tendon reflexes were hyperactive, bilateral plantar reflexes were dorsal leakage, urinary incontinence, anesthesia for light touch, and hypoesthesia below the cervical 3-4 dermatome. The complete blood count (hemoglobin, hematocrit, and platelet count), biochemistry profile (kidney function, liver function, proteins, and glucose), prothrombin time, and INR were normal, but he had additional comorbidities (irregular hypertension, coronary artery by-pass surgery, smoking). Drainage system was not present in the surgical area of the patient. According to electroneuromyography, the patient had bilateral C3-T1 segments of anterior forearm, anterior horn and chronic periodic axonal injury. Early period CT revealed pneumorrhachis in the cervical region (Figure 7) and epidural hematoma extending from cervical to thoracic region was detected in MRI (Figure 8-11). We started anti-edema treatment. We planned decompression surgery. The patient and his family refused surgery. Conservative treatment was continued. A high-dose steroid treatment was started and continued for 7 days. We started early physiotherapy. Seven days after surgery, there was an improvement in paresis at first lower extremities than upper ones. He could resist gravity in bed. After two weeks, his sensorimotor function recovered. He was able to walk by himself. After 3 weeks, the patient's neurological findings improved and he was discharged.

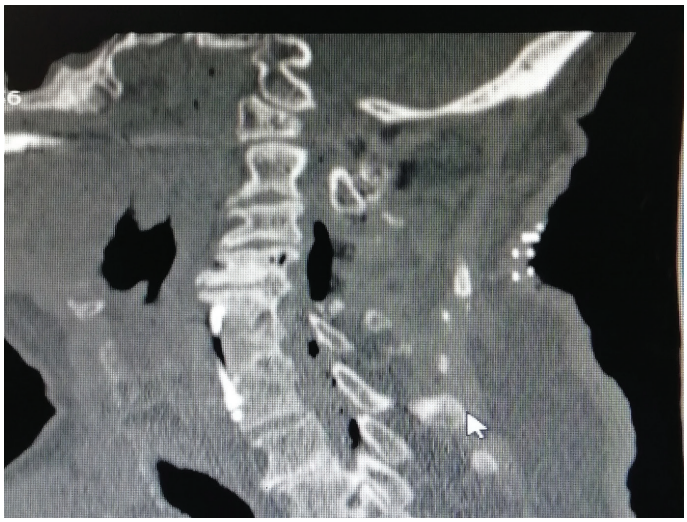

Figure 7. Postoperative Sagittal cervical computed tomography shows air at the region

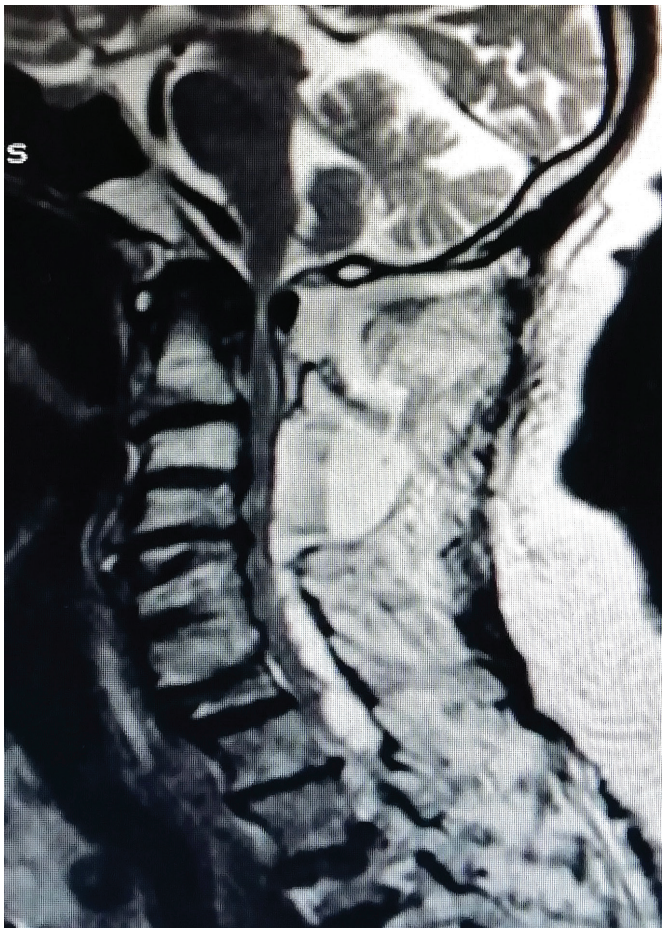

Figure 8. Postoperative sagittal T2-weighted magnetic resonance imaging show the hemorrhage

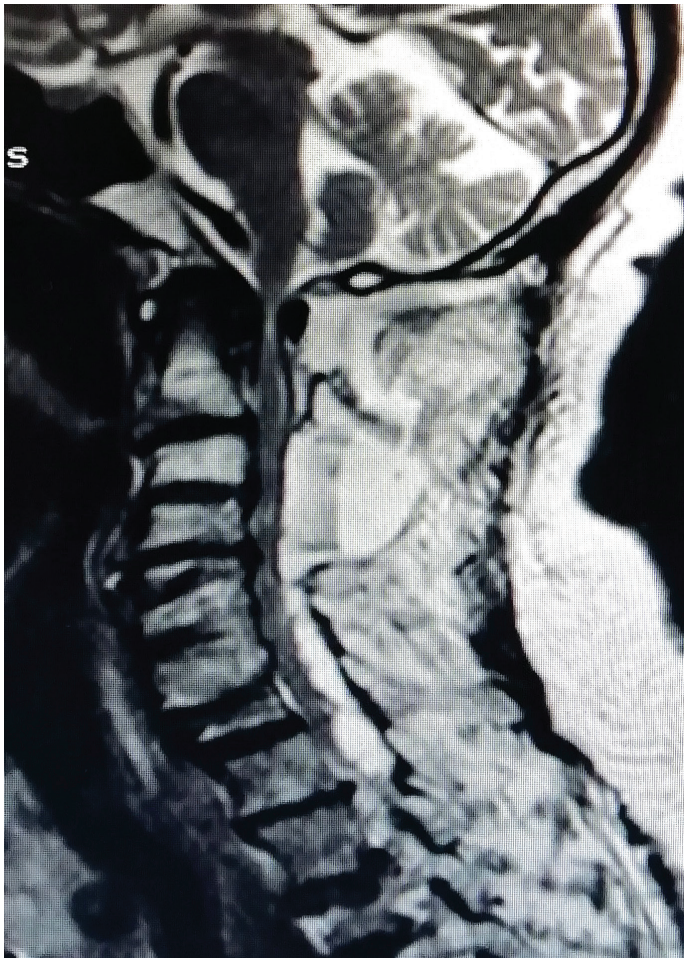

Figure 9. Postoperative cervical axial T2-weighted magnetic resonance imaging

DISCUSSION

Total incidence of PSEH was 0.090%[10]. Anterior cervical approach procedures (0.0563%) rate is less than posterior ones (0.13%)[10]. The incidence rate ranged from 0.1% to 3%, occurring in approximately 1 out of 1000 spinal surgery cases[3,9,10]. Acute spinal epidural hematoma is mostly seen at the thoracic spine. At cervical region, epidural hematoma was seen at the highly mobile C6-7 segment (90%)[4]. However, in opposition to the literature, some published studies suggest that the cervical spine may be the most common region of bleeding[4]. Using non-steroidal anti-inflammatory medication, Rh positive blood, elderly patient (above 60 years), pregnancy, preoperative coagulopathy and multilevel surgery (more than 6 levels), greater blood loss, and smoking may be the risk factors [2,3,8,10]. The risk of spinal epidural hemorrhage increases with long level surgery and high blood loss. The usage of drainage system reduces the risk of hematoma's mass effect and neurological distress. It reduces the wound complications[9,11]. The anticoagulants agents increase the risk of postoperative epidural hematoma. It is recommended to use low-dose heparin instead of acetylsalicylic acid and warfarin sodium before surgery. Four days after stopping acetylsalicylic acid, operation is recommended[3,7]. Low-dose heparin use has not been associated with the occurrence of epidural hematoma[3]. Both acetylsalicylic acid and non-steroidal anti-inflammatory medications block the cyclooxygenase system, inhibiting platelet aggregation and reducing prostaglandin synthesis. Warfarin sodium acts as an antagonist of vitamin K. Smoking causes thrombosis[8]. If there is an acute neurologic regression, absorbable hemostatic agents should always be thought in differential diagnosis[1,11]. It usually appears within the first

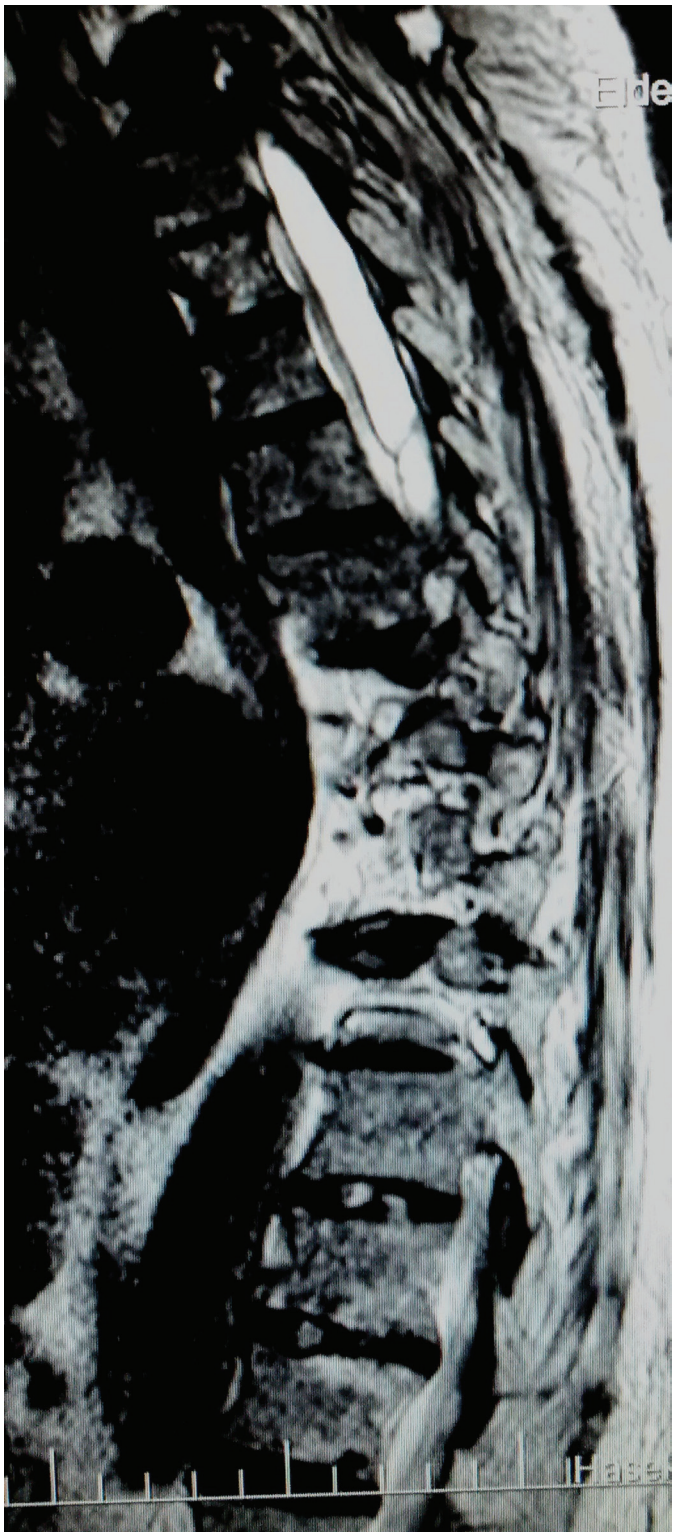

Figure 10. Postoperative thoracic T2-weighted axial magnetic resonance imaging

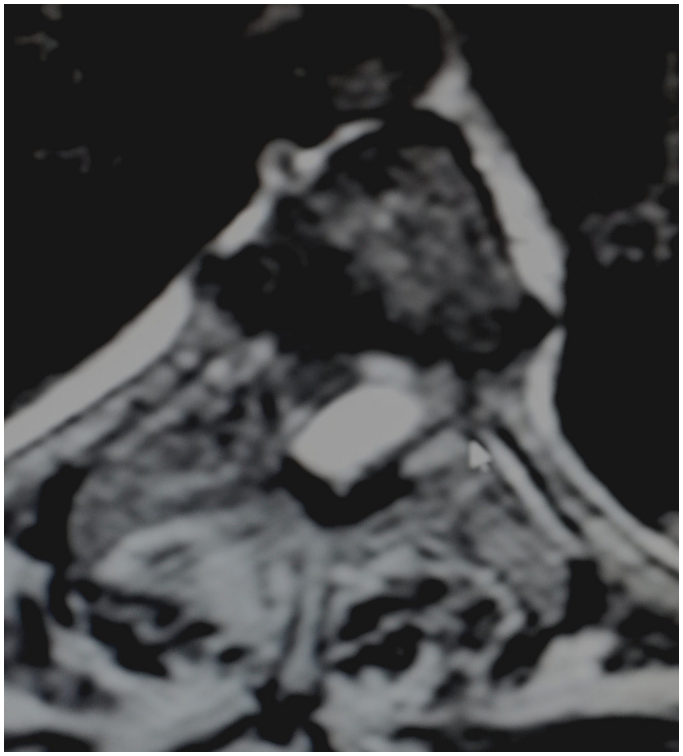

Figure 11. Postoperative thoracic sagittal T2-weighted magnetic resonance imaging

24 hours. In the late period, the percentage of spinal epidural hematoma (after 4-7 days) was 0.05-0.17%[2]. Neurological impairment occurs within 12 hours and is often followed by rapid progression to complete paralysis[4]. After spinal surgery, if there is a neurologic deterioration with new radiologic abnormalities, the literature advises immediate decompressive surgery[5,11]. The use of conservative treatment for PSEH with paresis is not favorable at first step treatment management. However, very few reports have discussed the effective nonsurgical management of PSEH[4,5]. Here, fortunately the first patient's neurologic deficits improved well in 3 hours. After a high-dose steroid treatment, non-surgical management of PSEH may be a choice in this kind of cases. He had the risk due to smoking and the blood type of Rh (+). In the second patient, there was neurological wellness after 3-week time without surgical decompression. The patient's age was over 60 years. Multilevel spine surgery, blood type of Rh (+), previous history of hypertension and use of acetylsalicylic acid, smoking for more than 40 years, non-use of a drainage system in the operation region were all increased risk factors for spinal epidural hematoma.

PSEH is a rare and dramatic event. It is important to diagnose an epidural hematoma as soon as possible. The major site and common source of bleeding are not clarified. CT scan and MRI are the most accurate methods for precise diagnosis. If neurological deterioration is present, surgery is advised during the first hours. However, conservative management is an alternative pathway in well selected patients with non-progressive course, but the ethical problem is which patient will have or not. We planned both medical treatment and surgery at the same time. Verifying surgical results and risk factors need to be investigated in larger series.

Ethics

Informed Consent: All patients signed the free and informed consent form.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.A., M.K., Concept: A.A., B.M.K., N.A., Design: A.A., B.M.K., N.A., Data Collection or Processing: A.A., M.K., T.T., Analysis or Interpretation: A.A., M.K., Literature Search: A.A., B.M.K., T.T., 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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REVIEW ARTICLE
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DECISION MAKING FOR SURGERY IN ADULT SCOLIOSIS REVIEW OF THE CURRENT LITERATURE

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ABSTRACT

Adult spinal deformity is a challenging condition in spine surgery. Adult scoliosis (AS) is an important health issue with potential to cause severe surgical adverse ramifications in aging population. Deciding who is going under the knife is still a debatable issue with no clear algorithm. This review of the recent literature is representative of the results of modern intervention methods and it references to competent authorities aiming to help clinicians to supply a guideline for surgical decision making in AS. A search in the National Library of Medicine (PubMed) database using keywords AS was performed. Our search yielded 4247 articles published between January 2005 and March 2019. When added the "surgical decision", it accounted for 105 articles. For the literature review, of papers, especially focusing on surgical decision-making, 27 were selected as guiding articles.

Non-surgical interventions for symptomatic AS cases lack a high level of evidence. Successful results were reported for local decompression, limited short segment fusion, and deformity correction with long segment fusion surgeries for selected cases. Leading factors for surgery seems to be a symptomatic case with a functional problem (primarily painful radiculopathy), self-image problems, a higher curve, and recently with an extra emphasis on sagittal malalignment. Patient's expectations, pain intensity, functional status, perception of self-image and medical risk stratification, surgeon's experience, and contentment will shape the strategy needed for decision-making for surgery and whether to address either a focal pathology or comprehensive deformity correction. Every case has to be managed according to its own characteristics.

Keywords: Adult scoliosis, degenerative, idiopathic, decision-making process, surgical indication, spine surgery

INTRODUCTION

Adult scoliosis (AS) is a term to define a lateral curvature of the spine more than 10 degrees of Cobb curve with accompanying vertebral axial rotation in a skeletally mature spine[47,13]. The incidence of AS is approximately 1.4-32%, and as high as 68% in patients over 60 years of age in a healthy adult population[74] and it is rising in conjunction with the aging population. Young patients with scoliosis almost always have a self-image complaint when they have been first seen in the clinic. However, patients with AS, in addition to deformity and cosmesis, mostly have a complaint like pain, neurological deficits, and psychosocial concerns namely "disability". Two main types of AS are idiopathic and degenerative subtypes. Idiopathic form is a continuation of an infantile or adolescent onset diagnosis whereas degenerative or so-called "*de novo* scoliosis" is believed to develop through asymmetric disk space collapse and facet degeneration with subsequent lateral and/or rotatory listhesis[7]. Differentiation of adult degenerative scoliosis from idiopathic counterpart can be somewhat confusing because of the complexity of the disease process and difficulties in the description and classification of the deformity. Sometimes it is very challenging to discriminate degenerative scoliosis just by inspecting the X-ray images. Even so, there are some clues for radiological differentiation. For idiopathic AS, deterministic factors are younger age, larger Cobb angled curves (>40°), an obvious compensatory curve, and a rotatory deformity along the whole curve. On the other hand, degenerative cases have an older age (>50), lesser curve size (<40° Cobb angle), a rotatory deformity at the apex, and a higher incidence of spinal stenosis, lateral vertebral subluxation of vertebral body, and sagittal imbalance (Figure 1)[7,10,17,36,67]. The ideal treatment of AS has not yet been identified; both surgeons and clinicians face multiple challenges, including non-surgical and surgical treatment. For surgical treatment; choosing the included segments, preserving lower lumbar vertebrae and pelvis, setting ideal sagittal and coronal alignment, the ideal age, timing for surgery, and maybe still some cosmetic issues as in AIS should be concerned. In addition, deciding whether to go for surgery or to perform which surgical intervention (local decompression, short segment fusion or longer fusions) is limited to "expert opinion or surgeon's personal bias in the facility which they were educated". However, patients with AS constitute a heterogeneous population with a clinical complaint and additional degenerative changes, thus, it is difficult to compare the outcomes of different management strategies in meaningful

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numbers of patients. In addition, there is still a lack of outcome assessment tools for this complex group of patients. The factors affecting the surgical decision in the literature are mainly from "what we did and succeeded or failed" inferences. These mainly focus on patient-reported outcome measurements (PROMs) and complication rates. If one surgery has a significant improvement in health-related quality of life (HRQoL) and with a low complication rate on a similar group of AS patients, then it is logical to choose more patients in the same condition, who are waiting for a decision to be made. Through the past two decades, understanding the importance of the restoration of normal sagittal alignment is one of the fundamental goals in deformity correction surgery, and rod pre-contouring is a standard procedure in almost all modern correction techniques for sagittal alignment control. However, defining ideal sagittal shape and alignment for the surgically corrected spine is still a debatable topic today[26,27,49,71]. AS was found to have a devastating effect on HRQoL in several studies[5,61], like the Short Form-36 Physical Component Score values for this cohort were similar to the values reported by patients with chronic heart disease, and the disease impact of large sagittal malalignment (sagittal vertical axis >10 cm) was greater than that reported by patients with limited vision and patients with limited use of arms and legs. A reputable classification system for AS should be that it distinguishes between clinically significant groups of cases with the disease, it is easy to apply in clinical settings, it is reproducible over time and among observers, it guides the surgical treatment, and it predicts outcomes. Ad hoc, first, King and Lenke classifications took place for adolescent scoliosis in 1983 and 2001, respectively, and then the need for more comprehensive definitions arose for AS. The Simmons classification system[55], Aebi[1], Scoliosis Research Society[4] and the SRS-Schwab Adult Spinal Deformity Classification[6] have emerged for these needs. One put effort to cover others' inadequacy, mainly focusing not only the coronal deformity but also the sagittal alignment and the disabled state of the patient. The simple pathogenesis-based approach of Aebi[1], the strong clinical relevance of the Schwab approach, and the richly descriptive SRS systems all gained popularity. Moreover, the ideal classification system for AS continues be re-evaluated researchers. Many groups continue to devise classification systems as both surgical techniques and the understanding of scoliosis are refined. During the past decade, advancements in surgical techniques, instrumentation, supported with the multidisciplinary advance in anesthesia, radiology, and understanding the importance of sagittal global alignment and its proportions have changed the management of adult spinal deformity surgery and led to improved long-term outcomes. Therefore, this study focuses on the current literature for reliable and valid information.

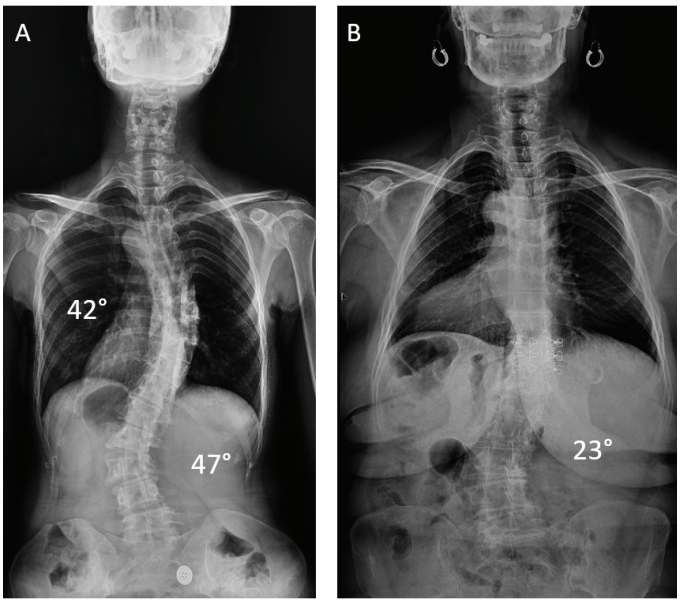

Figure 1. Case examples for 37 years old patient with idiopathic (A) and a 67 years old patient with degenerative adult scoliosis. Note the lesser curve size and absence of compensatory curve in (B)

MATERIALS AND METHODS

A search in the National Library of Medicine (PubMed) database using the keywords AS' has yielded 4247 articles published between January 2005 and March 2019. When added the "decision", it accounted for 105 articles. All information on outcome measures was extracted. Referenced clinical studies were retained in full text analyzed. We assessed the quality of each study based on following criteria: minimal number of patients, construct validity, internal consistency, criterion validity, reproducibility, responsiveness, up-to-dateness, and interpretability. As a result, 27 papers, especially focusing on surgical decision-making, were selected for the review (Figure 2) (Table 1).

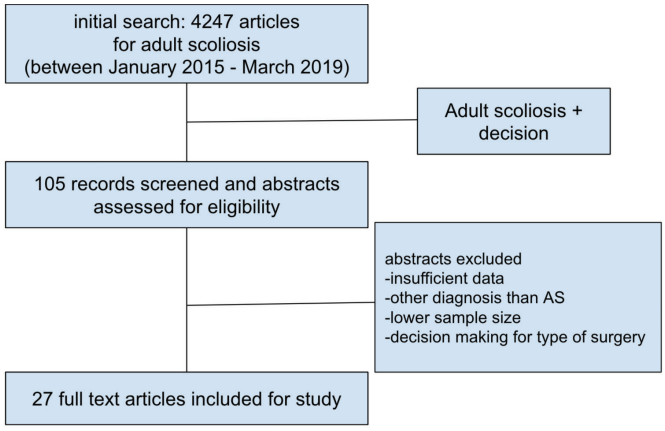

Figure 2. Flowchart of the study selection process

DISCUSSION

The PROMs, the intensity of symptoms, patient demographics, accompanying co-morbidities, coronal deformity and imbalance,

Table 1. Papers and remarks related to decision making for surgery in adult scoliosis

Publish year	Author	Study design	Cobb curve	Remarks
2006	Glassman et al.[21]	RP	>30°	Sagittal plane deformity, worse PROMs more in surgical groups
2007	Glassman et al.[24]	RP	>30°	Nonsurgical patients had greater preoperative medical risk factors. Surgical patients had more frequent leg pain, a higher mean level of daily back pain, and more frequent moderate-to-severe back pain
2008	Smith et al.[57]	RP	>20°	Development of neurological symptoms and/or deficits is strongly associated with the decision to pursue operative treatment
2009	Pekmezci et al.[39]	R	>30°	BMI, comorbidity scores, back pain, and leg pain incidence, and severity were similar among operative or nonoperative groups. Functional limitations are more important than pain for adult deformity patients when deciding for operative or nonoperative treatment
2009	Smith et al.[58]	RP	>10°	Compared to nonoperative treatment, surgery can offer significant improvement of back pain for adults with scoliosis
2009	Smith et al.[59]	RP	>10°	Surgical treatment has the potential to provide significant improvement of leg pain in adults with scoliosis
2009	Wood et al.[67]	R	>30°	Patients treated operatively reported significantly less pain and better health-related quality of life, self-image, mental health, and global restoration. Preoperative radiographic parameters were not determined to be a significant factor for predicting whether an operative or nonoperative treatment course was chosen
2009	Bridwell et al.[8]	P	>30°	Common nonoperative treatments do not change the HRQoL in patients with ASLS at 2-year follow-up. However, operative treatment does significantly improve HRQoL
2009	Bess et al.[5]	R	>20°	Counter to previous reports, age, comorbidities, and sagittal balance did not influence treatment modality for AS. Operative treatment of younger adults with scoliosis was driven by coronal deformity. Operative treatment of older adults with scoliosis was driven by pain and disability, independent of radiographic deformity
2010	Fu et al.[20]	PR	>20°	Operative intervention group reported worse health, greater disability and had a higher level of comorbidity. Relative contraindications to surgery; age greater than 75 years and a Charlson Comorbidity Index score greater than 5 are used as discouraging criteria
2011	Smith et al.[61]	PR	>30°	Elderly, despite facing the greatest risk of complications, may stand to gain a disproportionately greater improvement in disability and pain with surgery
2011	Kotwal et al.[30]	Review	-	The presence of lateral listhesis, spondylolisthesis, and sagittal or coronal decompensation, despite a low Cobb angle, is believed to be more important in decision-making
2012	Lonergan et al.[33]	R	-	Age alone should not be the deciding factor or a contraindication for patients in their 8th decade of life who are incapacitated by their painful spinal deformity
2014	Cho et al.[10]	Review	-	Short fusion is indicated in cases with less Cobb angle, minimal rotational deformity, and no coronal and sagittal imbalance. Long fusion is indicated in cases of severe Cobb angle and coronal and sagittal imbalance
2015	Sciubba et al.[50]	PR	>20°	Surgery provides significant improvements in pain and disability in patients aged >75
2015	Scheer et al.[44]	PR	>20°	Surgical management resulted in significantly greater improvement in both back and leg pain severity than nonsurgical management. Moreover, patients whose ASD was managed nonsurgically were more likely to experience no improvement or worsening of their pain
2015	Smith et al.[58]	P	>20°	Operative treatment for ASD can provide significant improvement of HRQoL at a minimum 2-year follow-up. In contrast, nonoperative treatment on average maintains presenting levels of pain and disability

2016	Parent et al.[38]	P	>30°	Patients with worse PROs, more back pain, more back and leg pain with ambulation, and larger lumbar Cobb angles are more inclined to select surgical over nonsurgical management
2016	Shaw et al.[53]	Review	-	Patients experiencing complications are significantly older and there is a progressive increase in complication rates with each decade of life
2016	Graham et al.[42]	Review	-	Both objective radicular weakness and neurogenic claudication are essentially predictive of a patient with adult spinal deformity choosing to undergo surgery
2016	Pizones et al.[40]	PR	>20°	Clinical symptoms, particularly function impairment, motivated patients to undergo surgery. Neither demographic nor radiographic parameters influenced decision-making about surgery
2016	Christiansen et al.[12]	Review	-	Although more likely to experience complications, the older and more disabled patients may actually stand to gain the most from surgical intervention
2017	Teles et al.[63]	Review	-	No randomized controlled trial was identified in our search to support the long-term value of current nonsurgical therapeutic options
2017	Faraj et al.[18]	R	>10°-55°	No significant difference in functional outcome was found between surgical and nonsurgical groups after a mean follow-up of 10 years. Certain patients can benefit from nonsurgical management after long periods of time
2018	Fujishiro et al.[22]	PR	>20°	Aside from the HRQoL measures and coronal deformity, sagittal parameters were identified as a significant factor
2019	Lonner et al.[34]	Research support	>40°	The adult scoliosis patient begins with worse QoL and improves to a greater extent in most domains than their adolescent counterpart
2019	Fujishiro et al.[21]	PR	>20°	The first algorithm to guide the decision-making process for the ASD population and could be one of the indices for aiding the selection of treatment for ASD

RP: Retrospective review of prospectively collected data; R: Retrospective study, P: Prospective study, AS: Adult scoliosis, PROM: Patient-reported outcome measure, HRQoL: Health-related quality of life, BMI: Body mass index, ASD: Adult spinal deformity, ASLS: Adult symptomatic lumbar scoliosis

and sagittal malalignment all have a part in decision-making to pursue surgery for AS patients. Most studies have examined the factors influencing decision-making in AS by questioning the distinguishing determinant factors among surgical and nonsurgical cases.

Conservative Treatment

Initial management of symptomatic AS, without progressive neurologic deficit, basically comprises non-surgical treatments in order to avoid the inherent morbidity of extensive surgeries. However, nonsurgical modalities play a little role in ASD and there is a lack of evidence in the literature and most of the existing evidence is derived from observational studies with a high risk of bias[16,41,58,63,]. On the contrary, there is literature evidence of supporting conservative interventions for selected cases. Non-operative methods should be tried first and all means be consumed before the talk of surgery[32,50,56]. Conservative treatment includes aerobic exercise, aquatics/pool therapy, strength training, stretching exercises, postural training, body mechanics physical agents methods, analgesics, nonsteroidal anti-inflammatory drugs, narcotics, pain management, epidural blocks, facet or nerve root injections, bracing, bed rest, weight loss programs or "no treatment". On the other hand, there is the option of "surgical treatment" with up to 80% (9.52%-81.52%) complication rates and more than 50% re-operation rate, reported in several papers[8,9,63,68]. Teles et al.[62] reported postoperative radiological (7 main categories) and instrument-related (7 main categories) complications and Christiansen et al.[12] modified their work and stated 46 major and 41 minor complications under 10 main categories (infection, implant-related, neurological, cardiopulmonary, gastrointestinal, radiographic, renal, wound problems, operative, and vascular). Surgery may be considered if patients have inadequate improvement with nonoperative measures. Thus, researchers sought for the answer to the question: "why all these patients still choose the operative treatment, despite this much complication rate?".

Why Surgery?

Answers to this question were given by several studies in the scope of risks and benefits. Smith et al.[58] compared propensity-matched 286 operative and 403 nonoperative patients and reported that 71.5% of operative patients had at least 1 complication, and reported still significant improvements in HQRoL measurements. Bridwell et al.[8] revealed 31 complications among 85 operated patients and still reported improvements in all HRQoL parameters. Zimmerman et al.[73] also stated that in spite of high complication rates (49%), patients benefited from surgery. Trommell et al.[64] grouped patients in three categories as decompression only, decompression with limited fusion and long fusion and they concluded similar inference with prementioned studies in improvements in PROMs contrast to complications. First three studies also emphasized little or no change in PROMs in non-operative groups in the follow-up. Moreover, Smith et al.[57,60] reported in two different studies that despite having started with significantly greater leg, back pain

and disability, surgically treated patients at 2-year follow-up had significantly less pain and disability than nonoperatively treated patients who gained nearly no improvement. Surgery has been shown to be superior to non-operative treatment in AS patients with severe disability[8,49,50].

Back Pain

Back pain is the most common symptom of AS and widely a subjective quality of life measure. It usually presents on the convex side of the curvature. It has been found that the prevalence of back pain in scoliotic adults is no higher than that in the normal population[25]. Back or leg pain that is refractory to conservative measures is an indication for surgery. Ha et al.[25] found that low back pain was no more severe in patients manifesting with lumbar scoliosis than in nonscoliotic cases; however, a specific pain profile, notably a high frequency of cruralgia and inguinal pain, existed for scoliotic patients.

Radicular Pain (Neurological Symptoms and Deficit)

Spinal canal or concave side neuroforaminal stenosis related to either degenerative changes or the scoliotic curve itself can enhance severe enough to result in neurological deficits. Both objective radicular weakness and neurogenic claudication are essentially predictive of a patient with adult spinal deformity, choosing to undergo surgical intervention[57].

Plenty of reports have showed that the presence of leg pain is an independent predictor of a patient's preference for surgical over nonsurgical care[23,39,57,73]. Smith et al.[57] described a best-fit model for a surgery candidate as having 3 of these: severe radiculopathy, radicular weakness, and greater sagittal imbalance. They also excluded the severe back pain from their model.

Age

There is a clear connection between increasing age and higher rates of major short-term complications, a factor that ought to be taken into account during decision-making for treatment and patient counseling[14,33,53]. Older age was once reported to be a relative contraindication[20]. However, in spite of higher complication rates, more recent studies are in favor of surgery because of its positive impact on PROMs[50,64,74,]. Bess et al.[5] in their study, stratified their patients into 3 groups (G1<50 years, G2=50-65 years, G3>65 years) and demonstrated larger curves in G1 and G2 versus G3, progressively worsening sagittal imbalance in older age groups, and worse HRQoL scores in G3 versus G1 and G2.

A very sophisticated study is from Lonner et al.[34] They matched 28 AS patients with 56 (1:2) AIS patient, estimating their natural history of curve progression as a future equivalence of AIS deformities. They found the adult counterparts having greater levels fused, longer operative time, and higher complication rates than the AIS counterpart. Therefore, they emphasized the negative effects of waiting for surgery.

Comorbidities

Fu et al.[20] suggested criteria for relative contraindications to surgery as; age greater than 75 years and a Charlson Comorbidity Index score greater than five. In contrast, Sebaly et al.[50] reported that in elderly patients greater than 75 years of age, reconstructive surgery can provide significant improvements in pain and disability over a two-year period. The presence of comorbidities, like the age, was once perceived as a restrictive factor for surgical intervention. However, this does not necessarily result in poor outcomes in recent literature, and favorable outcomes are not without complications[12,74]. Somehow, higher risk subjects potentially have more to gain, even if they encounter complications[12,50,61].

Extension of Surgery

While some authors favor the local decompression in selected cases[64,73], others advise it should be avoided to protect further curve progression[10]. One important issue is that if a long segment fusion surgery is decided for an AS case, the sagittal profile must be corrected properly to avoid postoperative complications[4,64,70]. Based on this, in case of a patient with a severely disproportioned (SD) sagittal spine profile, if one cannot properly restore the sagittal alignment, it is better to do a focal solution or even no surgery.

Patient-reported Outcome Measurements

Several researchers have studied factors influencing decision-making in AS by examining the distinguishing factors between surgical and nonsurgical cases. These factors mainly include the PROMs, the intensity of symptoms, coronal and sagittal imbalance, comorbid state of the patient, and demographics for selecting surgical management and provide information on the decision-making process for the adult spinal deformity (ASD) population. Worse HRQoL scores [Oswestry Disability Index (ODI) >20, SRS <4] in surgically treated groups were reported to be prevalent than the nonsurgical comparisons[8,20,22,38,39,50,57,74] and after the surgical recovery period passed, these measures were also reported to be improved significantly in surgery cohorts, while the nonsurgical group remained with no significant change[8,50,74]. Glassman et al.[23], in a database of 585 nonsurgical ASD patients, divided the group into high-symptom (335) and low-symptom (250) subgroups, based on age-adjusted ODI scores and found that the 2 groups differed significantly on all standardized patient-reported health status measures ($p<0.0001$). Patients in the low-symptom group (49% vs. 38%) had a primary diagnosis of adult idiopathic scoliosis (<0.01). In the same paper, they also compared 335 high-symptom patients with 476 surgical ASD cases and found a higher incidence of sagittal plane deformity in favor of the surgical group.

Lateral Listhesis and Rotatory Subluxation

Lumbar lateral listhesis is common in AS and it is reported in 13%-34% of cases and it is stated to be an important finding leading to radiculopathy ranging between 43 and 65%[19,29]. The incidence of back pain in patients with AS and rotatory subluxation has been reported as high as 80%[65]. Rotatory subluxation seems to be the initial element of progression

for degenerative scoliosis, while it is the consequence of progression for idiopathic scoliosis[36].

Glassman et al.[24] and Wood et al.[67] found that the greater apical vertebral translation led to an increased likelihood of surgical treatment among radiological parameters. In contrast, Pizones et al.[40] found no differences between surgical and nonsurgical groups in terms of radiographic preoperative data, including Apical translation and lumbar rotatory subluxation. Ferrero et al.[19] found a correlation between PROMs and rotatory subluxation as the number of level increase significantly correlated with ODI scores.

The Coronal Curve Imbalance

Sagittal analysis has been broadly outlined in the literature during the past decade, whereas coronal deformity (as it should be a straight line), took little attention. Not like AIS patients, flexibility is limited in AS cases. Coronal alignment seems to have limited influence on the intensity of pain and functional disability[47].

In the majority of studies, patients in the surgical groups have higher Cobb curve magnitudes than the nonsurgical comparison groups[21,22,24,54]. Glassman et al.[24] reported that a coronal shift greater than 4 cm was strongly correlated with a decreased HRQoL and even so they stated that the correction of coronal balance within 4 cm of neutral may not be as important a goal as restoration of appropriate sagittal alignment. The goal should be a balanced coronal spine, rather than zero straight one. The coronal plane does have an effect on the clinical picture and the postoperative failures but seems to have no statistically significant role in decision making[11,37,51]. A clinical note is that patients with a pre-operative trunk shifted to the convex side of the coronal curve are predisposed to having a post-operative coronal imbalance and should be carefully evaluated for decision-making[37,69].

Sagittal Plane Deformity

In the last decade, spine literature has been reshaped by the "new understanding of sagittal plane analysis". Significant correlations have been detected in ASD between sagittal lumbopelvic parameters and functional outcomes[4,49,51,70]. It has been shown in many studies now that positive sagittal balance is the radiographic parameter highly correlated with adverse health status measures, poor clinical outcomes, and also postoperative mechanical complications[13,24,43,57,70]. Glassman et al.[23] reported a greater percentage of conservative treatment patients with high symptoms had a diagnosis of sagittal plane deformity ($p<0.01$) and afterward, compared those 335 high-symptom conservative treatment patients with 476 surgical ASD cases and found a higher incidence of sagittal plane deformity in this time in the surgical group. Schwab et al.[44] also demonstrated that patients with worse scores in back and leg pain presented greater improvements in HRQoL scores postoperatively. Sagittal parameters such as pelvic incidence/lumbar lordosis (PI-LL) mismatch[21], relative LL[71] or relative spinopelvic alignment[72] are a strong indicator for pursuing surgical treatment.

Scoring Systems

Global Alignment and Proportion Score

The Global Alignment and Proportion (GAP) score is a new PI-based proportional method of analyzing the sagittal plane in patients undergoing surgery for adult spinal deformity. It can either be used for pre and postoperative sagittal analysis and surgical planning[70,71,72]. For the study[70], sixth week postoperative sagittal radiograms were evaluated. Adding the age factor as the co-morbidity state, GAP score falls into 3 categories as proportioned (0-2 points), moderately disproportioned (3-6 points), and severely disproportioned (7-13 points). Each category gives a prediction about mechanical complication occurrence. This revolutionary scoring system has also been validated[2,27,70] and it is still a new concept having ongoing validations.

The Adult Spinal Deformity-Surgical Decision-making Score

In a very recent article on March 2019 on behalf of European Spine Study Group[21], a total of 316 patients with ASD were analyzed to develop and internally validate a scoring system: the ASD surgical decision-making score, specific to the decision-making process for ASD patients younger than 40 years old. A 10-point scoring system was created from four variables: self-image score in the SRS-22 score, coronal Cobb angle, PI-LL mismatch, and relative spinopelvic alignment, and the surgical indication was graded into low (score 0-4), moderate (score 5-7), and high (score 8-10) surgical indication groups.

Surgical planning is mostly at the preference of the surgeon and also affected by whether the surgeon had a previous history of spinal surgery fellowship training or not[3]. Advancing literature supports the benefits of surgical treatment for selected ASD patients, further high-quality studies are required to compare operative and nonoperative treatment. It should be noted that one of the internal difficulties in the designs of these studies is the matter that AS patients referred to a spine surgeon might be more symptomatic and hence not representative of the population as a whole. A majority of AS patients may be treated by their primary care providers and never referred to a tertiary spine center. This may considerably alter the findings in most studies.

CONCLUSION

A considerable portion of the AS is asymptomatic and maybe never seen by a spine surgeon. Patients with debilitating symptoms, who are referred to the spine surgeons, are mainly decided to pursue surgery mostly influenced by; sagittal plane deformity, functional problems like radicular unbearable leg and lower back pain especially in walking, larger coronal curves, thereby clinical appearance, worse HRQoL measures, surgical indications among the physicians and assessment of medical risk factors. The radiological parameters especially in coronal

plane, as opposed to AIS, are not as effective as functional limitations and disability in AS for surgery decision-making. Despite high complication rates in adult spinal deformity surgery, benefits patients gain after the surgery overweigh the complication risk. Surgical treatment has the potential to provide significant improvement of leg and back pain in adults with scoliosis. Patients with functional disabilities have a higher tendency to surgical modalities. With the new attempts on classifications and scoring systems, by managing every case according to its own characteristics, surgeon's experience and contentment and the patient's expectations and medical risk stratification will shape the strategy needed to address the pathological processes in adult spinal deformity.

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