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About Us

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

JOURNAL OF TURKISH SPINAL SURGERY

Instructions to Authors

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

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PEER REVIEW

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

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

AUTHOR'S RESPONSIBILITY

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

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

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

CONFLICTS OF INTEREST

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

ARTICLE WRITING

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Journal article:

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

Book chapter:

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

Entire book:

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

Book with volume number:

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

Journal article in press:

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

Book in press:

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

Symposium:

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

Papers presented at the meeting:

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

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

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

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

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

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

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

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

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

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

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

- Practical Tips:

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

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

3. Avoid references and statistical values in the Abstract.

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

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

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

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

7. Regularly count words from the Introduction through Discussion.

TABLE-1. LEVELS OF EVIDENCE

LEVEL- I .

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

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

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

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

5) Multi-center, randomized, prospective studies

LEVEL –II.

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

2) All Level-I studies with no randomization

3) Randomized retrospective clinical studies

4) Meta-analysis of Level-II studies

LEVEL– III.

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

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

3) Meta-analysis of Level III studies

LEVEL- IV.

1) Case presentations

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

LEVEL – V.

1) Expert opinion and review articles

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

TABLE-2. CLINICAL AREAS

Anatomy

Morphometric analysis

Anesthesiology

Animal study

Basic Science

Biology

Biochemistry

Biomaterials

Bone mechanics

Bone regeneration

Bone graft

Bone graft sustitutes

Drugs

Disc

Disc Degeneration

Herniated Disc

Disc Pathology

Disc Replacement

IDET

Disease/Disorder

Congenital

Genetics

Degenerative disease

Destructive (Spinal Tumors)

Metabolic bone disease

Rheumatologic

Biomechanics Cervical Spine

Cervical myelopathy

Cervical reconstruction

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

Fractures

Dislocations

Spinal cord

Spinal Cord Injury

Spinal stenosis

Cervical

Lumbar

Lumbosacral

Tumors

Metastatic tumors

Primary benign tumors

Primary malign tumors

APPLICATION LETTER EXAMPLE:

Editor-in-Chief

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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 privileged to be the person responsible for publishing this, the 2nd issue, of our professional journal this year. Publishing this issue was extremely difficult because of the pandemic. Therefore, I want to extend a heartfelt thanks to all the authors, reviewers, assistant editors, secretaries and the Galenos publishing team for the effort they expended in order to get it done. The Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spine Society. I hope in the near future our journal will be indexed by other important international indexes. In addition, we are very happy to announce that we will be accepting new reviewers for our journal. Please apply to us, as soon as possible, if you are interested.

This issue includes several clinical research studies and a couple of case reports. I hope that each of you will take the time to review this issue very carefully, and add the information and insights contained herein, to your already very well informed knowledge bases.

In this issue, there are eight clinical research studies and five case reports. The first study is a Retrospective Clinical Study about Lenke 5 curves. Authors compared two groups of 59 patients in order to determine whether or not thoracic fusion was really necessary. The second study is a Clinical and Radiological Comparison of Spinopelvic Fixation Methods. 56 patients with S2-Alar-Iliac Screw, and Conventional Iliac Screw, were compared. The third, is a clinical study, entitled Respiratory Function in Adolescent Girls with Mild and Moderate idiopathic Scoliosis. The fourth article is a single center experience entitled Bakker Classification in Treatment of Sacral Stress Fractures. The authors of the fifth study examined Radiofrequency Ablation Plus Vertebroplasty in the Treatment of Symptomatic Vertebral Hemangiomas Without Neurological Deficit. The sixth study is a Clinical and Radiological Comparison of Surgical Treatment Methods in Patients with Cervical Spinal Stenosis while, in the seventh, the authors Evaluated Risk Factors of 1453 patients with Early Recurrent Lumbar Disc Herniation. The eighth article is a Retrospective Study about Management and Surgical Outcomes of Adult Spinal Intradural Lesions. The ninth article is a case report about Spontaneous Spinal Epidural Hematoma Following Warfarin Treatment. The tenth study is a case report about C7-T1 Disc Herniation Treated by Posterior Approach. The eleventh article is a case report entitled Cutaneous Meningioma Which is Uncommon Tumor at the Uncommon Region. A case report and Review of the Literature about Thoracic Intradural Extramedullar Arachnoid Cyst in an Adult is the twelfth article, and the thirteenth is a Case Report and Review of Literature about Isolated Degenerative C1 Spinal Stenosis

Once again, I'd like to recognize the efforts of everyone who worked tirelessly to get this issue out to our readers in spite of the issues posed during these very unusual and difficult times. I hope our readers appreciate the work that went into this, and that each of you take the time to read and absorb the vital information contained here. As always, it's our goal to provide you with the most current research available, and information on current practices and methodology. Our mission is to guarantee that we remain on the forefront of all the latest developments, and this issue is intended to further that goal.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

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LENKE 5 CURVES: IS THORACIC FUSION REALLY NECESSARY?

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ABSTRACT

Objective: The recommended surgery for Lenke type 5 curve is only the fusion of structural curve (SF: Selective fusion). However, some surgeons prefer to fuse both the thoracolumbar and lumbar (TL/L) curve and the non-structural thoracic (T) curve (NSF: Non-selective fusion). There is a lack of data with regard to the mid-to-long-term outcomes of the SF and NSF. In this study, it was aimed to compare SF and NSF in terms of TL/L and T curve correction rates and the prognosis of the corrected curves.

Materials and Methods: A retrospective study of AIS patients treated at a single institution was conducted. A total of 59 patients (55F/M4) were included in the study. Preoperative, early postoperative and last follow-up TL/L Cobb and T Cobb angles were measured with software. SF and NSF correction rate comparison was done using the Mann-Whitney U test.

Results: Overall, 35 patients underwent NSF while 24 patients underwent SF. The mean follow-up duration was 43±18.05 months (54-98). Early T Cobb correction rate was 69% in group 1 (SF) and 79% group 2 (NSF); however, this difference was not statistically significant when the groups were compared (p=0.71138). Last follow-up T Cobb correction rates for group 1 and group 2 were 66% and 79%, respectively (p=0.5485). Early TL/L Cobb correction rate was 78% in group 1 and it was 79% in group 2 (p=0.8493). Last follow-up TL/L Cobb follow-up correction rates for groups were 79% and 76%, respectively (p=0.9203).

Conclusion: This study concluded that SF had favourable outcomes without loss of correction for the patients with Lenke type 5C AIS in the mid-to long-term.

Keywords: Lenke type 5C AIS, selective fusion, non-selective fusion, loss of correction, prognosis

INTRODUCTION

Lenke type 5 adolescent idiopathic scoliosis (AIS) covers a structural thoracolumbar and lumbar (TL/L) curve and nonstructural proximal or main thoracic (T) curves[1]. The widely accepted treatment for Lenke type 5 curves is performing selective fusion (SF) of the structural TL/L curve[1-4]. However, some spine surgeons treat these curves non-selectively, while others tend to treat selectively, with the aim of protecting certain mobile segments in the thoracic spine[5,6]. The SF technique was reported to be more advantageous in terms of shorter operation time, shorter hospital stay and lower morbidity[7-9]. The non-selective fusion (NSF) technique, involving the fusion of both the structural and minor T curves, was reported to have higher correction rates and longer preservation of the corrections, as the main advantages[2,3,9]. To the best of our knowledge, studies comparing the outcomes of SF versus NSF treatment of patients with Lenke type 5C AIS are limited and the available data are controversial[10,11]. The aim of this study was to present the mid-to long-term radiologic outcomes of the patients with Lenke type 5C AIS who underwent SF and NSF, by evaluating the correction rates and the loss of correction of the TL/L and T curves.

MATERIALS AND METHODS

This was a retrospective review of 71 patients with Lenke type 5C AIS who underwent SF versus NSF (Figure 1). All of the patients were operated by one surgeon at a single institution between June 1998 and July 2009. The inclusion criteria were as follows: patients with Lenke type 5C curve, operated only with the posterior approach, using pedicle screws, having no past history of spine surgeries, together with having standing full-body spine radiographs taken preoperatively, early postoperatively and during the last follow-up visit. Patients with a follow-up period of at least 2 years were included in the study. Patients who had previous surgery, hybrid constructs, anterior surgery, spinal osteotomies and patients whose radiographs did not meet the required standards were excluded from the study. Therefore, twelve patients who did not meet the inclusion criteria were excluded.

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Fifty-nine patients (55 females, four males) with a mean age of 16.7±3.8 and a mean follow-up period of 43±18.05 months, in concordance with the inclusion criteria were included in the study. The choice of treatment was basically determined according to two criteria: (1) The presence of a thoracic hump upon examination and the need to perform a long -level fusion to handle it. (2) The aim of a better correction of the trunk shift, with a long-level fusion. Thus, patients were divided into two groups: Group 1 was composed of 24 patients (22 females/two males) who underwent SF and group 2 was composed of 35 patients (33 females/two males) who underwent NSF (Table 1). The surgeries were performed by the same experienced spinal surgeon on the basis of his personal experiences according to the clinical examination and the posteroanterior (PA) and lateral side-bending radiographs prior to surgery. All the patients were operated under general anaesthesia and placed in a prone position on a surgical table. All the patients also underwent posterior instrumentation and fusion. The pedicle screw rod system was used for fixation. Several surgical manoeuvres were used such as apical vertebral de-rotation, rod rotation, convex compression and concave distraction.

The study was performed by the ethical standards of the 1964 Declaration of Helsinki (ethics committee permission number 2017/17-3). Oral and written informed consent was obtained to publish the data.

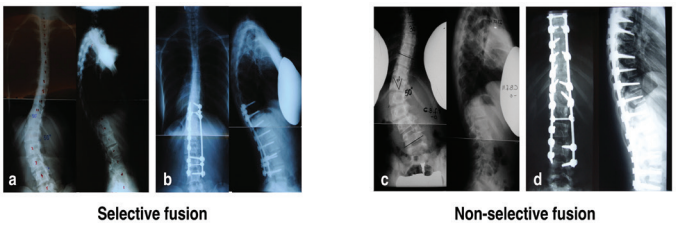

Figure 1. **(a)** Preoperative and **(b)** Postoperative radiography of a 16-year -old female patient with a 50° TL/L Cobb angle corrected by selective fusion **(c)** Preoperative and **(d)** Postoperative radiography of an 11-year-old female patient with a 50° TL/L Cobb angle corrected by non-selective fusion

Statistical Analysis

Radiologic evaluations were based on standing fullbody radiographs that were taken preoperatively, early postoperatively (first week) and at the latest follow-up visit by a researcher who did not participate in the surgeries. TL/L Cobb angle and T Cobb angle were measured. Radiographic measurements were done using the Surgimap software (New York, NY, USA). Kolmogorov-Smirnov test was used to assess the distribution of the data, while the Mann-Whitney U test was used to compare the outcomes. Statistical significance was defined as $p<0.05$ (SPSS 24.0, IL, USA).

RESULTS

In patients with SF (group 1), the mean TL/L Cobb and T Cobb angles in the preoperative, early postoperative periods and at the last follow-up visit were 39.68°±9° and 16.5°±6.7°; 8.7°±8.2° and 5.3°±5°; and 9.5°±8.4° and 6°±4.9°, respectively (Table 2). Comparing the preoperative and early postoperative data , we found that the spontaneous postoperative correction of the T curves was statistically significant ($p<0.05$), while the loss of correction observed during the follow-up period was found not to be statistically significant ($p>0.05$). In patients with NSF (group 2), the mean TL/L Cobb and T Cobb angles in the preoperative, and early postoperative periods were 43.6°±8.4° and 25.2°±9.5°; and 8.4°±6.6° and 5.3°±5.6°, respectively. At the last follow-up visit, the mean TL/L Cobb angle was 8.9° and T Cobb angle was 5.45° (Table 2).

Although the early T Cobb correction rate seemed a little lower in group 1 (69%) when compared to group 2 (79%), this difference was not statistically significant (p=0.71138). The T Cobb correction rates at the last follow-up were 66% and 79%, respectively (p=0.5485) (Table 3).

Table 1. Patients' demographic characteristics

	Group 1 (SF) (24 patients)	Group 2 (NSF) (35 patients)	*p* value
Gender	22F, 2M	33F, 2M	1.00
Mean age at surgery (year)	16.5 (range, 14-21)	17 (range, 11-26)	0.594
Follow-up duration (month)	40 (range, 24-77)	45 (range, 24-98)	0.105

SF: Selective fusion, NSF: Non-selective fusion, F: Female, M: Male

Table 2. Radiographical outcome measures at all study interval assessments

Variables		Pre-operative			Early post-operative			Last follow-up		
		Group 1	Group 2	*p* value	Group 1	Group 2	*p* value	Group 1	Group 2	*p* value
TL/L Cobb Angle (degree)	Min-max Mean ± SD	27-61 40±9	27-66 44±8	0.081	0-36 9±8	1-33 8±7	0.9703	1-36 9.5±8	1-32 9±6	0.767
T Cobb Angle (degree)	Min-Max Mean ± SD	6-29 16.5±7	3-45 25±9.5	0.001	0-17 5±5	0-20 5±5	0.9875	1-17 6±5	0-18 5±6	0.6498

TL/L: Thoracolumbar/Lumbar, T: Thoracic, Min: Minimum, Max: Maximum, SD: Standard deviation

Early TL/L Cobb correction rate was 78% in group 1 and 79% in group 2 (p=0.8493). The TL/L Cobb correction rates at the last follow-up were 79% and 76%, respectively (p=0.9203) (Table 4).

DISCUSSION

The main goal of surgery in patients with Lenke type 5 AIS is to prevent progression of the curve and to correct the deformity with minimum fusion levels, in order to provide a mobile and functional spine[1,5,7]. In line with the recommendations of the Lenke classification , many surgeons prefer SF in the treatment of patients with Lenke type 5 AIS[10,11]. However, in many studies, it has been reported that a considerable number of experienced spine surgeons prefer NSF for this group of patients, in up to 17% of cases[9-11]. That could be because they believe that adequate correction cannot be achieved in minor T curve with SF[5] or that the prognosis of the correction obtained is uncertain[3]. On the other hand, in a study conducted by Zhang et al.[5], it has been reported that the TL/L curve correction rate was 84.9% and the spontaneous T curve correction was 48.5% in patients with Lenke type 5 AIS, while no significant increase with regard to the loss of correction was detected during the long-term follow-up. Similar to Zhang et al.[5]'s findings, Senkoylu et al.[3] reported that the spontaneous correction in T curves was satisfactory and there was no loss of correction at a mean follow-up of 4 years. Also, correction loss was not found to be statistically significant in patients with both SF and NSF at long-term follow-up by Sanders et al.[8]. In our study, the correction rate, which was 68% in the early period for T Cobb and 66% at a mean follow-up of 42.3 months, agrees with the findings of the aforementioned studies.

In contrast, Zang et al.[5] reported a loss of correction in 22 of 45 patients with Lenke type 5C AIS at a mean follow-up of 36 months. The authors defined higher flexibility and better immediate correction as risk factors for the loss of correction.

Sanders et al.[8] reported a TL/L:T Cobb ratio >1.25; might be the best predictor with regard to the correction of the minor curve when combined with the degree of T curve, while reporting that a ratio close to 1 could lead to progression of the T curve. In our study, the TL/L:T Cobb ratio was 2.4 and favourable outcomes were obtained with a rate of 69% in the correction of minor T curve in the SF group. The lower angle in the T curve was found to be an important factor in fixing the frontal plane deformity, while a T Cobb angle greater than 60° was shown to make the spontaneous regression impossible[8]. None of the patients in this study had a T Cobb angle greater than 60°. It was reported that the TL/L Cobb angle had an important influence on the surgical success. Although structural TL/L curves with higher angles were reported to be more difficult to correct, full correction of the major TL/L Cobb was also reported to be the main factor for the spontaneous correction of a minor T curve[8]. The highest angle of TL/L Cobb was 53° in this study and we detected no significant difference with regard to the loss of correction during the follow-up; even with the high TL/L curve angles.

On the other hand, it was observed that there is only one study comparing SF and NSF in patients with Lenke type 5 AIS in the literature. Lark et al.[6] stated that the T Cobb angle improved significantly in both groups; however, the degree of improvement was significantly higher in the NSF group at the 2-year follow-up of 150 patients. Contrary to previous reports, the relatively higher correction rates obtained in the NSF group was not statistically significant in our study. The authors stated that the shortcoming of that study was a non-standardised surgical procedure (anterior or posterior) and a short follow-up period of 2 years. The mean follow-up of 42.3 months, standardised posterior approach and evaluating loss of correction can be other strengths of our study.

Study Limitations

This study was retrospective in nature and contains similar limitations like other retrospective studies. In addition, outcomes of SF and NSF were evaluated only radiologically. The

Table 3. Statistical comparison of the T Cobb correction rate in the early postoperative period and at the last follow-up

Variables		Group 1 (n=24)	Group 2 (n=35)	*p* and *z* value
Early correction rate (%)	Min-max Mean ± SD	31-100 69±25	40-100 79±21	z=0.3716 p=0.7113
Last follow-up correction rate (%)	Min-max Mean ± SD	31-100 66±24	40-100 79±21	z=59656 p=0.5485

z: Mann-Whitney U statistic, T: Thoracic, Min: Minimum, Max: Maximum, SD: Standard deviation, n: Number

Table 4. Statistical comparison of the TL/L Cobb correction rate in the early postoperative period and at the last follow-up

Variables		Group 1 (n=24)	Group 2 (n=35)	*p* and *z* value
Early correction rate (%)	Min-max Mean ± SD	50-100 78±36	38-98 80±38	z=0.1906 p=0.8493
Last follow-up correction rate (%)	Min-max Mean ± SD	50-96 76±36	63-100 79±36	z=−0.0991 p=0.9203

z: Mann-Whitney U statistic, TL/L: Thoracolumbar/Lumbar, Min: Minimum, Max: Maximum, SD: Standard deviation, n: Number

decision to perform a SF versus NSF was based on the surgeon's preference rather than randomisation. However, this potential study bias was minimised by the preoperative similarity in terms of age, gender, follow-up duration, preoperative TL/L Cobb and T Cobb of both groups being compared. The patients in this study were homogeneous and underwent posterior instrumentation and fusion performed by the same surgeon, with the same pedicle screw instrumentation system.

CONCLUSION

The findings of this study suggest that NSF is not superior to SF in the correction of coronal plane deformities in patients with Lenke type 5C AIS. Moreover, it was found that there was no loss of correction, which was obtained in T minor curves in patients who underwent SF. However, it should be noted that if SF is to be performed, the angle of the major curve together with the T minor curve, TL/L:T Cobb angle ratio, and higher flexibility would be the major determinants of radiological outcomes, predicting the prognosis.

Acknowledgements: The authors would like to thank Assoc. Prof. Kerim Sarıyılmaz, M.D. for his remarkable comments.

Ethics

Ethics Committee Approval: The study was performed by the ethical standards of the 1964 Declaration of Helsinki (Acıbadem University and Acıbadem Health Institutions Medical Research Ethics Committee permission number 2017/17-3).

Informed Consent: Oral and written informed consent was obtained to publish the data.

Authorship Contributions

Surgical and Medical Practice: Ü.D., Concept: Ü.D., G.K., Design: Ü.D., G.K., Data Collection or Processing: G.K., Analysis or Interpretation: G.K., Literature Search: G.K., Writing: G.K.

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

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

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ORIGINAL ARTICLE
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CLINICAL AND RADIOLOGICAL COMPARISON OF SPINOPELVIC FIXATION METHODS: S2-ALAR-ILIAC SCREW VERSUS CONVENTIONAL ILIAC SCREW IN LONG SEGMENT FUSION

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ABSTRACT

Objective: This study aimed to compare two different screw techniques used in spinopelvic instrumentation: the S2-alar-iliac (S2AI) method and the conventional iliac screw method, in terms of their radiographic parameters, health-related quality of life and associated complications.

Materials and Methods: A total of 56 patients aged over 60 years, who underwent spinopelvic fixation using two different screw techniques, because of degenerative spinal diseases between 2012 and 2017 were retrospectively enrolled. They were divided into two groups based on the type of screw technique used; twenty-nine patients underwent the S2AI screw method (group 1) while 27 patients underwent the iliac screw method (group 2). Preoperative and postoperative radiographic parameters [sagittal vertical axis (SVA), sacral slope (SS), pelvic tilt (PT) and lumbar lordosis (LL)] and the Oswestry Disability index (ODI) were measured and compared.

Results: Generally, all the radiographic parameters (SVA, SS, PT, LL) demonstrated a significant postoperative improvement in the whole study group; however, there were no significant differences between group 1 and group 2 (p=0.696, p=0.218, p=0.245, p=0.117). Regarding the ODI, a significant improvement was observed in all the patients in the postoperative period compared with the preoperative period, although no significant differences were detected between group 1 and group 2 (p=0.522). Overall, complications occurred in 32.1% (18/56) of patients: 24.1% (7/29) of patients in group 1 and 40.7% (11/27) of patients in group 2 (11/270), but no statistically significant difference was found.

Conclusion: This study revealed that the two screw methods being compared have yielded similar results in terms of radiographic parameters and clinical outcomes. Therefore, we recommend that surgical teams should use the screw technique they are most experienced and familiar with.

Keywords: Long-segment fusion, spinopelvic fixation, S2-alar-iliac screw

INTRODUCTION

High-grade spondylolisthesis, long-segment posterior thoracolumbar instrumentation, sacral fractures and instability after sacral tumours are indications that require the ilium to be included in the fusion procedures[1-6]. Particularly, after long-segment posterior thoracolumbar instrumentation (generally over five levels), spinopelvic fixation is performed to prevent insufficiency in the lumbosacral junction. Therefore, many publications recommend that the ilium should be included in the fusion procedure from the thoracolumbar area to the sacrum, to prevent pseudarthrosis[7-10].

Fixation of the pelvis to the spine may be performed using different techniques[11,12]. Due to their high biomechanical strengths, conventional iliac screw placement and the S2-alar-iliac (S2AI) screw technique are widely accepted in spinal surgery[6,13].

The purpose of this study was to compare two different spinopelvic fixation methods applied to patients with long-segment posterior instrumentation, in terms of radiological parameters and quality of life.

MATERIALS AND METHODS

This was a retrospective study involving patients over 60 years of age, who had undergone iliac fixation with inclusion of the ilium in the long-segment (minimum 5 levels) posterior fusion between 2012 and 2017. Informed consent was obtained from all the participants included in the study. We included patients with multilevels of degenerative lumbar disease, who had not responded to physical therapy and medical treatment in the past 6 months. However, patient who had undergone previous decompression or fusion involving the L5 or S1 vertebrae were excluded from the study. In total, 56 patients were included in this study and they were separated into two groups based

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on the screw technique used: S2AI screw group (group 1) and conventional iliac screw group (group 2). There were 29 patients in group 1 and 27 patients in group 2, and all the patients were followed-up for at least 24 months.

A diagnosis of symptomatic degenerative spinal disease was made by radiological examination (plain radiography, computed tomography and magnetic resonance imaging) and clinical neurological examination. All the patients had undergone a hemilaminectomy or a bilateral hemilaminectomy for decompression after posterior pedicle screwing. Smith-Petersen and pedicle subtraction osteotomies were frequently done, while interbody cage with otograft placement between the vertebral bodies was selectively performed in some patients. All the surgical procedures were performed by two experienced spinal surgeons.

The S2AI screws were placed at 2 mm lateral to the first dorsal sacral foramen and in line with the S1 screw, to place rods without offset connectors. S2AI screws were placed towards the major trochanter, aiming at 45° horizontally and 30° caudally. Conventional screws were applied from the posterior superior iliac spine toward the superior portion of the acetabulum, using a longer incision and more dissection, at 45° horizontally and 30° caudally. Rod placements were done with offset connectors. Screws with 8 mm diameter and 80-100 mm length were applied in all cases.

All the patients were evaluated with a full-body orthoroentgenogram preoperatively and on postoperative day one, during the first month and at all outpatient follow-up visits. Considering the long follow-up duration, the preoperative and final postoperative images were used for the measurements. The following radiographic parameters were measured: Sagittal vertical axis (SVA), lumbar lordosis (LL), sacral slope (SS) and pelvic tilt (PT). The pelvic incidence parameter was not evaluated because it was considered as a constant value.

Quality of life was evaluated preoperatively and postoperatively using the Turkish version of the Oswestry Disability index (ODI), which consists of 10 questions[14]. The first and final calculated values for each group were used to make comparisons.

Since the study group consisted of patients with degenerative spines, the left femoral neck value was used to measure the bone mineral density (BMD) and to prevent inaccurate results due to osteophytic spurs.

Complications such as screw cover loosening, S1 and iliac screw loosening, rod fracture, infection, haematoma, iliac screw malposition and sacroiliac joint pain were also assessed.

Statistical Analysis

SPSS 25.0 (IBM Corparation, Armonk, New York, United States) and PAST 3 (Hammer, Ø., Harper, D.A.T., Ryan, P. D. 2001. Palaeontological statistics) softwares were used to analyse the variables. Conformity of the univariate and multivariate data to a normal distribution were evaluated with the Levene's test and the Mardia (Dornik and Hansen omnibus) test, respectively, while variable homogeneity was evaluated with the Box's M test. An independent samples t-test with bootstrap results was used to compare the two independent groups based on the quantitative data, while the Mann-Whitney U test was used with Monte Carlo results. The Wilcoxon signed-rank test was used with Monte Carlo results to compare duplicate measurements of the dependent quantitative variants, while the general linear model repeated ANOVA was evaluated using bootstrap results to examine repeated quantitative measurements of variables according to groups. To compare categorical variables, Fisher's exact test was evaluated using exact results while testing with the Fisher-Freeman-Halton test with a Monte Carlo simulation. Quantitative variables used mean ± standard deviation and median (minimum/maximum), while categorical variables were shown as n (%). Variables were examined at 95% confidence, and $p<0.05$ was considered statistically significant.

RESULTS

A total of 56 patients participated in this study: 53 females and three males. The mean age of the study participants was 69.4±5.8 years and there was no significant difference in age between the two groups (p=0.948) (Table 1). The mean follow-up duration was 38.5 months and there was no significant difference between the two groups in terms of follow-up duration (p=0.784) (Table 1). The mean instrumentation level was 10 and the mean BMD was 2.64; no statistically significant difference was observed between the groups in terms of instrumentation level and BMD (p=0.115, p=0.324, respectively) (Table 1) (Figure 1 and 2).

Among the radiographic parameters, SVA decreased from 102 mm (50/235) to 60 (16/180) mm in group 1 and from 96 mm (30/184) to 64 mm (30/122) in group 2 (p=0.796, p=0.863). No significant difference was observed between the two groups when SVA changes were examined (p=0.696) (Table 2).

SS increased from 28° (13-41) to 33° (19-55) in group 1 and from 24° (8-50) to 33° (16-62) in group 2 (p=0.973, p=0.5). No significant difference was observed between the two groups when SS changes were examined (p=0.218).

The PT value decreased from 27.5°±8.0° to 21.0°±6.3° in group 1 and from 30.9°±6.4° to 22.7°±5.8° in group 2 (p=0.089, p=0.317). No significant difference was observed between the two groups when PT changes were compared (p=0.245).

LL values were significantly increased in both groups in the postoperative period (p<0.001, p<0.001). The LL value increased from 23° (4/46) to 40° (26/50) in group 1 and from 21° (4/52) to 33° (17/62) in group 2. There were no significant differences between the two groups with regards to LL (p=0.117) (Table 2).

A total of 113 osteotomy procedures (105 SPO+8 PSO) and 21 interbody cage with otograft placements were done in the participants of this study (Table 3).

In terms of quality of life, both groups demonstrated significant improvements in the postoperative ODI scores (p<0.001, p<0.001 respectively). There were no significant differences between the two groups in terms of changes in the postoperative ODI scores (p=0.522) (Table 2) (Figure 3 and 4).

A total of 18 complications were observed in this study (Table 1). The total complication rate was 32.1% (18/56): 24.1% (7/29) in group 1 and 40.7% (11/27) in group 2. After evaluating the complications in terms of specific causes, screw cover loosening was observed only in group 2 among two patients (7.4%) (2/27). S1 and iliac screw loosening were observed in 8.9% of patients (5/56) (Figure 5); two out of 27 patients (6.9%) in group 1 and 3 out of 27 patients (11.1%) in group 2. Rod fractures were observed in 7.1% of patients (4/56): 6.9% of patients (2/29) in group 1 and 7.4% of patients (2/27) in group 2. Superficial surgical site infection was detected only in one patient (3.7%) in group 2 within the whole study population. Postoperative haematoma was observed in three patients (5.4%) within the whole cohort. Postoperative haematoma was observed in one patient (3.4%) in group 1 and two patients (7.4%) in group 2. Only one patient (3.7%) in group 2 presented with sacroiliac joint pain in the whole study. Iliac screw malposition was observed in two out of 29 patients (6.9%) in group 2 (Figure 6). Four patients with rod fracture, five patients with sacral and iliac screw loosening and two patients with screw cover loosening underwent revision surgery. Patients with postoperative haematoma and superficial infection were re-operated for debridement and irrigation. Revision surgery was proposed to patients with sacroiliac joint pain, although they refused.

No pain related to screw prominency was reported.

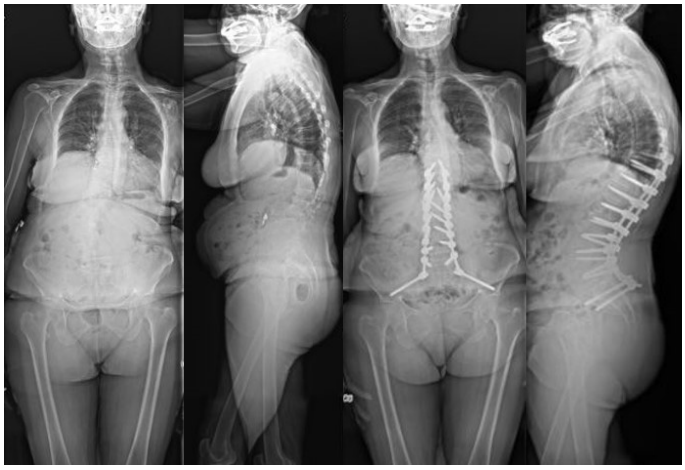

Figure 1, 2. Standing preoperative/postoperative (2 year after surgery) radiographs in the anteroposterior and lateral projections of a 71-year-old woman who underwent a posterior instrumented fusion from T10-ilium (S2AI). In the 2-year period, preoperative LL improved from 21° to 56° and SVA decreased from 45 mm to 16 mm

Table 1. Demographic data and list of complications in the study cohort

	Total (n=56) Mean ± SD (min/max)	Group 1 (S2AI) (n=29) Mean ± SD (min/max)	Group 2 (ILIAC) (n=27) Mean ± SD (min/max)	p
Age (yr)	69.4±5.8 (60/82)	69.4±6.3 (60/82)	69.3±5.3 (61/80)	0.948[1]
	n (%)	n (%)	n (%)	
Gender				
Female	53 (94.6)	29 (100.0)	24 (88.9)	0.106[2]
Male	3 (5.4)	0 (0.0)	3 (11.1)	
Complications				
Screw nut loosening	2 (3.6)	0 (0.0)	2 (7.4)	
Sacral and iliac screw loosening	5 (8.9)	2 (6.9)	3 (11.1)	
Rod fracture	4 (7.1)	2 (6.9)	2 (7.4)	
Infection	1 (1.8)	0 (0.0)	1 (3.7)	
Haematoma	3 (5.4)	1 (3.4)	2 (7.4)	0.428[3]
Sacroiliac joint pain	1 (1.8)	0 (0.0)	1 (3.7)	
Iliac screw malposition	2 (3.6)	2 (6.9)	0 (0.0)	
Total	18 (32.1)	7 (24.1)	11 (40.7)	
	Median (min/max)	Median (min/max)	Median (min/max)	
Follow-up period (month)	38.5 (24/62)	41 (24/62)	38 (24/59)	0.784[4]
Level of instrumentation	10 (6/16)	10 (7/16)	10 (6/16)	0.115[4]
BMD (femur neck)	−2.25 (−4.1/1.5)	−2.3 (−4.1/1.5)	−2.2 (−3.9/−0.2)	0.324[4]

SD: Standard deviation; min: Minimum, max: Maximum, BMD: Bone mineral density
[1]Independent sample t-test (Bootstrap); [2]Fisher's exact test (exact); [3]Fisher–Freeman–Halton test (Monte Carlo); [4]Mann-Whitney U test (Monte Carlo)

DISCUSSION

Fusion between the sacrum and the lumbar spine has been very challenging, since the time instrumentation was introduced in spinal surgery. The anatomical properties of the lumbosacral intersection and the weak and cancellous structure of the sacrum makes it difficult to achieve rigid fusion. Therefore, many surgical strategies have been developed, one of which is inclusion of the pelvis in the instrumentation and this has been commonly used in spinal surgery[12]. This new strategies are very important because historical pelvic fixation techniques did not ensure adequate fusion and pseudarthrosis was also observed at a rate of 40%[6,12]. Fusion success was achieved in 90% of cases using iliac and S2AI screws[15,16].

Iliac and S2AI screws form a significant fixation force for lumbosacral intersection. Biomechanically, McCord et al.[17] defined the pivot point located in the middle column of the sacrum in the lumbosacral area. Both iliac and S2AI screws

Table 2. Comparison of radiographic parameters and health-related quality index between the groups

	Total (n=56)	Group 1 (S2AI) (n=29)	Group 2 (Iliac) (n=27)	p value for between groups
	Median (min/max)	Median (min/max)	Median (min/max)	
ODI				
Preoperative	67 (15/98)	66 (15/98)	68 (40/86)	0.850[3]
Postoperative	39.5 (5/91)	38 (5/91)	40 (16/86)	0.923[3]
Change in ODI (postoperative-preoperative)	−24 (−69/25)	−26 (−60/25)	−18 (−69/10)	0.522[3]
p value for intra groups	**<0.001[4]**	**<0.001[4]**	**<0.001[4]**	-
SVA				
Preoperative	99.5 (30/235)	102 (50/235)	96 (30/184)	0.796[3]
Postoperative	63 (16/180)	60 (16/180)	64 (30/122)	0.863[3]
Change in SVA (postoperative-preoperative)	−41 (−175/95)	−42 (−175/58)	−36 (−126/95)	0.696[3]
p value for intra groups	**<0.001[4]**	**<0.001[4]**	**<0.001[4]**	-
Sacral slope				
Preoperative	27.5 (8/50)	28 (13/41)	24 (8/50)	0.973[3]
Postoperative	33 (16/62)	33 (19/55)	33 (16/62)	0.500[3]
Change in SS (postoperative-preoperative)	8 (−4/19)	6 (−4/19)	8 (0/19)	0.218[3]
p value for intra groups	**<0.001[4]**	**<0.001[4]**	**<0.001[4]**	-
Lumbar lordosis				
Preoperative	23 (4/52)	23 (4/46)	21 (4/52)	0.647[3]
Postoperative	38 (17/62)	40 (26/50)	33 (17/62)	0.031[3]
Change in LL (postoperative-preoperative)	15.5 (−4/29)	17 (−4/29)	8 (−4/24)	0.117[3]
P value for intra groups	**<0.001[4]**	**<0.001[4]**	**<0.001[4]**	-
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Pelvic tilt				
Preoperative	29.1±7.4	27.5±8.0	30.9±6.4	0.089[1]
Postoperative	21.8±6.0	21.0±6.3	22.7±5.8	0.317[1]
Change in PT (postoperative-preoperative)	−7.3±5.6	−6.5±6.0	-8.2±5.0	0.245[2]
P value for intra groups	**<0.001[2]**	**<0.001[2]**	**<0.001[2]**	-

SD: Standard deviation, min: Minimum, max: Maximum, ODI: Oswestry disability index, SS: Sacral slope, LL: Lumbar lordosis, PT: Pelvic tilt
[1]Independent samples t-test (Bootstrap), [2]General linear model repeated ANOVA (Wilks's Lambda, bootstrap), [3]Mann-Whitney U test (Monte Carlo), [4]Wilcoxon signed ranks test (Monte Carlo)

create a strong fixation centre in the anterior portion of the pivot point, thereby reducing the load applied on the sacral screw[13,18]. Although they are similar in terms of their fixation force, iliac and S2AI screws can be distinguished in several ways. One of the greatest disadvantages of conventional iliac screws is that they create a prominence under the skin and cause pain, especially in slim patients[11]. In addition, the entry point of the iliac screw on the posterior/superior iliac bone is far from that of the sacral screw, requiring a longer skin incision and the use of an offset connector. Kebaishi et al.[19] aimed to identify solutions to these problems when defining S2AI screws. The screw which extends to the iliac crest passing through the dorsal foramen of S1 and S2, ends within the iliac crest in parallel with the S1 screw tip, by passing through the sacroiliac joint. This anatomical superiority makes it easy to place rods and tightly fixes the sacroiliac joint[18].

Table 3. Types of osteotomies and levels

Levels	Interbody cage + otograft	SPO osteotomy	PSO osteotomy
L1-2	-	-	-
L2-3	-	9	-
L3	-	-	2
L3-4	1	17	-
L4	-	-	6
L4-5	6	35	-
L5-S1	14	44	-
Total	21	105	8

SPO: Smith-Petersen osteotomy, PSO: Pedicle substraction osteotomy

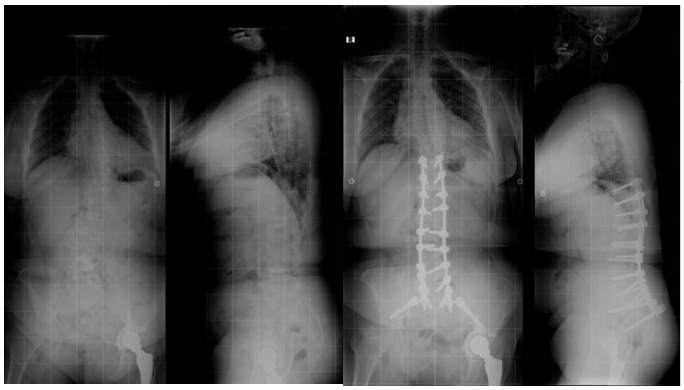

Figure 3, 4. Standing preoperative/postoperative radiographs in the anteroposterior and lateral projections of a 66-year-old woman who underwent posterior instrumentation from T10-ilium (conventional iliac screw). Please note that offset connectors were used to place the rods. LL improved from 40° to 53° and SVA remained same

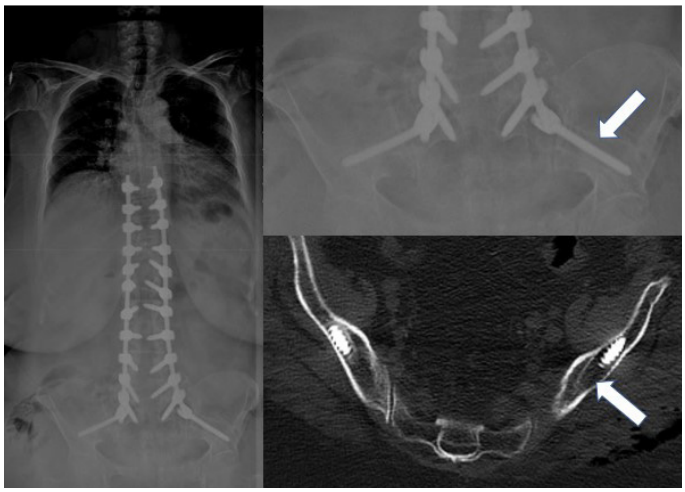

Figure 5. White arrow indicates loosening of the iliac screw

In this study, we examined the results of two different iliac screw applications in patients who had undergone sacropelvic fixation. There were no significant differences between group 1 and group 2 in terms of the radiographic parameters measured (SVA, SS, PT, LL). While recovery was observed in the sagittal alignment in both groups, no significant difference was observed between the groups in terms of SVA, PT, SS and LL. This result supports the assertion that both screws have similar effects in terms of their pelvic adhesion force[13].

In the ODI scale, we used a life-quality index, which demonstrated significant recovery in both groups in the postoperative period with respect to the preoperative assessments ($p<0.001$). No significant difference in the ODI was observed between the two groups ($p=0.522$). Although there are no studies comparing the direct effect of iliac fixation and the S2AI screw method on the quality of life, some previous studies are similar to the present study. Güler et al.[20] examined the complications of patients with adult spinal deformity and sacropelvic fixation and found a moderate recovery according to the ODI measurements in the first 6 months and during the last follow-up assessments. Another study performed three pelvic fixation procedures (Galveston technique, iliac screw and S2AI) on patients with spinopelvic deformities and found significant recovery in the Oswestry scores of the patients who underwent each of the three techniques[21] ($p<0.001$). In light of this information, the recovery observed in the ODI scores in this study is in agreement with existing literature.

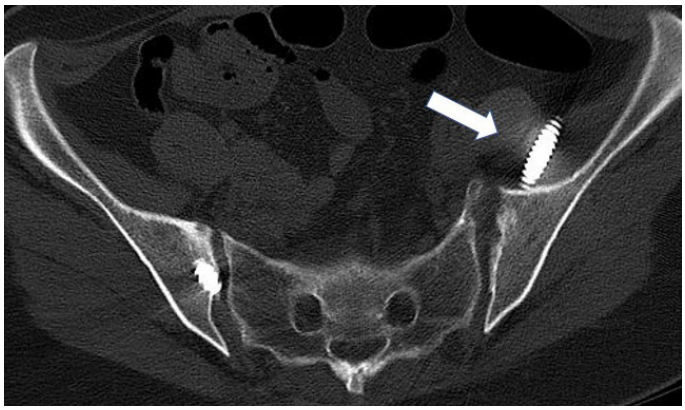

Figure 6. White arrow indicates the malposition of the iliac screw

Numerous publications evaluated the complications in patients who had undergone surgery for spinopelvic fixation. The perioperative process is time-consuming and the patients experience problems postoperatively. Conditions are hemodynamically challenging and problems occur in relation to clinical management in both the early stages and in the long-term. In the present study, we studied patients for an average of 40 months. Complications were observed in 18 (32.1%) (18/56) patients in all the groups. There were seven (7/29) (24%) of S2AI screw patients and 11 (11/27) (40%) of conventional iliac screw patients with complications. Implant-related complications, evaluated as mechanical complications (screw cover loosening and screw loosening), were more common in patients with conventional iliac screw placements. However, no statistically significant difference was found, since the sample size of the study was relatively small. The frequency of implant-related complications could be explained by the fact that may be the entry point of the iliac screw is not in parallel with the screw head placed from the S1 pedicle. We think that a non-proportional increase in the load applied on the iliac screw creates a strong pull-out effect on the implant at the distal-most portion. Nonetheless, further biomechanical studies will help confirm this assertion more accurately. In this study, only one patient belonging to the iliac screw group developed a wound infection and was treated with appropriate antibiotic therapy and debridement.

Persistent hip pain is a commonly encountered problem after sacropelvic fixation and it generally occurs due to degeneration of the sacroiliac joint or irritation of the screw head under the skin[22,23]. The mechanism responsible for the sacroiliac joint degeneration are similar to that of the adjacent segment disorder[24]. In the present study, sensitivity upon palpation of the sacroiliac joint and degeneration of the sacroiliac joint in computed tomography were detected in one patient in group 2, after prolonged persistence of his hip pain. It seems that pain occurred in the joint due to increased stress and capsular tension. In the present study, no parameters were specifically studied to identify sacroiliac pains and only one patient in group 2 experienced severe pain. In group 1, no patient went through a similar clinical process, which is likely because S2AI fixation rigidly fixates the joint[17,22].

Study Limitations

The present study has certain limitations, the most important of which is its retrospective design. The second limitation is that the quality of life measures were limited when evaluating the patient groups. Although the ODI scale was used, incorporating additional quality of life measures would ensure a more objective assessment of the study groups. However, a strength of the present study is that a long follow-up period was used to examine the cases both clinically and radiologically.

CONCLUSION

The use of multilevel fixation in degenerative spinal surgery has increased in recent years. The inclusion of pelvic fixation is one of the most controversial points. In this study, the two pelvic fixation methods provided an improvement in both radiographic and functional parameters. We believe that both techniques positively impact patient comfort in the postoperative period, especially in the geriatric population.

Ethics

Ethics Committee Approval: Retrospective study.
Informed Consent: Informed consent was obtained from all individual participants included in the study.

Authorship Contributions

Concept: A.A., S.K.O., İ.İ., V.A., Y.G., Design: A.A., S.K.O., İ.İ., V.A., Y.G., Data Collection or Processing: A.A., S.K.O., İ.İ., V.A., Y.G., Analysis or Interpretation: A.A., S.K.O., İ.İ., V.A., Y.G., Literature Search: A.A., S.K.O., İ.İ., V.A., Y.G., Writing: A.A., S.K.O., İ.İ., V.A., Y.G.
Conflict of Interest: No conflict of interest was declared by the authors.
Financial Disclosure: There was no funding source.

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RESPIRATORY FUNCTION IN ADOLESCENT GIRLS WITH MILD AND MODERATE IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: First, this study aimed to compare the respiratory function in adolescent girls with idiopathic scoliosis (AIS) who were not involved in any previous treatment and compare them with an age-matched control group in girls. Second, it investigated the relationship between respiratory function (RF) and curve magnitude and location of the curvature in patients.

Materials and Methods: Thirty-five females with AIS, aged 10 to 17 years, and thirty-five age-matched healthy females were involved in the study. RF was measured using a handheld spirometer. Measurements included the forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow (PEF), and the FEV1/FVC ratio. The AIS group was classified according to the location of the major Cobb angle (thoracic, lumbar, and thoracolumbar). Statistically, all results were compared between groups, and the RF was correlated with the major curve magnitude and the location of the curvature in patients with AIS.

Results: The mean value of the major Cobb angle in degrees was 35.2°±6.5° (minimum-maximum: 22°-48°). Ten patients had thoracic, 16 had lumbar, and nine had thoracolumbar scoliosis. When compared with the results of the RF test, females with AIS had significantly lower values in all tests ($p<0.05$). There was no relationship between RF and the degree of the major Cobb angle. There was a significant negative correlation ($p=0.033$) between thoracic scoliosis and PEF values.

Conclusion: Patients with AIS with the mild and moderate scoliosis had worse RF than healthy adolescents. Thoracic scoliosis was more negatively affected. Exercise programmes should consider strengthening respiratory muscles in patients with AIS, especially those with thoracic scoliosis.

Keywords: Adolescent idiopathic scoliosis, respiratory function, idiopathic scoliosis

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is defined as the abnormal lateral curvature of the spine more than 10° that is measured using the Cobb method from a standing posterior radiograph from an anterior radiograph of an individual who is between 10 years old and the end of maturity[1]. AIS comprises about 80% of all idiopathic scoliosis (IS), and its common prevalence ranges from approximately 2% to 4%[2,3]. The female to male ratio is 1.3:1 when the scoliosis is mild (Cobb angle 10°-20°), but the ratio increases to 5.4:1 when the Cobb angle is between 20° and 30°[4]. Spinal deformities are seen in the sagittal, frontal, and transverse planes in scoliosis because of the vertebral rotation[5]. The thoracic cage is directly affected by this three-dimensional deformity, aesthetically as well as functionally[6]. A narrower rib cage in children with AIS was documented earlier when compared with their counterparts without scoliosis[2]. It was reported that lung compliance is reduced secondary to scoliosis. So, much effort is needed to breathe at rest and/or during physical activity, especially in children with severe IS[7-9]. Although it has been well established that restrictive lung disorder is characteristic of severe scoliosis, less data is available on the respiratory function (RF) of patients with AIS with both mild and moderate Cobb angles, and conflicting results have been reported. Some authors suggest that respiratory dysfunction occurs in scoliosis cases in which the Cobb angle exceeded 50 or 65 degrees[8,10-12]. However, other researchers have confirmed respiratory disorders in mild scoliosis (Cobb angles below 30 degrees)[13,14]. It is reported that AIS with mild curves do not have significant reductions in ventilatory parameters when compared with healthy subjects.

This study was presented in the 27th National Physical Medicine and Rehabilitation Congress, on 17-21 April in 2019.

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On the other hand, the results showed a reduced exercise capacity in these patients[15].

Our first aim in this study was to investigate whether IS negatively influences ventilatory function in adolescents with mild and moderate curve when compared with healthy children. Second, we aimed to show whether there is a relationship between ventilatory function tests and curve magnitude with a different apex location. If it is possible to show the reduced RF variables, it will be advisable and essential to add exercises to individualised exercise programmes of patients to improve RF. We think that these exercises will be an essential rehabilitative factor for the quality of life in patients with AIS.

MATERIALS AND METHODS

This study is the first step of our main ongoing study named "The impact of scoliosis-specific exercises and bracing on RF in adolescents with IS". It was a prospective, non-randomised controlled study. The research protocol was approved by the scientific research ethics committee of the Haliç University (decision no: 150, date: June 28, 2017). After a detailed explanation of the study objectives and evaluation procedures, written informed parental consent was obtained from all participants.

Study Design

Between June 2017, and January 2019, 35 females with IS, aged 10 to 17, recruited from two clinics (Formed Scoliosis Centre and Special Özülkü Medical Centre) were assigned to the study group. Another 35 age-and gender-matched healthy adolescent females, who were free of scoliosis, were assigned as the control group. Age, weight, height, body mass index [weight (kg)/height^2 (m^2)], menarche status of all participants in the two groups were recorded for the demographic data. Screening via the Adams' test using a scoliometer was conducted for all participants. They were screened by two experienced physicians. A standing anteroposterior standard radiograph that was performed only for participants who were initially diagnosed as having scoliosis (depending on the forward bending test and scoliometer results)[16]. The diagnosis of AIS was confirmed based on the Cobb angle method[4]. All Cobb angles were measured digitally by the same experienced physiatrist. The subjects with scoliosis were classified into three groups for further analysis according to the location of the major Cobb degree of lateral curves; thoracic (T2-T11/12 disc), lumbar (L1/L2 disc-L4) and thoracolumbar (T12-L1)[4].

Inclusion and Exclusion Criteria

All subjects with AIS were diagnosed according to the guideline of the Scoliosis Research Society[4] and enrolled based on the following inclusion criteria: (1) age of scoliosis onset between 10-17 years, (2) Cobb angle >10° with axial rotation and (3) unknown aetiology of scoliosis.

The exclusion criteria included: Boys, adolescents who had been previously or were already being managed for scoliosis by any type of treatment, thoracic or abdominal surgery, smoking, obstructive and/or restrictive ventilatory defects, previous respiratory complaints in the last two months.

Evaluation of Respiratory Function

Respiratory function was performed using a handheld spirometer (Contec SP10W) in a sitting position. The test was explained and shown to all participants by a physical therapist and a physiatrist before the data were collected. All measurements were taken three times, and the highest values of them were recorded. The measurement was composed of volume and flow parameters. We analysed forced vital capacity (FVC), expiratory volume in the first second (FEV1), peak expiratory flow (PEF) in absolute values and the FEV1/FVC ratio in the percentage of predicted values by validated reference data[17].

Statistical Analysis

The statistical analysis was performed using the statistical package SPSS version 20. Numeric data are presented with the mean and standard deviations (SD) as mean ± SD. The Kolmogorov-Smirnov test was used to assess the normal distribution in all data. Descriptive statistics were used to represent the mean values of the evaluated variables. An independent t-test was used for comparisons between groups for normally distributed data. The Mann-Whitney U test was used for the comparison between the groups for data that were not normally distributed. Pearson's and Spearman correlation tests were used to examine the relationship of each variable with the subgroups. The level of significance was set at $p<0.05$.

RESULTS

In this study, we evaluated 35 females diagnosed with AIS (study group) and 35 healthy females as the control group to compare RF. The demographic and anthropometric characteristics of the two groups are shown in Table 1. There were no significant differences regarding age, weight, height, BMI and menarche status ($p>0.05$).

Table 1. Characteristics of the girls in AIS group and control group

	AIS group (n=35)		Control group (n=35)		p
	Mean	SD	Mean	SD	
Age (yr)	12.9	1.89	13.02	1.5	0.595
Height (cm)	157.3	9.2	161.1	7.5	0.069
Weight (kg)	49.05	11.83	49.41	6.93	0.404
BMI (kg/m^2)	19.6	3.6	19.01	2.20	0.981
Menarch status (yr)	12.4	1.15	12.09	0.9	0.125

AIS: Adolescent idiopathic scoliosis, BMI: Body mass index, SD: Standard deviation
Mann-Whitney U test, Significance was set to $p<0.05$

In the AIS group, the mean value of the major Cobb angle in degrees was 35.2°±6.5° [maximum-minimum (max-min); 48°-22°]. When we classified the curves according to the location of the major Cobb angle, we have determined that 10 patients had thoracic scoliosis, 16 had lumbar scoliosis. Nine had thoracolumbar scoliosis (Table 2). The mean values of Cobb angle in degrees of these subgroups were thoracic 31.2°±8.64°, lumbar 34°±7.64° and thoracolumbar 33.1°±5.48°.

The results of RF tests in the two groups were compared. The AIS group had significantly lower values than the control group in FEV1, FVC and PEF values (p<0.05). The mean values were; FEV1 (2.20±0.52 vs 2.47±0.35), FVC (2.34±0.38 vs 2.61±0.43) and PEF (4.48±0.81 vs 5.41±0.97) in the AIS group and control group, respectively. The mean values of the FEV1/FVC ratio were lower in the AIS group than the control group (91.2% vs 94%), but it was not statistically different (p>0.05) (Table 3).

The correlation between the location and magnitude of curves with RF test parameters is shown in Table 4. Correlation analysis indicated that there was no significant relationship between the patients' major Cobb angle with any RF test (p>0.05). There was a statistically significant relationship between thoracic scoliosis and PEF values (r=−418, p=0.033) (Figure 1). No significant relationship was found between the location of the curve with FVC values, and FEV1 and FEV1/FVC ratio values (p>0.05) (Table 4).

Table 2. Size and types of curves in AIS group

	n	Mean	SD	Range
Thoracic	10	31.2°	8.6	10-45°
Lumbar	16	34.0°	7.6	20-48°
Thoracolumbar	9	33.1°	5.4	24-42°
Major Cobb angle	35	35.2°	6.5	22-48°

AIS: Adolescent idiopathic scoliosis, SD: Standard deviation

DISCUSSION

Although the deteriorating effect of severe scoliosis (more than 65°) on RF is well known, little is understood about the impact of mild and moderate scoliosis (less than 50°) because of conflicting results[2,18,19]. AIS is generally seen in apparently healthy children, and the absence of other underlying disorders; mild to moderate scoliosis does not produce significant respiratory signs and symptoms[2,5]. However, ventilatory abnormalities, which are secondary to structural rib cage deformation, can probably be seen in these patients. The main purpose of the present study was to determine whether mild to moderate IS affects the RF in adolescents at rest compared with healthy adolescents and then to analyse its relationship with

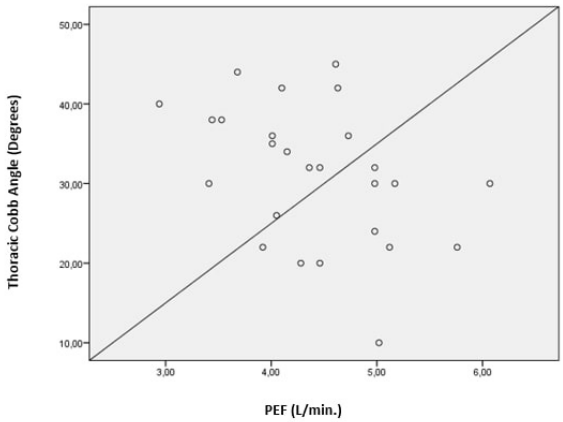

Figure 1. Correlation of Thoracic Cobb angle with PEF values
PEF: Peak expiratory flow

Table 3. Respiratory function test results in AIS and healthy girls

	AIS group (n=35)		Control group (n=35)		p
	Mean	SD	Mean	SD	
FEV1 (L)	2.20	0.52	2.47	0.35	*0.002
FVC (L)	2.34	0.38	2.61	0.43	*0.009
PEF (L/min)	4.48	0.81	5.41	0.97	*0.000
FEV1/FVC (%)	91.2	0.16	94	0.56	0.115

AIS: Adolescent idiopathic scoliosis, FEV1: Forced expiratory volume in 1 second, FVC: Forced vital capacity; PEF: Peak expiratory flow, SD: Standard deviation, Mann-Whitney U test, *Significance was set to p<0.05

Table 4. Correlation between respiratory function tests and curve size and types

	FEV1	FVC	PEF	FEV1/FVC %
Thoracic curve	0.364	0.180	*0.033	0.872
Lumbar curve	0.059	0.344	0.225	0.382
Thoracolumbar curve	0.863	0.951	0.699	0.871
Major Cobb angle	0.199	0.305	0.328	0.557

AIS: Adolescent idiopathic scoliosis, FEV1: Forced expiratory volume in 1 second; FVC: Forced vital capacity; PEF: Peak expiratory flow, Spearman correlation test, *Significance was set to p<0.05

curve features. Using traditional pulmonary function testing is a reliable and valid method to measure lung function in normal and pathological adolescents[6]. Lung volume is assessed with the value of FVC and is decreased in restrictive respiratory diseases. At the same time, the flow function is evaluated with FEV1 and PEF, which are reduced in an obstructive pattern. The FEV1/FVC ratio is measured for the identification of obstructive or restrictive ventilator defects[17].

The present study revealed that the FVC, FEV1 and PEF were significantly lower in patients with AIS than in patients in the control group consistent with previous studies[5,20]. It was reported that patients with mild AIS were vulnerable to mild ventilatory and functional impairment[5]. However, Barrios et al.[15] did not show any significant differences between mild and moderate scoliotic and healthy females in basal ventilatory parameters such as FVC and FEV1.

Another ongoing ambiguity is the correlation between the Cobb angle degree and RF in mild and moderate scoliosis[18,19]. In our AIS group, the mean value of the major Cobb angle was 35.2°±6.5° (max/min; 48°-22°). When we correlated RF tests with all patients' major Cobb angle, no significant relationship between them could be found and, therefore, was consistent with the previous study[5]. Johari et al.[21] evaluated 38 preoperative patients with AIS and demonstrated that an inverse relationship between Cobb angle and FVC as well as FEV1; however, it was not statistically significant. In addition, they found a significant negative correlation between the thoracic curve and FVC. Vitale et al.[22] found that the thoracic curve degree was negatively correlated with FEV1 and FVC. It was emphasised that spinal curvature in a more cranial location had a potentially greater negative impact on the pulmonary function of patients[2]. In this study, after classifying the AIS group to the location of the major Cobb angle as thoracic (n=10), lumbar (n=16) and thoracolumbar (n=9), a significant correlation existed between only thoracic scoliosis and PEF values. However, there was no significant correlation between the FEV1, FVC, FEV1/FVC ratio values and thoracic scoliosis. These results can be associated with a relatively small study sample size and a considerable amount of lumbar scoliosis. While both FEV1 and PEF are accepted as spirometric measures that provide information about the level of airflow obstruction, the PEF primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the patient[23]. We think that our result associated with the PEF was probably due because of the strength of expiratory muscles rather than the obstruction of airways in patients. It is known that expiratory flow rates decrease in proportion to the restricted lung volume, although the mean FEV1/FVC ratio is normal[2]. In our study, although it was not significantly different, the FEV1/FVC ratio in the AIS group (91.2±0.16%) was lower than in the control group (94±0.56%), and both were in the normal predicted range. The factors that affect the pulmonary function in children with AIS are hypothesised in different ways. A deformed thoracic cage increases the stiffness of the chest wall, reduces the force of the respiratory muscles and causes mechanical dysfunction of the diaphragm[21,24]. Also, respiratory muscle weakness is a potent contributor to ventilatory impairment in mild, moderate and severe forms of scoliosis[25,26]. The weakness of the respiratory muscles is caused by trunk rotation and distortion of the rib cage and results in abnormal mechanics of the intercostal muscles and diaphragm[25,27,28]. Therefore, the respiratory impairment observed in patients is in a restrictive pattern. However, obstructive or mixed lung disease has been reported in patients with scoliosis but is uncommon.

Study Limitations

Our study's important limitation is lack of measurement of respiratory muscles' strength. It would be valuable if we could show the role of intercostal or diaphragm in terms of respiratory dysfunction in our patients.

CONCLUSION

Our study showed that the RF of children with AIS with a mild and moderate Cobb angle is negatively affected when compared with that of healthy controls. We think that, although a restrictive pattern usually accompanies scoliosis, the factors causing obstructive disease should be considered, especially respiratory muscle function and strength. Therefore, we recommend designing in individualised exercise programmes regarding the strengthening of respiratory muscles in children with AIS, especially those with thoracic scoliosis.

Ethics

Ethics Committee Approval: The research protocol was approved by the scientific research ethics committee of the Haliç University (decision no: 150, date: June 28, 2017).

Informed Consent: Informed consent was obtained from all patients.

Authorship Contributions

Concept: H.Y., Design: H.Y., Data Collection or Processing: A.K.Ö., B.Y., Analysis or Interpretation: A.K.Ö., B.Y., H.Y., Literature Search: A.K.Ö., H.Y., Writing: A.K.Ö.

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ORIGINAL ARTICLE
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BAKKER CLASSIFICATION IN TREATMENT OF SACRAL STRESS FRACTURES: A SINGLE CENTER EXPERIENCE

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ABSTRACT

Objective: Sacral stress fractures mostly occur in patients with a compromised bone structure. Both surgical and nonsurgical modalities are used in the treatment of these patients. However, there is not a well-established treatment guideline.

The purpose of this study was to evaluate whether the Bakker classification can be used as a guide when selecting a treatment modality for the treat sacral stress fractures.

Materials and Methods: This retrospective study assessed 19 consecutive patients who were diagnosed with a sacral stress fracture. The patients' demographics, imaging studies, treatment modalities and outcomes were extracted from their records. Imaging studies were re-evaluated according to the Bakker classification, and fractures were classified accordingly. Finally, the distribution of treatment modalities regarding fracture types was evaluated.

Results: Three patients had type A sacral stress fractures, 11 had type B sacral stress fractures. Five patients, four of whom had prior lumbosacral fusion surgery, had type C fractures. All type A cases were relieved by conservative management. Eight type B fractures were treated by percutaneous procedures. All patients with type C fractures have undergone lumbopelvic fusion. The mean follow-up period was 31.2±18.9 months, and a marked reduction in pain was found after all therapeutic approaches.

Conclusion: The management of sacral stress fractures primarily depends on the type of fracture. The authors recommend lumbopelvic fixation for fractures with prior lumbosacral instrumentation and conservative treatment for type A fractures. Though percutaneous sacroplasty is effective in type B fractures, some can be managed by conservative treatment, whereas others require percutaneous sacroiliac fusion. Further prospective studies with larger populations are needed to confirm the suggested fracture classification-based treatment algorithm.

Keywords: Sacrum, stress fracture, insufficiency fracture, treatment, Bakker classification

INTRODUCTION

As life expectancy has increased over the last decades, so has the prevalence of sacral stress fractures (SSF)[1]. SSF is mostly observed in people with underlying diseases that affect the bone structure, especially in osteoporotic individuals[2]. It is also reported in patients who underwent spinal fusion[3]. Apart from bone structure, SSF may also be related to biomechanical factors, such as hyperlordosis, impaired pelvic ring stability, repetitive microtrauma and weight gain[4,5].

SSF is both a diagnostic and a treatment challenge for the physician. Symptoms are usually non-specific and vary from low back pain and tenderness to sacral radiculopathy. A prolonged lower back pain - with or without radiation to the buttocks, hip or groin - in physically active patients without trauma history or immobile patients with a low energy trauma history requires an investigation regarding SSF[6].

The complex pathogenesis involving both bone structure and biomechanical factors make the treatment of SSF challenging. Also, the expectation of patients, patient's prior lifestyle, comorbidities, duration of pain and fracture morphology should be considered in the treatment decision. Conservative management, including immobilisation and analgesics, is generally the first choice of treatment modality[7]. For those patients in whom conservative management failed, percutaneous sacroplasty, iliosacral fixation and spinopelvic fixation are some of the available surgical modalities[8-10]. Given the high complication rates, mobilisation of patients as early as possible is advocated regardless of treatment modality[11]. However, there is no widely accepted treatment algorithm.

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Treatment is mostly up to the treating physician's preference.

To date, SSFs have been classified either in conjunction with pelvic ring fractures or separately by some authors[12-16]. However, they were based on a younger population, were not specific to SSFs and did not define fracture morphology relative to the sacral foramina, which is an important anatomical structure regarding surgical procedures. Recently, Bakker et al.[17] proposed a new classification for SSFs since they found that the existing classification systems were inadequate for use in decision making for sacroplasty.

The aim of this retrospective study was to re-evaluate our patients' data, classify the fractures according to the Bakker classification and assess treatments and their outcomes regarding fracture types.

MATERIALS AND METHODS

Data of nineteen consecutive patients who were diagnosed with SSF and treated accordingly in our institute between April 2013 and March 2018 were analysed retrospectively. All patients provided written consent to be enrolled in the study. The treatment modality was decided by the treating physician. The mean follow-up period was 31.2±18.9 months. The following data were collected from electronic patient records and the hospital-based data archiving and communication system: patients' demographics, imaging studies, treatment modality (conservative vs surgical), type of surgical procedure if surgery was performed and outcome scores. A visual analogue scale (VAS) is in routine use at our centre, and patients are assessed at each visit. The scores on the VAS are used as outcome scores. VAS scores of the study population were assessed for low back pain before the treatment and at follow-up visits. Magnetic resonance imaging (MRI) of patients were re-evaluated, and fractures were classified according to Bakker et al.'s[17] study (Table 1).

RESULTS

In the study population, the mean age was 50.9±16.7 years, and the mean body mass index was 26.2±1.3 kg/m^2. Of 19 patients, 11 were female. All patients had acute onset low back pain that radiated to the posterior thigh and worsened while standing or walking. All patients described a new onset of difficulty walking. The mean VAS score of the patient population was 76.5±11 before the treatment, 57±9, 46.5±9.6 and 27.5±6.9 in the sixth week, third month and sixth month, respectively after the beginning of treatment. This regression in VAS score was statistically significant at all intervals (p=0.001).

When fractures were classified, three of 19 patients had type A fractures, and all were relieved with conservative treatment (Figure 1a, b). Eleven patients had type B fractures (Figure 1c, d). Six of these patients required percutaneous sacroplasty, whereas three patients were managed successfully with conservative treatment. The remaining two patients required percutaneous sacroiliac fixation (Figure 1e, f). Five patients had type C fractures. Four have undergone lumbosacral instrumentation previously. All five patients were treated with lumbopelvic fusion (Figure 1g, h) The distribution of patients and treatment modalities regarding the type of fractures are summarised in Table 2.

DISCUSSION

SSF, first described by Lourie, are an important cause of low back pain[18]. They can be either "fatigue" fractures resulting from abnormal repeated stress on healthy bones or "insufficiency" fractures due to the inability of a bone with deficient elastic resistance to withstand physiologic stress[17,19]. Insufficiency fractures are mostly associated with osteopenia/osteoporosis in the elderly. Finally, it is known that short lumbosacral fusion or long-segment fusion may precede SSF, especially in older females with instrumentation[20,21]. In the present study, the patients lacked a bone mineral density test, so we were unable to subclassify the fractures. However, most of the population were older than 65 years old, and no patient had a high-energy trauma history. Thus, we think that most, if not all, fractures in the dataset can be classified as insufficiency fractures.

The presence of prolonged lower back pain, with or without radiation to the buttocks, hip or grain, or local tenderness with

Table 1. Summary of Bakker's Classification

Type	Subtype	Region	Characteristics
A	A1	Ala	Bone bruise in MRI with no cortical disruption in CT scan
	A2		Deformation of the anterior cortical bone without disruption of the cortex
	A3		Compression fractures of the anterolateral rim of ala
B	B1	Ala	Fracture is parallel to the sacroiliac joint
	B2		Fracture involves the sacroiliac joint
	B3		Fracture line involves the neural foramina
C	C1	Corpus	Fractures extend from the anterior cortical bone to the dorsal corpus
	C2		Fractures extend into the neural foramina or the spinal canal unilaterally
	C3		Horizontal fractures of the corpus with bilateral sagittal completion

MRI: Magnetic resonance imaging, CT: Computed tomography

no obvious pathology should direct the physician to a possible SSF. The MRI is the most sensitive imaging modality for the diagnosis of stress fractures[22]. However, computed tomography (CT) can demonstrate fracture morphology in more detail in the presence of cortical disruption[19].

For treatment, there is not a universally accepted guideline, and treatment is mostly decided on a case by case basis[12,13,16]. Since most SSF cases are stable fractures, conservative management has been the primary treatment modality. Bedrest, analgesics and physical therapy alone or in combination, was shown to have good functional outcomes[23].

Figure 1. Coronal T2-weighted (T2W) short tau inversion recovery (STIR) sequence demonstrating hyperintensity located within the right sacral ala **(a)**. The fracture is healed with conservative treatment **(b)**. Hyperintensity in coronal T2W STIR sequence suggestive of bilateral sacral alar fracture **(c)**. Percutaneous sacroplasty achieves functional improvement **(d)**. Bilateral alar fractures are seen as hyperintensity zones on MRI **(e)** are treated successfully by bilateral percutaneous sacroiliac fixation **(f)**. Sacral stress fracture accompanying lumbosacral instrumentation **(g)** can be treated with lumbopelvic fusion **(h)**

When conservative management fails or the immediate control of pain and rapid mobilisation is the goal, surgical procedures are considered. With sacroplasty, a significant reduction in pain and improvement in mobility can be achieved in patients with an SSF[24,25]. Another treatment method for nondisplaced SSF is the stabilisation with minimally invasive sacroiliac (SI) screws that are inserted percutaneously through the SI joint and fixed to the vertebral body of S1 or S2[26]. In all SSF cases following lumbar spinal fusion, lumbopelvic instrumentation is advised to avoid risk factors and activity modification[9].

Recently, Bakker et al.[17] proposed a classification system for sacral insufficiency fractures based on CT findings since previous classification systems do not provide sufficient insight regarding the relation of fracture lines to neural foramina, which is important during sacroplasty. The classification is summarised in Table 1. They considered sacroplasty as feasible in SSFs of types A and B. On the other hand, the C3 subgroup is unstable and may require open reduction and stabilisation. They consider the Bakker classification to be useful in differentiating fractures of less mechanical importance and assessing risk for cement leakage toward neural structures during sacroplasty.

The patients in this retrospective study were diagnosed by lumbar and pelvic MRI. Treatment did not follow a specific algorithm but was decided on a case by case basis. However, as a general approach, treatments progressed from the most conservative to the most invasive as they failed. In cases of unstable SSFs or those following lumbar spinal instrumentation, a lumbopelvic stabilisation was performed without any prior treatment. In our daily practice, regardless of treatment modality, all treated patients were mobilised rapidly without any activity modification following their respective treatments. When the fractures were re-evaluated based on Bakker's classification, we found that all patients with type A fracture were successfully treated with conservative methods. All patients showed improved VAS scores and functional improvement in the short term when compared with their pre-treatment evaluation. However, our sample size was small, and there might be patients with type A fractures who will be refractory to conservative treatments.

The majority of patients in our series (n=11) had type B fractures. Most of them were treated effectively with

Table 2. Satisfactory treatment modalities regarding fracture types

		Fracture type		
		A	B	C
Patients	Overall (F:M)	3 (2:1)	11 (5:6)	5 (4:1)
Prior lumbosacral instrumentation		-	-	4
Treatment	Conservative	3	3	-
	Percutaneous sacroplasty	-	6	-
	Percutaneous sacroiliac fixation	-	2	-
	Lumbopelvic fusion	-	-	5

F: Female, M: Male

percutaneous sacroplasty. All but three patients were relieved with conservative treatment, and two required percutaneous stabilisation of the sacroiliac joint. Further studies with larger sample sizes might reveal factors (i.e. subtype of the fracture, age, bone mineral density, and others) that are associated with satisfactory results with conservative management in this type of fracture.

In our series, five patients had type C fractures. Four patients have undergone lumbosacral instrumentation previously. All but one patient has received treatments previously without satisfactory outcomes. All patients showed functional improvement and a decrease in pain scores with sacroiliac fixation. Since there was one isolated type C fracture, we cannot generalise this treatment for type C fractures.

Study Limitations

This study is not devoid of limitations. First, this is a retrospective study, and though all consecutive patients with SSF were included, no strict diagnostic and treatment protocols were used in decision making. Second, though the authors used the insufficiency fracture classification proposed by Bakker et al.[17], there is no supporting evidence that cases in this study were insufficiency fractures. Another limitation is the small population size but considering the incidence and difficulty in the diagnosis of SSF, any report on the subject would be helpful for further studies.

CONCLUSION

Conservative management is recommended as the first line of treatment in type A fractures. Percutaneous sacroplasty and sacroiliac fixation are effective treatment methods for type B fractures. However, physicians should also consider conservative management since not all of them require invasive procedures. Our data is not sufficient to make any recommendation for type C fractures. We recommend sacroiliac fixation for SSFs with previous lumbosacral fusion surgery since most patients show no improvement with other treatments.

Ethics

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

Authorship Contributions

Concept: S.B., V.N., S.A., S.P., E.A., Design: S.B., V.N., S.A., S.P., E.A., Data Collection or Processing: V.N., S.A., Analysis or Interpretation: S.B., V.N., S.A., E.A., Literature Search: S.B., V.N., S.A., Writing: S.B., V.N., S.A.

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

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RADIOFREQUENCY ABLATION PLUS VERTEBROPLASTY IN THE TREATMENT OF SYMPTOMATIC VERTEBRAL HEMANGIOMAS WITHOUT NEUROLOGICAL DEFICIT

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ABSTRACT

Objective: The most common benign neoplasms of the spine are vertebral hemangiomas (VH). This study aims to demonstrate the safety of radiofrequency (RF) ablation plus vertebroplasty in the treatment of VHs.

Materials and Methods: The records of patients who underwent percutaneous RF ablation and vertebroplasty for the treatment of symptomatic VH between 2016 and 2018 were retrospectively reviewed and included in this study. The visual analogue scale (VAS) was used to measure the pain immediately after the procedure and in the first and sixth postoperative months.

Results: The average follow-up period was 23.6 months. The average duration of the procedure was 45.7 min. VAS score with activity was 5.29±1.2 before the operation and improved to 2.14±1.3 immediately after the operative (p=0.0309). It was 0.7±0.3 in the first month and 0.3±0.2 in the sixth month postoperatively (p=0.0010).

Conclusion: Although only 1% of all VHs become symptomatic, symptomatic VHs cause disability during daily life. RF ablation plus vertebroplasty can be used separately in the treatment of symptomatic VHs.

Keywords: Radiofrequency ablation, vertebroplasty, vertebral haemangioma

INTRODUCTION

The most common benign neoplasms of the spine are vertebral hemangiomas (VH). VHs can be defined as benign vascular lesions with an incidence of 10-12%[1-6]. In general, VHs are asymptomatic and no specific treatment is needed. Only 1% of VHs cause axial pain and rarely cause compression fractures[2,3,6-8]. If VH extends to the spinal canal or a compression fracture occurs, neurologic injury may be possible[4,9].

The treatment methods of symptomatic VHs include vertebroplasty, embolization, ablation, radiotherapy and radiosurgery[1,3,10,11]. There are several ablation methods for vertebral tumours. Radiofrequency (RF) ablation, cryoablation, laser ablation, microwave ablation and alcohol ablation are minimally invasive treatment options[11-15]. RF ablation probes are inserted via percutaneous transpedicular guides. The tip of the probe produces frictional heat by charged tissue molecules. When the local temperature rises to 60°C-100°C, protein denaturation and coagulative necrosis occur[11]. In vertebroplasty, polymethylmethacrylate (PMMA) is injected under fluoroscopic guidance to ensure support to the weak vertebral body[3,16]. In this study, we present our results of RF ablation combined with vertebroplasty in the treatment of symptomatic VHs.

MATERIALS AND METHODS

The records of patients who underwent percutaneous RF ablation and vertebroplasty for the treatment of symptomatic VHs between 2016 and 2018 were retrospectively reviewed and are included in this study. Fourteen patients were operated for a total of 16 levels of disease. All patients had axial pain resistant to conservative treatment.

Their symptomatic level was determined by a physical examination. Radiological evaluation was performed using plain X-rays, computed tomography and magnetic resonance imaging for all patients.

All procedures were performed under general anaesthesia with fluoroscopic guidance. Based on the radiological evaluation before the procedure, the easiest percutaneous transpedicular approach was determined and the guides were inserted. Biopsies

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were routinely performed for all levels. Once the exact position of the guides was verified, the thermocouple was inserted. The tip of the electrode conducts the current that oscillates in the high frequency range (average, 480 kHz). RF ablation was performed with impedance and temperature controls. The procedure was immediately stopped if the proximal temperature reached 45°C. When the tissue impedance decreased, the procedure was stopped. Under fluoroscopic control, PMMA was filled into the created cavity as much as possible. In case cement leakage was noticed, the injection was stopped (Figure 1).

The visual analogue scale (VAS) was used to assess the pain of the patients. VAS scores were obtained on the day of the treatment, immediately after the treatment and in the first and sixth postoperative months. The approach (unipedicular/bipedicular), duration of the procedure, amount of cement injected, cement leakage, complications and analgesic use were recorded.

Statistical Analysis

For statistical analyses, the Kolmogorov-Smirnov test was used to evaluate whether the distribution of continuous variables was normal. For parameters that showed normal distribution, the paired sample t-test was used. For parameters that did not show normal distribution, the Mann-Whitney U test was used. The chi-square test was used to analyse categorical variables. Statistical significance was set at $p<0.05$.

RESULTS

Fourteen patients (10 females, four males) with VHs with an average age of 48.5 years were treated using RF ablation and vertebroplasty. The average follow-up period was 23.6 months. The number of treated levels was 16, and two levels were operated by a bipedicular approach to get access to the whole lesion. Three lesions were located in the lower thoracic spine; the others were located in the lumbar spine. The average duration of the procedure was 45.7 min (40 min per level). The average amount of cement injected was 3 cc. Cement leakage to the intervertebral disc occurred for two levels. No cement leakage occurred towards the spinal canal. The biopsy samples confirmed the preoperative diagnosis as VH for all levels.

VAS score with activity was 5.29±1.2 before the operation and improved to 2.14±1.3 immediately after the operation ($p=0.0309$). It was 0.7±0.3 in the first month and 0.3±0.2 in the sixth month postoperatively ($p=0.001$). At the final follow-up, only two patients reported that they rarely needed analgesics.

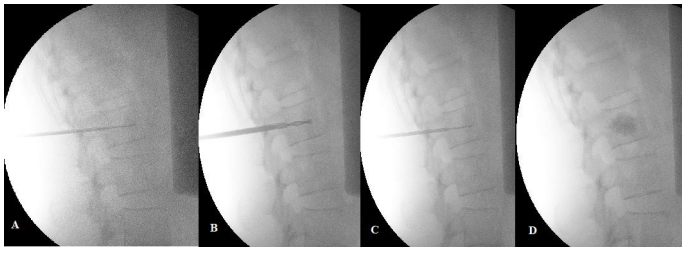

Figure 1. A) Insertion of the guidewire. **B)** Obtaining biopsy samples from the lesion. **C)** Radiofrequency probe insertion and ablation. **D)** Vertebroplasty

DISCUSSION

VHs are benign lesions that rarely become symptomatic unless they behave like an aggressive tumour and extend to the spinal canal and posterior elements of the spine. The most common symptom is axial pain[3,4,6,9]. Numerous methods are used in the treatment of symptomatic VHs. In this study, we present a combination of RF ablation and vertebroplasty for the treatment of symptomatic VHs[1,3,6,7,11].

RF ablation is one of the most effective, minimally invasive ablation techniques for the treatment of VHs. The use of RF ablation was first reported in 1990 as a treatment for hepatic tumours. This study demonstrated that RF ablation is a safe and effective treatment option for VHs. Real-time monitoring of the temperature of the spinal canal and intact cortical bone of the vertebral body provides the surgeon comfort, convenience and confidence during the operation. Moreover, RF ablation can even be used in malignancies to safely destroy the bone cortex[7,11,17-19]. No complications associated with RF ablation were observed in any of the patients in this study.

Vertebroplasty is one of the most common treatment options for symptomatic VHs[3,20]. Vertebral augmentation with PMMA is done under fluoroscopic guidance. With cement polymerisation, the exothermic reaction causes tumour necrosis. Cement itself ensures mechanical stability of the vertebral body and prevents vertebral collapse[3,16]. Cement leakage is the most common complication of vertebroplasty, and the risk is high in VHs due to anomalous intervertebral vascularisation[3]. In this study, RF ablation of the lesion destroyed the dilated vessels and created space for cement injection. The combined procedure enabled a safer treatment option. Intradiscal cement leakages occurred for two levels where the lesions were about to destruct the endplates.

Study Limitations

Alcohol ablation can be used for the treatment of VHs. The main limitation of this treatment is inadequate control of the ablation zone and diffusion of the alcohol in the tissue, which can lead to neurological complications[15,21]. The embolisation of the lesion can reduce intraoperative blood loss in aggressive VHs[22]. In this study, the lesions were limited to the vertebral body and were small in size. As a result of this, we did not need to perform embolisation of the lesions. Radiotherapy is another treatment method for VHs that can be administered in a single high dose or fractionated doses. This method offers effective pain and tumour control, but good results are dose-dependent. Moreover, pain control after radiotherapy treatment requires 3-6 months[23,24]. In this study, patients achieved pain control immediately after the procedure. VAS scores decreased more than 3 points on the first day of the treatment.

The major limitations of this study are its retrospective design and small sample size. The reason for the small sample size

is that there are payment limitations of the national social security institution. Further, our treatment method is only suitable for lesions limited to the vertebral body.

CONCLUSION

Although only 1% of all VHs become symptomatic, they can cause disability during daily life. RF ablation plus vertebroplasty can be used separately in the treatment of symptomatic VHs. In this study, we used both methods and demonstrated the safety of this combined treatment.

Ethics

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

Informed Consent: Informed consent was obtained from the patients.

Authorship Contributions

Surgical and Medical Practices: Ö.E., H.Y.T., N.S.K., A.B.B., T.E., Concept: Ö.E., H.Y.T., T.E., Design: Ö.E., N.S.K., Data Collection or Processing: H.Y.T., N.S.K., Analysis or Interpretation: Ö.E., N.S.K., A.B.B., Literature Search: Ö.E., H.Y.T., N.S.K., Writing: Ö.E., A.B.B., T.E.

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

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CLINICAL AND RADIOLOGICAL COMPARISON OF SURGICAL TREATMENT METHODS IN PATIENTS WITH CERVICAL SPINAL STENOSIS

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ABSTRACT

Objective: The comparison of patients who underwent different surgical procedures for cervical spinal stenosis in clinical and radiological terms with various factors.

Materials and Methods: Sixty-two patients (52 males, 10 females) were divided into groups as corpectomy (group 1), laminectomy (group 2) and laminoplasty (group 3). The patients were evaluated retrospectively considering their neurological examinations, Japanese Orthopaedic Association scores and radiological findings pre and postoperatively.

Results: The mean recovery rate was 63.2±3.7%. The pre-op/post-op JOA scores of the patients were found to be 15.7±1.6/16.1±1.6 in group 1, 13.9±3.4/13.3±3.42 in group 2 and, and 14.1±3.7/15.4±3.0 in group 3. In terms of JOA scores the increase of the pre-op and post-op changes only in group 3 was found to be statistically significant. Statistically significant results were obtained in group 1 in terms of post-op JOA scores of the patients under the age of 60; whose sagittal cord diameter was measured as 6 mm or less in the pre-op cervical computed tomography (CT), with lordotic alignment of the pre-op cervical axis and who did not have T2 signal intensity increase in the pre-op magnetic resonance imaging (MRI). While evaluating group 2, no statistically significant results were obtained in any of the parameters. In group 3, it was seen that the factors including male gender, age below 60 years, sagittal cord diameter being 6 mm or less in pre-op cervical CT measurement, lordotic alignment of the pre-op cervical axis and no increase in T2 signal intensity in pre-op cervical MRI were seen to be statistically significant indicators for the result.

Conclusion: Early results show that better outcomes can be obtained when anterior corpectomy and fusion and open-door laminoplasty is performed in patients with under the age of 60, have pre-op a sagittal cord diameter of 6 mm or less and lordotic alignment and no myelomalacia on MRI. It has been observed that better clinical and radiologic recovery can be expected in selected patients.

Keywords: Cervical spondylosis, corpectomy, lateral mass, laminoplasty

INTRODUCTION

Cervical spinal stenosis (CSS) is a progressive degenerative condition affecting the intervertebral discs and facet joints as a result of the degenerative process that develops congenitally or with advancing age. The spinal cord and the emerging roots are compressed, and patients develop radicular and myelopathic discomforts (pain). Radiologically, the incidence rate of cervical spondylosis is around 10% in people aged 25 years and younger, whereas it reaches 95% in people aged 65 years and older. The male to female ratio is 2.4:1[(1)]. The diagnosis is made when the diameter of the cervical cord is 6 mm or less assessed using radiological imaging methods. The treatment aims at expanding the spinal stenosis and removing the compression on the neural structures through anterior or posterior surgical approaches[(2)]. When appropriate surgical treatment is provided in a timely manner, the progression of the disease can be stopped, and the discomfort to patients can be eliminated[(2)]. Nowadays, the availability of diagnostic methods, improved living conditions, increased life expectancy, and diversified treatment options support the need for further studies about cervical spondylosis.

The aim of this study is to evaluate the clinical and radiological outcomes of patients who were treated with different surgical methods for CSS at the authors' clinic and to compare the efficacy of treatment methods with those reviewed in the literature.

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MATERIALS AND METHODS

Sixty-two patients who underwent surgical treatment for cervical spondylosis between 2006 and 2014 at the authors' clinic were evaluated retrospectively. Demographic, clinical and radiological data were obtained from the patient files. The subjects of the research were divided into the following groups depending on the method of operation: Group 1 had anterior corpectomy plus fusion with a cage/bone graft, group 2 had posterior decompression with laminectomy plus fusion with a lateral mass screw, and group 3 had open-door laminoplasty. Regardless of gender, patients were aged 40 to 80 years, were diagnosed with spondylotic CSS, were informed about the study, and agreed to participate. In addition, those who underwent surgery for two or more cervical intervertebral pathologies attended the follow-up examinations regularly and had cervical magnetic resonance imaging (MRI), cervical computed tomography (CT), and posteroanterior or lateral cervical direct digital radiography in the last six months were included. Follow-up examination appointments were scheduled to examine the patients for controlling purposes. Radiological examinations (lateral cervical direct digital radiography and non-contrast-enhanced cervical CT) were performed. Then, the patients were asked to fill in the Japanese Orthopaedic Association (JOA) Cervical Myelopathy Evaluation Questionnaire based on their conditions one week after the surgery and before the surgery for their conditions. The cervical lordosis angles were measured with the use of the Cobb method on the lateral cervical direct digital radiographs, and the preoperative and postoperative values were calculated. The sagittal cord diameter was calculated by measuring the anterior–posterior intradural distances with the use of the preoperative and postoperative sagittal plane cervical CT images. In this study, myelomalacia was described as the increase in signal intensity in the spinal cord, as seen in the T2-weighted sequence on the sagittal cervical MRI. The results were compared with the preoperative tests, and they were statistically analysed.

Statistical Analysis

The conformity of the data for the normal distribution was tested using the Kolmogorov-Smirnov normality analysis. The data that conformed to a normal distribution and met the parametric conditions were defined as X ± SD. The differences between the two groups were determined using the Student' t-test. The differences between the dependent groups were identified using the paired t-test, and the differences between more than two groups were analysed by a one-way ANOVA test. Identification of the different groups was tested using the Scheffe procedure. The distributions of the data that did not meet the parametric condition and did not conform to the normal distribution are provided as the median (min-max). In the comparison of three groups that did not conform to the normal distribution, the Kruskal-Wallis variance analysis was used. The different groups were identified using the Mann-Whitney U test corrected by Bonferroni. Any data, including frequency, was expressed as a percentage. P<0.05 was considered statistically significant. SPSS 20.0 statistical program was used for the analysis.

RESULTS

The mean age of the patients included in the study was 56.6±8.3 (43-76) years. Of 62 patients, 52 were male (83.9%) and 10 were female (16.1%). The follow-up period of the patients was 6-40 months (mean, 12.7±9.2 months). When the compression level on the spinal cord was examined, 17 patients had single, nine patients had two, 10 patients had three, 16 patients had four, and 10 patients had five levels of involvement. The most frequently involved level was at the cervical segment C3-6 level, which was found in 12 patients. The mean diameter of the cord was 9.01±1.6 mm, and the range was 6-13 mm. The cord diameter was measured as 6 mm or less in 48 (77.4%) patients and above 6 mm in 14 (22.5%) patients. During the pre-op period, the sagittal alignment was straight in three (4.8%) patients, lordotic in 34 (54.8%) patients and kyphotic in 25 (40.3%) patients. As for the post-op sagittal alignment, it was straight in nine (14.5%) patients, lordotic in 35 (56.4%) patients and kyphotic in 18 (29.0%) patients. During the pre-op period, there was no signal change in the T2-weighted sequence in 35 (56.4%) patients, whereas the signal intensity in the T2-weighted sequence increased in 27 (43.5%) patients. The preoperative and postoperative parameters of all groups are given in the following tables (Tables 1, 2 and 3).

Comparison of Gender

When the pre-op and post-op JOA scores were compared concerning sex, there was a statistically significant increase in post-op JOA in males in group 3 (p<0.05).

Comparison of Age

The increases in post-op JOA values were statistically significant in group 1 and group 3 in patients under the age of 60 years (p<0.05).

Comparison of Compression Number

A statistically significant difference was found among the groups in group 3 with four or more segments under compression regarding pre-op and post-op JOA scores. An increase was observed in post-op JOA scores except for group 2 in patients with four or more segments under compression, but this increase was not statistically significant except for group 3 in patients with four or more segments under compression.

Comparison of Cord Diameter

There was a statistical significance in the pre-op and post-op JOA scores in the groups undergoing compression in group 1 and group 3 patients whose cord diameter was 6 mm and less.

Comparison of Sagittal Alignment

The group with the lowest pre-op and post-op JOA was the kyphotic group, but this was statistically significant only in

group 3. Although there was an increase in post-op JOA scores in all three groups, this increase was statistically significant only in group 1 patients with pre-op lordotic sagittal alignment and in group 3 patients with pre-op and post-op lordotic and kyphotic sagittal alignment.

Comparison of Myelomalacia Presence in MRI

In group 1, with no signal change in the pre-op T2-weighted sequence, the JOA score increased from 16.2±1.6 to 16.8±1.3, and in group 3, the JOA score increased from 14.6±3.4 to 16.2±1.9. These results were statistically significant. Although there was an increase in post-op JOA scores in all groups in the presence of myelomalacia, these increases were not statistically significant. In addition, although there was a decrease in the post-op JOA scores in group 2, no signal change was seen in the pre-op T2-weighted sequence. This decrease in JOA scores was not statistically significant (p>0.05).

Comparison of Diabetes Mellitus

The mean pre-op JOA score of the patients with Diabetes Mellitus (DM) was 14.9±2.2 in group 1, 13.5±2.6 in group 2 and 13.8±1.9 in group 3; whereas the mean post-op JOA score was 15.3±1.9 in group 1, 13.5±3.1 in group 2 and 15.3±3.4 in group 3. The mean pre-op JOA score of the patients without DM was 16.1±1.2 in group 1, 13.8±3.7 in group 2 and 14.8±4.2 in group 3; whereas the mean post-op JOA score was 16.5±1.4 in group 1, 12.8±3.6 in group 2 and 15.7±1.5 in group 3. Although there was an increase in the post-op JOA scores in three groups in the presence of DM, this increase was not significant in any group (p>0.05). Furthermore, there was a statistically significant difference in the post-op JOA scores in the absence of DM in group 3 (p<0.05).

Comparison of the Surgical Method

No statistically significant difference was found among these three surgical methods regarding age and pre-op JOA (p>0.05),

Table 1. Table of parameters for the anterior corpectomy + cage/bone graft fusion group (group 1)

Noun	Age	Gender	Pre-op Cobb angle (0)	Post-op Cobb angle (0)	Numbeof segments decompressed	Decompression levels	Pre-op Cord diameter (mm)	Pre-op JOA score	Post-op JOA score
1	62	M	28	22	2	C5-6	3.1	16	15
2	55	M	12	22	2	C4-5	4.9	14	15
3	51	F	16	12	1	C5	5.1	14	16
4	43	F	10	30	2	C5-6	9.2	17	18
5	51	M	8	4	1	C5	4.2	15	16
6	55	M	22	8	1	C6	4.4	14	16
7	47	F	18	14	1	C5	5.2	17	18
8	65	M	10	8	1	C6	5.2	16	14
9	58	M	31	26	1	C6	4.8	12	13
10	65	M	13	14	2	C5-6	7.8	17	18
11	65	M	16	10	1	C5	7.1	17	18
12	68	M	12	10	2	C4-5	5.6	13	13
13	61	F	14	6	1	C5	5.1	16	17
14	63	M	28	12	1	C6	6.1	15	13
15	65	M	24	22	2	C5-6	4.2	15	16
16	56	M	18	10	1	C6	6.8	17	17
17	62	M	12	8	1	C6	5.6	17	17
18	75	M	8	5	1	C7	4.8	16	17
19	63	F	19	23	1	C6	5.8	16	17
20	76	M	15	28	2	C5-6	5.9	14	15
21	67	M	28	21	1	C6	6.4	17	17
22	52	M	9	4	1	C6	5.6	15	17
23	69	M	25	23	1	C5	6.7	17	17
24	54	F	4	1	1	C6	6.8	17	17

JOA: Japanese Orthopaedic Association, Pre-op: Pre-operation, Post-op: Post-operation, M: Male, F: Female, n: Number

but a statistically significant difference was found in the post-op JOA and the pre-op cord diameter ($p<0.05$) (Table 4).
When the surgical methods were compared with one another, the JOA in group 3 was statistically significant ($p<0.05$). In group 1 and group 2, a statistically significant difference was not found ($p>0.05$) (Table 5).

DISCUSSION

Cervical spondylosis is a condition that starts at the intervertebral disc and spreads to the neighbouring bones and soft tissues as it develops. The intervertebral disc space gradually becomes smaller with the natural ageing process. Diffuse bulging and overflow of the disc are the results of this process. When hypertrophy of the ligaments (the posterior longitudinal ligament and ligamentum flavum) accompanies osteophyte formation and arthritic changes in the facet and uncovertebral joints, a circular stenosis of the spinal canal ensues. The stenosis causes compression of the medulla spinalis and nerve roots and results in myelopathy.
The surgical method to be selected in these patients is still a matter of debate. Although surgery can be performed using the anterior or posterior approach, many different results have been reported in the literature regarding the success rates of surgery using the anterior and posterior approaches. The purpose of surgery is to remove the compression that causes myelopathy and to stabilise the segmental hypermobility.

It was emphasised that many factors should be taken into consideration in the selection of the most appropriate surgical approach in cervical spondylotic myelopathy (CSM)[3]. These factors include the age of the patient; lordotic, straight, or kyphotic cervical sagittal alignment; hyperintensity on MRI; the presence of more anterior or posterior compression; the number of spinal cord compression levels; and the normal range of motion and abnormal movements of the vertebra. In this study, considering the aforementioned criteria, anterior corpectomy, posterior decompression plus fusion with a lateral mass screw, and open-door laminoplasty were adapted. In a study comparing the results of the anterior and posterior approaches, Sakura et al.[4] found that both the anterior and posterior approaches resulted in similar neurological improvement. As a result of a retrospective study conducted in 629 patients with CSM, Shimomura et al. reported that no method was significantly superior to the other[5]. A recovery rate of over 80% using laminoplasty has been reported in the study by Kawai; however, in contrast, that rate in the study conducted by Morio was only 46.8%. In this study, when the difference between the JOA scores was evaluated, there was a statistically significant improvement in group 3.
A corpectomy and arthrodesis are required to be performed in multilevel disc diseases such as ossification of the posterior longitudinal ligament (OPLL) and extrusion of disc fragments behind the vertebral body[6]. In their study, Fessler et al.[7] detected some symptomatic improvement in 92% of

Table 2. Table of parameters for the posterior decompression + fusion with lateral mass screw (group 2)

Noun	Age	Gender	Pre-op Cobb angle (0)	Post-op Cobb angle (0)	Number of segments decompressed	Decompression levels	Pre-op Cord diameter (mm)	Pre-op JOA score	Post-op JOA score
25	67	M	32	8	5	C3-7	4.2	16	17
26	47	M	34	27	-	C4-7	5.6	11	10
27	49	M	17	28	3	C3-5	7.1	10	9
28	66	M	35	18	4	C3-6	5.4	16	16
29	50	M	32	38	5	C3-7	5.6	15	10
30	74	M	0	15	5	C3-7	4.5	17	13
31	56	M	36	7	4	C4-7	6.8	13	12
32	58	F	40	21	3	C3-5	5.8	17	17
33	54	M	20	25	5	C3-7	5.7	17	9
34	69	M	32	23	4	C3-6	4.2	16	16
35	58	M	24	10	5	C3-7	7.2	14	1
36	54	F	16	11	5	C3-7	6.8	16	17
37	56	M	26	20	4	C3-6	5.1	17	17
38	71	M	19	11	3	C3-5	4.3	5	7
39	52	M	4	6	5	C3-7	5.4	13	15
40	65	M	32	3	5	C3-7	4.4	10	12

JOA: Japanese Orthopaedic Association, Pre-op: Pre-operation, Post-op: Post-operation, M: Male, F: Female, n: Number

the cases and an increase in the Nurick scale score to 86% (mean: 1.24). During the mean of 49 months of the follow-up period, 37 patients, Yamazaki et al.[8] reported improvements in neurological functions and improvements in the gait in 29 of 37 patients with OPLL who underwent corpectomy. In this study, the results are similar to those in the literature.

The development of kyphosis in the long-term postoperative period is one of the most common problems after laminectomy. The most used method to prevent post-laminectomy kyphosis is the lateral mass screwing method developed by Roy-Camille et al.[9]. Although the lateral mass screwing method is very practical, it may cause neck and shoulder pain in patients during the postoperative period because they create especially on the muscle adhesion tips and facet capsules. In their series of 13 cases who underwent posterior spinal instrumentation and were followed-up for a mean period of 25 months, Heller

Table 3. Table of parameters for the open-door laminoplasty (group 3)

Noun	Age	Gender	Pre-op Cobb angle (0)	Post-op Cobb angle (0)	Number of segments decompressed	Decompression levels	Pre-op Cord diameter (mm)	Pre-op JOA score	Post-op JOA score
41	64	M	39	18	3	C4-6	2.2	14	16
42	68	M	28	38	2	C5-6	5.5	11	12
43	66	M	22	13	4	C3-6	3.3	15	15
44	51	M	17	17	5	C3-7	3.7	13	14
45	55	M	33	33	4	C4-7	3.4	12	14
46	64	M	25	0	4	C3-6	4.8	16	16
47	63	F	33	30	4	C3-6	5.1	17	17
48	72	M	35	32	4	C4-7	2.8	18	18
49	47	M	5	2	4	C3-6	4.1	18	18
50	55	M	7	4	3	C4-6	5.8	17	18
51	67	M	34	24	3	C4-6	6.1	7	17
52	43	M	19	13	4	C3-6	4.7	16	17
53	45	M	23	15	3	C5-7	5.2	17	18
54	57	M	25	17	3	C3-5	3.9	15	17
54	51	M	31	26	4	C3-6	6.7	13	15
56	67	M	10	4	4	C3-6	5.8	17	17
57	44	M	18	16	2	C4-5	4.1	17	17
58	76	M	14	5	3	C3-5	4.4	14	15
59	69	M	16	11	4	C3-6	3.9	16	16
60	71	M	25	10	3	C3-5	4.4	5	7
61	77	M	26	30	4	C3-6	3.4	7	8
62	57	F	34	30	4	C4-7	5.1	15	16

JOA: Japanese Orthopaedic Association, Pre-op: Pre-operation, Post-op: Post-operation, M: Male, F: Female, n: Number

Table 4. Comparison of surgical methods in terms of pre-op prognostic factors (age, pre-op and post-op JOA, pre-op cord AP diameter)

	Group 1 (n=24)	Group 2 (n=16)	Group 3 (n=22)	p
Age	60.3±8.3	59.1±8.4	60.4±10.5	0.896
Pre-op JOA	15.7±1.6	13.9±3.4	14.1±3.7	0.250
Post-op JOA	16.1±1.6	13.3±3.4	15.4±3.0	0.020*
Pre-op cord diameter	5.7±1.3	5.5±1.0	4.4±1.2	0.001*

JOA: Japanese Orthopaedic Association, Pre-op: Pre-operation, Post-op: Post-operation, AP: Antroposterior, n: Number

Table 5. Comparison of surgical methods to one another basing on the pre-op and post-op JOA and the improvement ratios

	n	Pre-op JOA	Post-op JOA	p
Group 1	24	15.7±1.6	16.1±1.6	0.092
Group 2	16	13.9±3.4	13.3±3.4	0.720
Group 3	22	14.1±3.7	15.4±3.0	0.001*

JOA: Japanese Orthopaedic Association, Pre-op: Pre-operation, Post-op: Post-operation, AP: anteroposterior, n: Number

et al.[10] reported improvement in the Nurick classification in seven cases, no changes in four cases, and deterioration in two cases. In this study, the kyphosis angles remained the same at the preoperative and postoperative periods (mean: 5°), and the lordosis loss could not be associated with the clinic or fusion. Although there was an increase in the postoperative JOA scores as compared with the preoperative JOA scores in cases treated with laminectomy, there was no statistical significance.

Degenerative changes in the spine become more apparent during the third and fifth decades of life. In different studies, patients were divided into different age groups in order to examine the age factor. In this study, the age of 60 years was accepted as the reference age when functional degenerative changes increase. Naderi et al.[11] found in their study that, as in many other studies, in general, age did not have an impact on the patients' postoperative neurological status, but the improvement in neurological status of the patients older than 61 years was statistically lower than those who were younger. In compliance with this finding, in this study, the postoperative neurological improvement rate of patients over 60 years old was less, which was significant. In this study, a significant difference was found between the preoperative and postoperative JOA scores of the patients over the age of 60 years in group 1 and group 3. This may result from other poor prognostic factors associated with increasing degenerative changes as age advances and low surgery tolerance of elderly patients. This finding also shows the insufficiency in the recovery of the nervous system in elderly patients.

In many studies, it is reported that the preoperative JOA scores were higher and improvement in these scores postoperatively was higher in the cases with multilevel spinal cord compression than those with single-level spinal cord compression. In this study, preoperative cervical MRI showed a statistically significant improvement in the postoperative JOA scores in patients with spinal cord compression with four levels or more in group 3.

The severity of myelopathy is known to be proportional to the anterior-posterior diameter of the spinal cord. In the studies conducted, it was reported that spinal cord diameters of 6 mm and less are significant regarding spinal cord compression, and 6 mm was accepted as a reference in this study[12]. In their study, Yamazaki et al.[8] reported that identifying the spinal cord diameter was found to be effective in predicting the prognosis of young age patients, but it was not that effective for all age groups. In this study, in the patients with spinal cord diameters of 6 mm or less measured using the preoperative cervical CT in group 1 and group 3, statistically significant differences were recorded between the preoperative and postoperative JOA scores.

Flattening of the natural lordotic curve of the spine as a result of cervical instability, "S"-shaped deformity, and kyphosis are among the long-term complications of laminectomy. In the study conducted by Naderi et al.[11]; the patients were divided into two groups: normal and abnormal sagittal alignment groups. It was concluded that there was a significant postoperative neurological improvement in patients with normal sagittal alignment, while the neurological improvement in patients with abnormal sagittal alignment was not significant. In this study, the improvement in the postoperative JOA scores was statistically significant in group 1 where the sagittal alignment was lordotic. In group 3 involving the patients with lordotic and kyphotic sagittal alignments, the increase in the postoperative JOA scores was statistically significant. Lee et al.[13] reported weak preoperative and postoperative neurological conditions of the patients with CSM, who have abnormal sagittal alignments. Similarly, in this study, the mean preoperative and postoperative JOA scores of kyphotic patients were lower than those of the patients with straight and lordotic sagittal alignments. In general terms, in order to prevent postoperative kyphosis in patients operated with all the three surgical methods, being lordotic preoperatively is important.

In the compressed spine, demyelination in the lateral columns, degeneration in the posterior columns, oedema, cell loss, necrosis development, and high signal intensity in the T2-weighted sequences on MRI are expressed to be caused by myelomalacia, and for the low signal intensity in T1-weighted sequence and high signal intensity in the T2-weighted sequence on MRI, cystic necrosis or secondary syringomyelia is in question. Many authors said that high signal intensity in the T2-weighted sequences on MRI correlates with neurological status[14], whereas some authors did not express a clear correlation. Morio et al.[15] reported that the high signal intensity in the T2-weighted sequences on MRI of the spinal cord in patients with CSM may reflect the pathological changes but cannot be used to predict the prognosis[16]. They also found out that patients with improved signal intensity in the T2-weighted sequence postoperatively recovered better. In contrast to this, in their study, Sorar et al.[17] examined the prognostic factors in patients with CSM they operated using the anterior approach. They concluded that although the decompression of the spinal cord was insufficient and the signal intensity in the T2-weighted sequence on postoperative MRI was lower compared with the

preoperative signal intensity, the patients benefited from the anterior approach surgery and better recovery rates can be secondary to the amount of postoperative fusion development. In this study, the postoperative improvement in patients with normal signal intensity in the T2-weighted sequence on MRI in group 1 and group 3 was statistically significant compared to the postoperative improvement in those with high signal intensity in the T2-weighted sequence on MRI, which adheres to the literature. In the patients with increased signal intensity in the T2-weighted sequence on MRI, the mean preoperative and postoperative JOA scores were lower. However, this was found to be statistically significant only in group 3. In addition to this, the neurological improvement in the patients with increased signal intensity in the T2-weighted sequence on MRI during the preoperative period that decreased during the postoperative period was found to be better compared with those with a continued postoperative signal intensity increase, and that was statistically significant. This result is consistent with the literature and suggests that patients with improved signal intensity are compatible with reversible histological changes. Less improvement in signal intensity during the postoperative period results in permanent damage to the patients. However, as in other poor prognostic factors, there was a neurological improvement after the operation in the patients with increased signal intensity in the T2-weighted sequence on MRI in the preoperative and postoperative periods, although it was not statistically significant. Improvement in JOA scores is statistically significant only in the group without myelomalacia. DM is frequently seen in the general population at a rate of 2.5% in developing countries and 5-10% in developed countries. The neurological changes that develop with DM cause axon damage in the spinal cord. In this study, 17 (27.4%) patients had DM, and the preoperative JOA scores of these patients were lower in all groups, which is consistent with the literature. Although there was an increase in the postoperative JOA scores in all three groups in the presence of DM, this increase was not significant. Moreover, in group 3, there was a statistically significant difference between the postoperative JOA scores in the absence of DM.

When we look at the literature, the likelihood of complications related to graft and/or instrument systems during corpectomy with three or more levels for decompression increases 2.5 times compared with single level corpectomy[18]. Biomechanical studies show that the following corpectomy with three levels or more, the graft and instrument systems get weaker[19]. Especially during flexion, the load on the plate and graft is reduced, and this reduces the likelihood of fusion development[20]. In the literature, anterior plate placement after graft placement is recommended as it increases the fusion rate, prevents deformity development or corrects the existing deformity, prevents the formation of a barrier in front of the graft, and prevents the graft from displacing forward. It also shares the load on the graft, preventing its collapse over the adjacent vertebra[20]. In this study, in the direction of this information, corpectomy with three or more levels was not considered as a surgical option and was not performed. Anterior plating was performed after cage/bone grafting in all the cases in this study, and plaque corpectomy cages were used in three of the patients. In only one patient, due to the posterior displacement of the fibula graft, early revision was performed during the postoperative period. In one of the patients, one of the plaque screws was identified to have loosened and then was removed one year after the operation, and, therefore, screw revision was performed.

The most common neurological complication after anterior surgical interventions is vocal cord paralysis[21]. It develops due to recurrent compression of the laryngeal nerve during surgical retraction and exploration or as a result of the occurrence of local ischemia resulting from the increased cuff pressure in the endotracheal tube. In the literature, the incidence of recurrent surgery-related laryngeal nerve damage ranges from 0.07% to 11%[22]. Approximately 80% of patients with laryngeal nerve damage recover spontaneously within 3-4 weeks postoperatively[23]. It is important to lower the cuff of the endotracheal tube after placing the retractors and then inflate it to avoid this complication. In this study, hoarseness developed in one of the patients during the early postoperative period and spontaneously improved in the second postoperative week. In addition, Horner syndrome may develop at a rate of 0.1-1.1% in the superior ganglion cervical or the lesions of the postsynaptic fibres arising from these in the anterior approach[24]. During physical assessment, miosis, ptosis, enophthalmos, anhidrosis on the face, and facial flashing are seen. In this study, one patient developed Horner syndrome, and the symptoms regressed significantly after three weeks.

In addition to these, in three of the patients who underwent anterior approach surgery, corpectomy was found to be insufficient in the policlinic follow-up and repeated examinations. This insufficiency was a result of the persistence and progression of the complications, and revision surgery was performed to complement the corpectomies at the same level. In the patients who underwent revision surgeries, the study parameters were evaluated after the first surgery.

In the patients with CSM, 0-12.9% developed C5 radiculopathy after laminectomy, 2.5-14.9% after laminoplasty, and 2.8-13.6% after anterior approach corpectomy[21]. The reason for the involvement of the C5 root is often because it has a short course and is very sensitive to traction injury after acute decompression. It has been indicated that the incidence rate of this complication is decreasing, which is thought to develop after the displacement of the spinal cord following decompression and keeping the corpectomy width small at the C4–C5 levels[25]. In this study, no patient developed postoperative radiculopathy.

Study Limitations

The limitations of this study include that it is a retrospective instead of being a randomised controlled study, its relatively short follow-up periods, and its low number of patients.

CONCLUSION

Early results show that better outcomes can be achieved when anterior approach corpectomy and fusion or open-door laminoplasty is performed in patients who are under the age of 60 years, have preoperative sagittal spinal cord diameters of 6 mm or less, have lordotic sagittal alignments, and have no myelomalacia on MRI. It has been observed that better clinical and radiological recovery can be expected in these patients.

Ethics

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

Authorship Contributions

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

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

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ORIGINAL ARTICLE
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RISK FACTORS FOR EARLY RECURRENT LUMBAR DISC HERNIATION: EVALUATION OF 1453 PATIENTS

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ABSTRACT

Objective: Early recurrence of lumbar disc herniation (eRLDH) is a common complication of lumbar disc herniation (LDH) surgery. The aim of this study was to determine the risk factors for eRLDH.

Materials and Methods: Data from 1453 patients who underwent surgery for LDH at our clinic between April 2012 and April 2019 were extracted from the hospital records. Eighty-eight patients underwent repeat surgery due to eRLDH in the postoperative period (between 2 and 12 months). In total, 101 patients who underwent surgery for LDH, but who did not present with eRLDH, were randomly allocated to the control group. The demographic characteristics, types of surgery and magnetic resonance images of the patients were examined.

Results: The mean age of the 189 patients was 46.5±11.4 years. Age, gender, occupation and body mass index were not risk factors for eRLDH. However, patients with eRLDH were shorter in height. Smoking status of the patients with LDH was a risk factor for eRLDH. No relationship was found between disc level and eRLDH. eRLDH was less common in patients who underwent aggressive discectomy. In addition, the location of the herniated disc in the axial plane, its migration in the vertical plane and its relationship with the posterior longitudinal ligament were not risk factors for eRLDH. The disc height in the operated level was lower in the eRLDH group.

Conclusion: Being short in height, smoking, limited discectomy and low disc height are risk factors for eRLDH.

Keywords: Early recurrence lumbar disc herniation, recurrent lumbar disc herniation, lumbar disc herniation, LDH

INTRODUCTION

A common complication of lumbar disc herniation (LDH) surgery is recurrence of the LDH. The rate of recurrence of LDH is between 5% and 15%[1,2]. In patients with LDH recurrence, a repeat surgery is more difficult due to the presence of epidural fibrosis and scar tissue[3]. In addition, functional impairment and increase in treatment costs pose an important problem. Some risk factors for recurrent LDH have been reported, such as limited discectomy and heavy workload[2,4,5]; however, the risk factors for early recurrence of lumbar disc herniation (eRLDH) have not been studied previously.

In the present study, we aimed to determine the risk factors for eRLDH in patients who underwent repeat surgery for LDH in the early postoperative period.

MATERIALS AND METHODS

This retrospective study was approved by the local ethics committee of our hospital (date: 15.02.2019, number: 2019.02.2.02.010.r018).

Data from 1453 patients who underwent surgery for LDH at our clinic between April 2012 and April 2019 was used for this study. These patients underwent single-level microdiscectomy using the unilateral fenestration technique. Ninety-six patients underwent repeat surgery for eRLDH in the postoperative period (2-12 months). Four patients whose records were incomplete and for whom magnetic resonance imaging (MRI) data was not available and four patients who reported that their pain did not subside in the postoperative period, were not included in the study. In addition, patients with a previous history of spinal surgery, bilateral or multilevel LDH, lumbar spinal stenosis, spondylolysis, tumour, trauma, infection, congenital or acquired deformity and instability and patients with eRLDH within 2 months after the first surgery were excluded from the study.

The study group consisted of 88 patients who underwent a repeat surgery for eRLDH. A total of 101 patients who underwent surgery for LDH, but who did not develop eRLDH were randomly allocated to the control group. The patients in the control group were contacted by phone to confirm that they had not undergone surgery for eRLDH and that there were no complaints associated with the disease in the first year after surgery. From the patients' hospital records, age, gender, weight (kg), height (cm), occupation, smoking status, recurrence time (days), the level and side of LDH and the type of surgery (limited

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or radical discectomy) were examined by the same spinal surgeon.

In addition, for the eRLDH and control groups, MRI data from each patient before the first surgery was examined. Specifically, the height of the herniated intervertebral disc (IDH; mm), horizontal placement of the disc (central/paramedian/foraminal/far/lateral), migration of the disc in the vertical plane (up/middle/down) and the relationship of the disc to the posterior longitudinal ligament (subligamentous/sequestrated) were examined. IDH was calculated as the mean of the herniated disc heights in the sagittal plane of the anterior portion, posterior portion and midpoint.

Statistical Analysis

Statistical analysis was performed using the Number Cruncher Statistical System 2007 software (Utah, USA) package programme with the help of a statistician. Using descriptive statistical methods (mean, standard deviation) and the Shapiro-Wilk normality test, the distribution of variables was examined. An independent t-test was used to compare binary groups with a normal distribution. A p value <0.05 was considered statistically significant.

RESULTS

The mean age of the patients (n=189) was 46.5±11.4 years (range: 20-70 years). Age was not found to be a risk factor for eRLDH. The median recurrence time after the first surgery was 167 days (range, 60-362 days). A total of 97 patients were male (51.3%) and 92 were female (48.7%). Body mass index (BMI) was greater in the group with eRLDH, although there was no statistically significant difference (p=0.295). A statistically significant difference was observed between the mean height of the patients in the two groups; patients in the eRLDH group were shorter (p=0.003). Heavy workload (occupation) was not shown to be a risk factor for eRLDH in patients with LDH (p=0.508), while smoking status in patients with LDH was a risk factor for eRLDH (p=0.001). The demographic data of the eRLDH and control groups is shown in Table 1.

Although eRLDH was more commonly observed at the level of L3-4, there was no relationship between disc level and eRLDH (p=0.457). Overall, there was one case of eRLDH at the level of L1-2, 2 cases at the level of L2-3, 11 cases at the level of L3-4, 44 cases at the level of L4-5 and 30 cases at the level of L5–S1 (Figure 1). There was no relationship between eRLDH and left or right sided LDH surgery (p=0.54). The development of eRLDH was not significantly affected by the location of the herniated disc in the axial plane. There was no relationship between eRLDH and migration of the herniated disc in the vertical plane. Whether the herniated disc was sequestered or subligamentous was also not associated with eRLDH (p=0.058). The mean IDH was lower in the eRLDH group (p=0.02). When correlation analysis was performed, IDH was found to be a risk factor independent of height. In addition, the recurrence rate was significantly lower in patients who underwent aggressive discectomy (p=0.015). MRI data from both groups is shown in Table 2.

Table 1. Demographic data of patients

	eRLDH (+) (n=88)	eRLDH (-) (n=101)	p
Age	47.59±11.3	45.67±11.4	0.250 0.699
⩽35 yrs	13 (14.8%)	15 (14.8%)	-
36-55 yrs	56 (63.6%)	69 (68.3%)	-
>55 yrs	19 (21.6%)	17 (16.9%)	-
Gender			
Male	43 (48.8%)	54 (53.4%)	0.528
Female	45 (51.2%)	47 (46.6%)	
Height (cm)	166.6±7.1	170.2±9.1	**0.003**
Weight (kg)	80.1±13	81.8±8.8	0.297
BMI	29±5.5	28.3±3.4	0.295
Occupation			
Light	57 (64.7%)	70 (69.3%)	0.508
Heavy	31 (35.3%)	31 (30.7%)	
Smoking			
Yes	58 (65.9%)	42 (41.5%)	**0.001**
No	30 (34.1%)	59 (58.5%)	

n: Number, eRLDH: Early recurrence of lumbar disc herniation, BMI: Body mass index

Table 2. Comparison of lumbar disc herniation MRI findings in groups

	eRLDH (+) (n=88)	eRLDH (-) (n=101)	p
Side			
Right	44 (50%)	55 (54.5%)	0.54
Left	44 (50%)	46 (45.5%)	
Axial Placement			
Far lateral	2 (2.3%)	2 (1.9%)	
Foraminal	17 (19.3%)	24 (23.8%)	0.679
Paramedian	52 (59.1%)	51 (50.5%)	
Central	17 (19.3%)	24 (23.8%)	
Vertical Migration			
Downward	38 (43.2%)	53 (52.5%)	
Disc Level	32 (36.3%)	25 (24.8%)	0.216
Upward	18 (20.5%)	23 (22.7%)	
Relationship with PLL			
Sequestered	29 (32.9%)	47 (46.6%)	0.058
Subligamentous	59 (67.1%)	54 (53.4%)	
IDH	7.6±1.5	8.3±1.6	**0.02**
Type of Discectomy			
Aggressive	29 (32.9%)	51 (50.5%)	**0.015**
Limited	59 (67.1%)	50 (49.5%)	

n: Number, eRLDH: Early recurrence of lumbar disc herniation, PLL: Posterior longitudinal ligament, IDH: Height of the herniated intervertebral disc, MRI: Magnetic resonance imaging

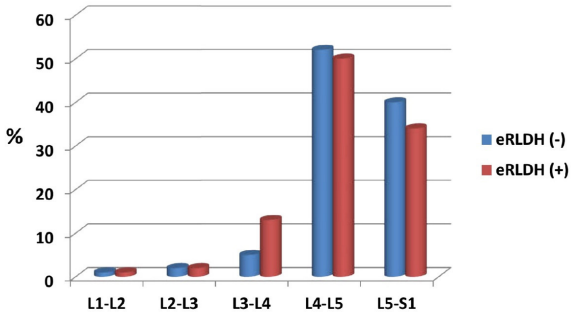

Figure 1. Percentage of patients with and without eRLDH by disc level

eRLDH: Early recurrence of lumbar disc herniation

DISCUSSION

LDH is a degenerative disease of the lumbar spine, which frequently occurs in young adults. Recurrence is a common complication of LDH. The patients are often admitted to the hospital complaining of pain and experiencing difficulties in movement[6]. Studies have shown that approximately 5-11% of patients undergo repeat surgery due to recurrence of LDH[4]. Oh et al.[7] considered recurrent LDH that occurred within 6 months as residual, while Leven et al.[1] considered recurrent LDH as residual when it was observed within 6 weeks after the first surgery. In another study, the time restriction was unnecessary and the emergence of complaints after a painless period was considered as recurrent[4]. In this study, we considered recurrent LDH occurring before 2 months as residual; thus, we did not include these cases in the study.

Yurac et al.[8] reported that patients under the age of 35 years are at risk of developing recurrent LDH; however, age was not a risk factor for eRLDH in our study. A previous study reported that the rate of recurrence of LDH is higher in males[9], while another study reported that it was higher in females[7]. However, Huang et al.[2] did not find gender to be a risk factor in their meta-analysis, which is similar to our study.

Quah et al.[10] reported that obesity is not a predictor of LDH recurrence. In addition, another study reported that BMI is not a risk factor for LDH recurrence[2]. In contrast, Meredith et al.[6] showed that obesity is an independent risk factor and reported that the risk of recurrence increases 12 times in patients with a BMI >30. In our study, although a relationship could not be established between BMI and eRLDH, patients with eRLDH were found to be shorter in height. In contrast, Shimia et al.[11] reported that LDH recurrence is more likely to occur in taller patients. In the same study, the rate of recurrence was higher in patients with LDH who were in occupations with a heavy workload. However, in agreement with our study, there are certain studies in the literature that do not support this[2].

In animal experiments, smoking has been shown to cause constriction of capillaries at the bone-disc junction and dramatically disrupts blood supply to the disc[12]. Numerous studies have revealed a relationship between recurrent LDH and smoking[4]. Our study also showed that smoking is a risk factor for eRLDH, which is in agreement with the literature. However, few studies have shown that there is no relationship between smoking and LDH recurrence[7].

It was previously reported that patients with subligamentous disc hernias are at risk of developing recurrent LDH[8]. Miwa et al.[13] studied the relationship between protruded, extruded and sequestrated disc fragments and recurrent LDH. They found that the rate of recurrence was higher in cases of extruded disc hernia. However, another study reported that the presence of a subligamentous disc in the first surgery is an important risk factor for LDH recurrence[9]. In our study, the rate of eRLDH occurrence in protruded discs was high. After examining the literature, no relationship was found between LDH recurrence and discectomy level[2]. Similarly, we did not identify a relationship between disc level and eRLDH. In addition, the side (right-left) from which the discectomy was performed was not found to be a risk factor for eRLDH.

Leven et al.[1] reported that the rate of paramedian disc hernia was 78% in patients with recurrent LDH. In our study, this rate was 59.1% and the placement of the disc in the axial plan was not shown to be a risk factor for eRLDH. This is similar to another study, which did not find this to be a risk factor for recurrent LDH[14]. In a previous study that enrolled 1020 patients, the herniated disc migrated caudally in 72.2% of patients[15]. In our study, this rate was 43.1% and there was no correlation between disc migration in the vertical plane and the development of eRLDH. Yurac et al.[8] reported that disc migration in the vertical plane is not a risk factor for recurrence, which is in support of our study.

Ledic et al.[16] reported a mean IDH of 8.3±1.8 mm. Kim et al.[17] reported that the rate of occurrence of recurrent LDH was observed to be higher in the group with a higher IDH. However, we found that eRLDH was more frequent in the group with a low IDH; therefore, low IDH was concluded to be a risk factor for eRLDH.

In the present study, the rate of eRLDH was higher in patients with limited discectomy. McGirt et al.[18] also reported that the most important cause of recurrent LDH is inadequate disk removal. Studies have shown that patients with limited discectomy reported a higher recurrence rate, but less back pain and better clinical improvement were observed in the first year[4,19].

Study Limitations

This study has the following limitations: disc degeneration of the patients was not evaluated and patients with comorbidities (Diabetes Mellitus, connective tissue diseases, etc.) were excluded from the study.

CONCLUSION

Risk factors for the development of eRLDH include being short in height, smoking, limited discectomy and low disc height. Gender, age, BMI, occupation, disc level and side, subligamentous or sequestrated discs, the location of the herniated disc in the axial plane and migration of the herniated discs in the vertical planes were not risk factors for the development of eRLDH. Accordingly, if some risk factors can be modified, the rate of eRLDH can be reduced.

Ethics

Ethics Committee Approval: This retrospective study was approved by the local ethics committee at our hospital (date: 15.02.2019, number: 2019.02.2.02.010.r018).

Informed Consent: No informed consent is required since this study is retrospective.

Authorship Contributions

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

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MANAGEMENT AND SURGICAL OUTCOMES OF ADULT SPINAL INTRADURAL LESIONS: A RETROSPECTIVE STUDY

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ABSTRACT

Objective: Spinal intradural lesions (IDLs) range from benign lesions to lethal malignant tumours. Approaches to treat the spinal lesions depend on their nature. This study aims to summarise our approach and strategies in treating IDLs by evaluating the surgical outcomes of 53 consecutively operated patients.

Materials and Methods: We retrospectively reviewed the medical records of 53 patients with spinal IDLs who underwent surgery at our institute spanning 6 years, from January 1992 to December 1997. The long-term surgical outcomes were evaluated. Based on the relevant literature, our surgical approaches and strategies were discussed.

Results: Overall, 53 cases were enrolled, 25 women and 28 men. The mean age was 52.2±18.4 years. The most common symptom was radicular pain (88.7%). Histopathologic diagnoses were meningioma (n=16), schwannoma (n=11), ependymoma (n=9), astrocytoma (n=6), lipoma (n=3) and other pathologies in eight cases. Gross-total (GTR), near-total (NTR) and subtotal (STR) resections were achieved in 34, six and 13 patients, respectively. Although 45 (84.9%) patients underwent total laminectomy, only one patient underwent fixation with posterior instrumentation after GTR 13 years later, when he presented with the progression of subtotally resected schwannoma. Intramedullary location was an independent factor to perform STR instead of GTR or NTR (p=0.032).

Conclusion: The treatment approach for IDLs depends on several factors, such as the patient's age, estimated survival, the nature of the lesion and the presenting symptoms. Based on the need for postoperative posterior fixation, we did not observed a statistical difference supporting the superiority of hemilaminectomy over total laminectomy. Nevertheless, further large, prospective studies are needed to support our findings.

Keywords: Spinal tumour, management, surgical approach, histopathological diagnosis, intradural lesion

INTRODUCTION

The spinal anatomy is a complex architecture consisting of 34 variously shaped and morphologically distinct vertebrae. This anatomy is frequently the restricting factor in performing surgical excision of neoplastic spinal lesions. Several factors have to be considered before treatment of the spinal tumours, such as the nature of the tumour, the estimated survival time, the morbidity of the lesion, the tumour's malignant potential, the location of the lesion, the comorbidities, the patient's age, symptoms of clinical presentation and overall prognosis. All these factors must be compared to the morbidity and potential mortality of radical resection of a tumour located near the neural tissues of medulla spinalis and nerve roots. Spinal tumours produce non-specific symptoms and may require to generate considerable suspicion to be investigated[1-3].

After the description of spinal tumour resection through laminectomy in 1887 by Sir Victor Horsley, the management of the spinal tumours have improved[4]. Notably, most primary spinal cord tumours are histopathologically similar to primary intracranial tumours, although spinal cord tumours are 10 times less commonly observed[2]. Because of the non-specific clinical presentation, patients may present with serious radicular or local pain and motor dysfunction[5-7]. Therefore, most patients are wrongly diagnosed with degenerative spinal disease, cervical spondylopathy or intervertebral disc herniation[3,6,7].
Presently, magnetic resonance imaging (MRI) is considered the gold standard for scanning all neoplastic lesions. MRI delineates the soft-tissue components and enables accurate diagnoses. Preliminary diagnosis obtained using MRI can help to plan the surgical intervention and reduce complications that may occur from surgery. Therefore, preoperative MRIs are essential before the surgical treatment of spinal tumours[1,6].

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Notably, the metastatic and high-grade malignant spinal lesions are associated with high morbidity and mortality. The consensus among spinal surgeons regarding the primary treatment of choice for spinal lesions is to perform gross-total resection (GTR) with preservation of neurological functions. GTR of spinal lesions provides excellent clinical outcomes in patients with moderate clinical findings[6,7]. Nevertheless, the surgical approach depends on the location, the spinal surgeon's familiarity, size and extension of the lesion. Furthermore, the use of intraoperative neurophysiological monitoring (IONM) has been noted to improve the extent of tumour resection with increased safety, particularly for intradural spinal lesions (IDLs) [1,6,7]. Nonetheless, the prognosis for patients with spinal lesions, especially IDLs, depends on the patient's age at diagnosis, neurological status at presentation, the extent of the disease and the histopathologic diagnosis, which is the major factor in deciding the treatment approach suitability[1,7]. This study aimed to summarise the treatment approaches for spinal IDLs by evaluating the long-term surgical outcomes of 53 consecutively operated patients with spinal IDL. Furthermore, the applied surgical approaches and long-term outcomes were discussed based on the relevant literature.

MATERIALS AND METHODS

Patient Data, Study Design and Study Criteria

This retrospective study was approved by the medical ethics committee of our hospital (Bakırköy Training and Research Hospital) in December 2015, bearing decision number 2015/508. All patients consented to surgical procedures. Written informed consent was obtained from all patients for publication of their cases and accompanying images.

We retrospectively reviewed the medical records of 110 patients with spinal tumours who underwent surgery at our institute spanning 6 years, from January 1992 to December 1997. Only patients who underwent spinal operation for the spinal IDLs detected on MRI were included (n=53).

The inclusion criteria were as follows: 1) patients who underwent surgical resection [GTR, near-total resection (NTR) or subtotal resection (STR)] for spinal IDLs (patients who underwent diagnostic biopsy were excluded), 2) diagnosis based on MRI findings, 3) patients with proven pathologic diagnosis of the material obtained from spinal surgery and 4) patients older than 15 years.

Exclusion criteria were as follows: 1) patients who underwent resection for recurrent lesions, 2) a history of multiple malignant lesions in all organs of the body (patients with multiple metastases), 3) patients who underwent diagnostic biopsy, 4) presence of contraindication for performing MRI and 5) patients who underwent resection of the spinal lesion determined using computerised tomography and not preoperative MRI.

GTR was defined as resection of the whole tumour mass under microscope. NTR was defined as removal of more than 95% of the tumour mass leaving the tumour pieces attached to the critical neural structure. If the resected tissue was less than 95% and more than 75% of the tumour mass, the surgical resection was defined as STR. These resections were performed under a microscope and confirmed using early postoperative MRI (in the first 24 h)[8].

The long-term surgical outcomes were evaluated. Our surgical approaches and strategies were discussed based on the relevant literature.

Surgical Procedure

Under general anaesthesia and using IONM, patients were positioned prone by using a supporting-roll on each side. A paramedian vertical midline incision was performed. After dissecting the paraspinal muscles, laminectomy or hemilaminectomy was performed. Bilateral laminotomies were performed using high-speed drills or Kerrison rongeurs. The ligamentum flavum and adipose tissue were then removed. The laminectomy or laminotomy was performed up to the tumour spanned levels. The operative microscope was brought into the operation field. The thecal sac was opened in the midline and tacked up bilaterally using strong sutures. After the dura was opened, a dorsal midline myelotomy was performed on any intramedullary lesions to reach the intramedullary region. After exposure, all nerve roots, spinal cord or terminal filum, arachnoid bands and neural tissues were distinguished from the tumoural tissue using the microscope and probe of IONM. After haemostasis using physiologic saline water and tight closure of dura by using 5.0 absorbable sutures, a duraplasty was performed using Fibrin Sealant Products (TISSEEL®; Baxter Company; USA). The operative field was kept clean, and the CSF circulation between the neural elements was preserved. All layers were closed appropriately with their anatomy[1,6,7,9].

Statistical Analysis

All data were expressed as the median or mean ± standard deviation with the range depicted in parentheses. Univariate analyses were conducted to examine the association between radiological and histopathological features. Intergroup differences between were assessed using Fisher's exact test and student's t-test with the SPSS 21.0 statistical package. Significance was determined using a p value of <0.05, and trend-level effects were defined as p=0.05-0.10. All p values were presented with an odds ratio (OR). OR were presented with the 95% confidential interval. When the OR could not be calculated, the risk ratio was calculated. All tests were two-tailed.

RESULTS

Patients' Characteristics and Surgical Treatment

Overall, 110 spinal tumours were operated at our institute during the period of the study. Of these, 57 tumours were excluded because they did not meet our study criteria. The final study sample comprised 53 patients, 25 women (47.2%) and 28 men (52.8%). The mean age was 52.2±18.4 years (21-73

years). The most common symptom was radicular pain (upper or lower extremities pain) (88.7%) (n=47), followed by motor deficit (84.9%) (n=45), loss of sensation (69.8%) (n=37), as well as lower motor neuron findings including change in reflexes (50.9%) (n=27) and sphincter dysfunctions, such as urinary or faecal incontinence or retention (37.7%) (n=20). The mean duration of preoperative symptoms was 4.2±5.9 years (0.33-15 years). Metastases (neuro-axis dissemination seeding of glioblastoma and germinoma) and high-grade glial tumours had a short preoperative course (short duration of symptoms) with an average of 8.9±3.4 months (4-16 months). On the other hand, meningiomas, schwannomas and lipomas had a relatively long preoperative course with an average of 4.6±6.9 years (0.5-15 years) (Table 1).

Table 1. Baseline demographic and clinical characteristics of investigated 53 patients with spinal intradural tumours

	Number of the patients (%) n=53
Gender	Female: 25 (47.2%)
	Male: 28 (52.8%)
Age (years)	52.2±18.4 (21-73)
Location according medullary	Extramedullary: 38 (71.7%)
	Intramedullary: 15 (28.3%)
Surgical resection	Gross total resection: 34 (64.2%)
	Near-total resection: 6 (11.3%)
	Subtotal resection: 13 (24.5%)
Clinical presentation	Radicular pain: 47 (88.7%)
	Motor deficit: 45 (84.9%)
	Loss of sensation: 37 (69.8%)
	Lower motor neuron reflex: 27 (50.9%)
	Sphincter dysfunction: 20 (37.7%)
Proven histopathlogical diagnosis	Meningioma: 16 (30.1%)
	Schwannoma: 11 (20.8%)
	Ependymoma: 9 (17.0%)
	Astrocytoma: 6 (11.3%)
	Lipoma: 3 (5.6%)
	Epidermoid Cyst: 2 (3.8%)
	Hemangioblastoma: 1 (1.9%)
	Ganglioglioma: 1 (1.9%)
	Paraganglioglioma: 1 (1.9%)
	Cavernous angioma: 1 (1.9%)
	Germinoma seeding metastasis: 1 (1.9%)
	Glioblastoma seeding metastasis: 1 (1.9%)
Preoperative course (years)	4.2±5.9 (0.33-15)

Histopathological Diagnosis and Locations of Tumours

Histopathological diagnosis was meningioma in 16 (Figure 1), schwannoma in 11 (Figure 2), ependymoma in nine (Figure 3), astrocytoma in six, lipoma in three and others in eight cases (epidermoid cyst in two, haemangioblastoma in one, ganglioglioma in one, paraganglioglioma in one, cavernous angioma in one, cervical seeding metastasis of suprasellar germinoma in one and cervical seeding metastasis of glioblastoma multiforme in one).

Overall, 53 cases were intradural lesions (38 extramedullary and 15 intramedullary). Locations of meningioma were the thoracic and cervical spines in 14 and two cases, respectively. The thoracic spine was the most affected with meningioma [p<0.001; OR=0.1 (0.01-0.3)] (Table 2). The accuracy of MRI (i.e. compatibility of MRI with histopathological diagnosis) is presented in Table 3. Hypo-, iso- and hyperintensity on T1-weighted imaging (T1WI), T2-weighted imaging (T2WI) and contrast-enhanced T1WI (C+T1WI) sequences of histopathologically confirmed and the four most misdiagnosed spinal pathologies are provided in Table 4. Even though MRI cannot diagnose all cases of these tumours, it had a high accuracy rate of up to 71.7%.

Management, Approaches and Surgical Outcomes (Table 5)

Notably, 32 of the 38 extramedullary lesions underwent GTR and NTR (28 and four, respectively) compared with eight of 15 intramedullary lesions that underwent GTR and NTR (six and

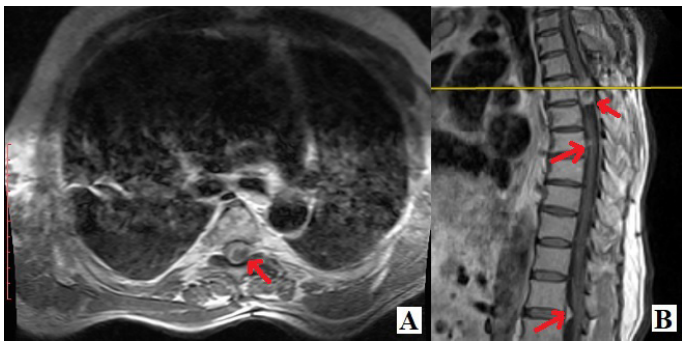

Figure 1. Lumbar and thoracic MRIs of a 66-year-old male patient who experienced back pain for 2 years. The patient has a history of T4 laminectomy 20 years ago and biopsy for suspected prostate carcinoma but the biopsy revealed no carcinoma cells. No history of neurofibromatosis type 2 was known. **A)** Axial C+T1WI sequence of thoracic MRI revealed heterogeneously enhanced intradural extramedullary hypointense lesion at the T5 level that was compressing the left side of spinal cord. **B)** Sagittal C+T1WI sequence of thoracic MRI revealed multiple involvements of intradural extramedullary lesion on the T5, and lesion at the T7 and T12-L1 levels that was suspected to be metastasis. He underwent NTR of an intradural lesion at the T5 level with a laminectomy. The lesion was confirmed to be a meningothelial meningioma WHO grade I. After physical therapy rehabilitation, the patient was doing well without recurrence. Red arrows indicate multiple lesions

MRI: Magnetic resonance imaging, NTR: Near-total resection, WHO: World Health Organisation

Table 2. Locations of investigated 53 patients with intradural tumours

Histopathological Diagnosis	Cervical	Thoracic	Lumbar
Meningioma (n=16)	2	14	-
Schwannoma (n=11)	4	3	4
Ependymoma (n=9)	4	1	4
Astrocytoma (n=6)	5*	1	-
Lipoma (n=3)	-	2	1
Epidermoid Cyst (n=2)	-	1	1
Hemangioblastoma (n=1)	1	-	-
Ganglioglioma (n=1)	1	-	-
Paraganglioglioma (n=1)	-	-	1
Cavernous angioma (n=1)	-	1	-
Germinoma seeding metastasis (n=1)	1	-	-
Glioblastoma seeding metastasis (n=1)	1	-	
Total	19	23	11

n: Number of the patients
*3 astrocytomas were span from the cervical region to thoracic but we accepted it as cervical because they largely occupied cervical more than the thoracic spine

Figure 2. A 70-year-old female patient who experienced low back and right leg pain for 5 months. C+T1WIs revealed a well-circumscribed lesion that eroded the right pedicle of the L4 vertebra and measured 27×28×16 mm, narrowed right L4 foramen and heterogeneous enhancement after contrast. She underwent an operation and neurosurgeons identified the lesion to be intradural extramedullary intraoperatively. GTR was performed. The lesion was confirmed to be a schwannoma. The patient's pain was relieved, and she was intact neurologically on her fifth-year postoperative control visit. Left side: sagittal C+T1WI; right side: axial C+T1WI
GTR: Gross-total resection, MRI: Magnetic resonance imaging, WHO: World Health Organisation

Table 3. Radiologic and histopathologic correlation in our intradural lesions

MRI diagnosis	n	Confirmed	Misdiagnosed	%	p	OR
Meningioma	17	14	Sch (2); Ep	82.4	***<0.001***	0.02 (0.003-0.15)
Schwannoma	10	8	Mening; Ep	80.0	***<0.001***	0.05 (0.01-0.22)
Ependymoma	10	5	Sch; Seeding GBM; Paragang; Astro; CA	41.7	***0.02***	0.15 (0.03-0.71)
Astrocytoma	10	5	Ep (2); Mening; Seeding Germ; Ganglioglioma	50.0	0.58	0.3 (0.003 -3.1)
Lipoma	3	3	-	100	***<0.001***	-
Epidermoid cyst	2	2	-	100	0.0014	-
Hemangioblastoma	1	1	-	100	0.067	-
Total	53	38	n=15	71.7	-	-

CV: Cavernous angioma, p: probability, OR: Odds ratio, n: number of patients, %: The accuracy percentage of MRI, Mening: Meningioma, Ep: Ependymoma, Sch: Schwannoma, Paragang: Paraganglioma, GBM: glioblastoma multiforme, Germ: Germinoma
Significant p values shown as bold and italic

Table 4. Radiologic features of histopathologically confirmed and the most misdiagnosed four spinal intradural lesions

MRI Diagnosis	Sequences	Hypointense	Isointense	Hyperintense	Contrast
Astrocytoma	T1WI	2	4	-	4
	T2WI	1	1	4	
Ependymoma	T1WI	5	3	1	9
	T2WI	1	3	5	
Meningioma	T1WI	4	11	1	16
	T2WI	1	3	12	
Schwannoma	T1WI	2	8	1	11
	T2WI	1	2	8	

two, respectively). Intramedullary location was an independent factor in deciding to perform STR instead of GTR or NTR [p=0.032; OR=0.2 (0.06-0.82)].

Overall, 45 patients underwent laminectomy, whereas eight underwent hemilaminectomy (Table 5). A male patient presented with the same initial presentation symptoms of severe back pain and upper thoracic kyphosis after 13 years. The patient experienced progression of the thoracic (T3-5) schwannoma after he underwent STR with T3-5 laminectomy. In the second operation, he underwent GTR and posterior instrumentation. A female who patient underwent NTR with a T9-11 laminectomy for extramedullary thoracic epidermoid cyst at age 19 years experienced two recurrences after 2 and 5 years.

Furthermore, five patients (9.4%) had worsened neurosurgical functions, nine (17.0%) were unchanged and 39 (73.6%) improved or fully recovered after surgical interventions. Notably, the location did not play any role in prognosis. Among the five patients who worsened after surgery, four had intramedullary and one had extramedullary lesions (p=0.08 and p=0.12, respectively). Among the 39 patients who improved or recovered, 30 had extramedullary and nine had intramedullary lesions (p=0.1 and p=0.2, respectively). Moreover, two patients with seeding metastases, two patients with astrocytoma World Health Organisation (WHO) grade III and one patient with recurrent cervical classic ependymoma WHO grade II were provided radiotherapy after STR. Except for the two patients with seeding metastasis of glioblastoma and germinoma, no patient died of the disease. Two of the five patients who experienced CSF leakage needed surgeries to treat the leakage, whereas the remaining three patients were followed up with lumbar drainages. Two patients with astrocytoma presented with symptoms of the syrinx after 14 and 18 years and were treated with T-tube and syringopleural shunt, respectively.

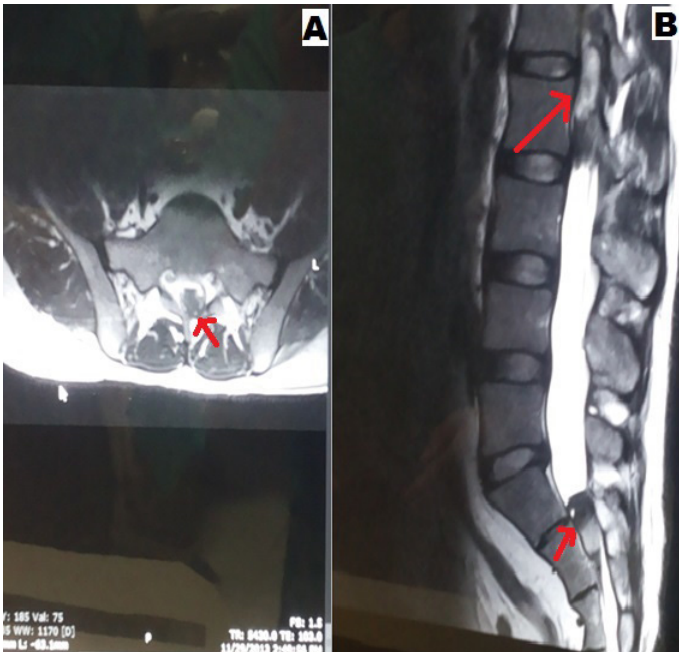

Figure 3. A 31-year-old male was referred to our emergency department with an unsteady gait, left leg numbness and weakness of seven weeks' duration. Retention of urine was developed over the past three days. Preoperative MRI demonstrated the presence of two well-circumscribed intradural extramedullary lumbar lesions at L1-2 and S2 levels. The lesions were hyperintense on T1WI and iso-hyperintense on T2WI. **A)** Axial T2WI at S1 level. **B)** Sagittal T2WI. GTR was performed for both lesions with two laminectomies. The lesions were confirmed to be WHO grade II classic ependymoma. The neurological examination did not change even after the patient underwent 30 sessions of physical therapy and rehabilitation. No recurrence or seeding was detected on his 272th control visit. Red arrows indicate the lesions

MRI: Magnetic resonance imaging, GTR: Gross-total resection, WHO: World Health Organisation

Table 5. The modalities and approaches to our studied spinal patients according to their histopathological diagnosis

Tumour	Applied modalities and approaches	n
Meningioma (16)	GTR with a laminectomy	9
	GTR with a hemilaminectomy	2
	NTR with a laminectomy	2
	NTR with hemilaminectomy	1
	STR with laminectomy	2
Schwannoma (11)	GTR with a laminectomy	8
	GTR with a hemilaminectomy	2
	STR with laminectomy (extramedullary)*	1
Ependymoma (9)	GTR with a laminectomy	3
	GTR with a hemilaminectomy	2
	NTR with a laminectomy	2
	STR with a laminectomy	2
Astrocytoma (6)	GTR with a laminectomy	1
	NTR with a laminectomy	2
	STR with a laminectomy	3
Lipoma (3)	GTR with a laminectomy	3
Epidermoid (2)	GTR with a laminectomy	1
	NTR with a laminectomy	1
HA	GTR with a laminectomy	1
Ganglioglioma	GTR with a laminectomy	1
PG	GTR with a hemilaminectomy	1
CA	GTR with a laminectomy	1
GermSM	STR with a laminectomy	1
GSM	STR with a laminectomy	1

HA: Hemangioblastoma, PG: Paraganglioglioma, CA: Cavernous angioma, GermSM, Germinoma seeding metastasis, GSM: Glioblastoma seeding metastasis, n: Number of the patients, GTR: Gross-total resection, NTR: Near-total resection, STR: Subtotal resection
*This patient presented with the same first presentation symptoms after 13 years, with severe back pain and upper thoracic kyphosis. The patient experienced the progression of thoracic (T3-5) schwannoma after underwent STR with a T3-5 laminectomy. In the second operation, he underwent GTR and PII

DISCUSSION

The management of the spinal lesions should be based on the overall health of the patient and the degree of associated blood loss. Metastatic or systemic tumour involvement in a patient could be a contraindication for radical resection of the paraspinal tumour because it may render the patient paralysed. Nevertheless, the primary purpose of spinal tumour treatment is palliative. In addition, the other objectives of treatment are restoration or preservation of neurological function, pain control or relief and the maintenance of spinal column stability to improve the patient's life quality. Corticosteroids can reportedly decrease the spinal cord oedema and have an oncolytic effect on certain neoplastic lesions. Even though corticosteroid efficacy is still debatable, some authors have suggested regarding its analgesic effect and efficacy in preventing neurological deterioration, such as paralysis or paraplegia[4,10].

A decompressive laminectomy is one of the most used approaches in the treatment of spinal tumours. Notably, a ventral burden of neoplastic lesion can destabilise the anterior column of the spine. Therefore, laminectomy without posterior instrumentation can worsen the clinical status and complaints of patients with spinal tumours[11,12]. Technical advances in spinal surgery that enable circumferential spinal cord decompression combined with posterior instrumentation have helped to design more aggressive and effective surgical interventions for patients with spinal IDLs[1,6].

The most common intradural extramedullary (IDEM) lesions were meningioma, schwannoma, ependymoma, lipoma, epidermoid cysts and paraganglioma, whereas astrocytoma was the most common intradural intramedullary (IDIM) lesion observed in our series. All intradural lesions (IDEM + IDIM) can be treated with one of the following three approaches: 1) total laminectomy, 2) hemilaminectomy and 3) laminoplasty. Regarding the resection totality, IDEM lesions can be removed using one of the following five technique: GTR, NTR, STR, partial resection, or biopsy. Nevertheless, according to our criteria, we excluded the latter two techniques and only the former three were applied to our selected patients. All our study patients underwent laminectomy or hemilaminectomy. None of our study patients underwent laminoplasty. Several recently published studies have demonstrated that laminoplasty[1,5,13] and hemilaminectomy[14] have superiority over total laminectomy concerning the prognosis and outcomes. However, this finding was not concordant with our study findings because among 45 patients who underwent total laminectomy, only one received a fixation operation after the second operation. This mismatch could have been related to the preservation of bilateral facet joints or the relatively small sample size of our patients.

Even though GTR of meningioma, schwannoma, lipoma and epidermoid cysts has been considered feasible[6], a literature review regarding the resection of IDEM lesions revealed that most IDEM lesions were resected subtotally[6,15,16]. Notably, there are several obstacles in performing GTR of all IDEM lesions, such as adhesions to the spinal cord because of haemorrhage, inflammation or subpial localisation[1,6,17]. In addition, another obstacle is the attachment of critical structures to extradural components outside the spinal canal, such as the vertebral artery in cervical tumours and the abdominal aorta in lumbar tumours. Moreover, giant-size tumours, as well as invasion of the bone and facet joints could be other surgical impediments[6]. Notably, patients with an IDL (IDEM/IDIM) require long-term observation after surgical resection to avoid serious complications of recurrence[1,6,15]. However, assessment of MRI, excellent knowledge of the anatomy of surrounding structures and selection of appropriate surgical techniques and approaches could overcome these obstacles. In the past three decades, the high rate of GTR in patients with intradural tumours can be explained based on the use of IONM during surgical interventions. The IONM guides surgeons to perform surgeries more safely and aggressively[1,6,7,15].

Postlaminectomy kyphosis is highly correlated with bilateral facetectomybecause of the increase in the degree of angulations with time[5,6]. Postlaminectomy kyphosis is typically associated with a total laminectomy of more than two levels. One of our schwannoma cases was treated with posterior instrumentation and no facets were removed, and the patient developed gradual stability. Although laminectomy is recommended to be less than 12 mm, bilateral facetectomy at one or more levels can cause acute angular kyphosis[5]. Despite the high control of tumour recurrence, unilateral facetectomy may predispose to a spinal deformity, such as angular kyphosis or scoliosis with angular kyphosis, which may both cause spinal cord compression[5,6].

Upon literature review regarding the approaches for the resection of IDL, several studies have recommended and preferred laminoplasty and hemilaminectomy rather than total laminectomy[1,6,7,15]. However, insufficient statistical evidence or first level (prospective) studies preclude affirming the efficacy of laminoplasty or hemilaminectomy. Through two different studies, Abdallah et al.[1,15] reported excellent long-term surgical outcomes of laminoplasty for ependymoma in a few children and untethering tethered cord syndrome. Another study by Kim et al.[13] revealed that laminoplasty prevented postoperative spinal deformities after the removal of spinal cord tumours in 16 cases compared with 89 cases of laminectomy. In addition, studies of Emel et al.[6] and Abdallah et al.[1,15] have evidenced the superiority of laminoplasty.

In adults, removal of the facet joints unilaterally for tumours located in the cervical or thoracic spine does not require fusion but might be necessary for those located in the lumbar spine[5,6,13,17,18]. Several approaches have been described for resection of IDEM and IDIM lesions, such as mini-open (minimal invasive) and traditional open laminectomy or laminoplasty; however, a wide laminectomy is still the standard approach used to explore extra- and intradural compartments.

Indications for radiotherapy in cases with intradural lesions include high-grade glial tumours, seeding metastasis, subtotal resection in WHO grade II lesions or highly radiosensitive neoplasms, such as metastasis of germ cell tumours and lymphoma. Posterior instrumentation is advocated in patients with significant kyphosis or with lesions at the thoracolumbar junction,as well as in patients who undergo two or more adjacent laminectomies to supplement the anterior reconstruction[5,5,9,19].

Study Limitations

Nonetheless, our study had few limitations. Our study sample included all the documented spinal lesion cases that were determined using MRI and histopathologically proven at our hospital over 6-year period. Therefore, the sample size was relatively small (n=53). Moreover, the sample does not represent a wide geographical area because all patients were from our city and surrounding area. Hence, the results represent a single institute experience and could not be generalised for other institutes. In addition, the study design was retrospective. Therefore, further prospective studies with large sample size and long follow-up periods are necessary to systematically investigate these findings.

CONCLUSION

Our treatment approaches were based on several factors, such as the patient's age, estimated survival, the nature of the lesion and the presenting symptoms. Regarding the surgical prognosis and necessity of postoperative posterior fixation, we did not find a statistical difference supporting the superiority of hemilaminectomy over total laminectomy. Nevertheless, further large, prospective studies are needed to confirm our results.

Ethics

Ethics Committee Approval: This retrospective study was approved by the medical ethics committee of Bakırköy Training and Research Hospital in December 2015, bearing decision number: 2015/508.

Informed Consent: Written informed consent was obtained from all patients for publication of their cases and accompanying images.

Authorship Contributions

Concept: M.A., A.A., Design: A.A., Ö.E.S., Data Collection or Processing: M.A., A.A., Analysis or Interpretation: A.A., M.G.P., Literature Search: A.A., M.G.P., Writing: A.A.

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

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Note: Drs. Asiltürk and Abdallah contributed equally to this work. Both of authors deserve the first name.

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SPONTANEOUS SPINAL EPIDURAL HEMATOMA FOLLOWING WARFARIN TREATMENT: CASE REPORT

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ABSTRACT

Spontaneous spinal epidural hematoma (SSEH) is a rare but clinically important disease, and delayed diagnosis may have serious consequences. When a patient presents to the emergency department with sudden, unexplained neck, back or low back pain during anticoagulant therapy, the possibility of SSEH should be considered. Magnetic resonance imaging (MRI) is important for early diagnosis of SSEH. In this article, we present a rare case of SSEH in the thoracolumbar region due to warfarin treatment in a 53-year-old woman and compare her clinical features and treatment approach with similar patients in the literature.

The patient was admitted to the emergency department with severe back pain and paraparesis. She was using warfarin as a part of anticoagulant therapy following a coronary bypass. Her blood test results showed that the international normalised ratio was 4.13. Spinal MRI revealed an SSEH extending between T11 and L1 levels and compressing the spinal cord. The hematoma was evacuated by surgery 1 day after the preoperative preparations. The patient was mobilised on the fifth postoperative day. On the 40th postoperative day, she visited the outpatient clinic with a full recovery.

In the literature, SSEH is usually presented in case reports and warfarin-induced SSEH is a very rare condition.

Keywords: Anticoagulant treatment, spontaneous spinal epidural hematoma, Warfarin

INTRODUCTION

Spontaneous spinal epidural hematoma (SSEH) is a rare condition that causes spinal cord compression. In many patients, the cause of SSEH is anticoagulant therapy. Interestingly, the anticoagulation status of most patients with SSEH is in the therapeutic international normalised ratio (INR) range. If a patient receiving anticoagulant therapy has local or reflected pain and loss of strength and sensation, SSEH should be considered. Spinal magnetic resonance imaging (MRI) is important for early diagnosis and treatment. Surgical intervention may be required in the management of SSEH. However, spontaneous recovery can also be observed in patients who are followed up conservatively[1,2].

In most patients, SSEH is located in the cervicothoracic or thoracolumbar junction. It is usually detected in the posterior or posterolateral areas of the spinal canal. The reason for the common occurrence of the hematoma in these areas may be the laxity of the epidural venous plexus. The incidence of SSEH is approximately one in one million individuals per year. It is more common in the age groups of 15-20 years and 47-75 years and occurs predominantly in men. The clinical picture is usually acute. Bladder and intestinal dysfunctions are common. The rate of spinal epidural hematomas due to anticoagulation therapy is 17% of the reported cases[3,4].

In this article, we present the case of a 53-year-old female patient with SSEH who received warfarin treatment following a coronary bypass.

CASE REPORT

A 53-year-old female patient presented to the emergency department with severe back pain and paraparesis that lasted for 24 h. She was brought to the examination room in a wheelchair. The muscle strength of both lower extremities was 1/5, and sensory loss was noted below T11. She had bladder and bowel dysfunctions. The patient had no history of trauma. She had a medical history of hepatitis C and hypertension and had previously undergone coronary bypass, for which she was

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on uncontrolled warfarin therapy. Her prothrombin time was 49.6 s (9.5-13.8), activated partial thromboplastin time was 116 s (22.7-31.8) and INR was 4.13. These values were higher than the therapeutic levels.

Her lumbar MRI revealed an SSEH, which extended along with the corpus of the T11–L1 vertebrae, mostly to the left of the spinal canal, causing 70% stenosis of the spinal canal and severely compressing it (Figure 1).

Fresh frozen plasma (FFP) and vitamin K were administered to the patient to correct the preoperative INR value. The INR value was 1.5 s 1 day after admission. The patient's general condition did not improve after one day of admission. Therefore, we decided to perform surgery.

Under general anaesthesia, the patient underwent a laminectomy along the SSEH and where the spinal cord was decompressed. Thoracolumbar instrumentation was performed following three distant laminectomies because of the risk of kyphosis development in the thoracolumbar junction in the future. On the fifth postoperative day, the muscle strength of both lower extremities was 3/5. She was mobilised with assistance. On the 40th postoperative day, she visited the outpatient clinic with a full recovery. The muscle strength of both lower extremities was 5/5. The control MRI showed relief of the spinal cord (Figure 2).

Six years postoperatively, the patient had no signs or symptoms, except for mild kyphosis.

DISCUSSION

In 1869, Jackson described the first case of a spinal epidural hematoma. Thereafter, the number of patients with SSEH who underwent surgical intervention exceeded 600. In recent years, case reports of patients with SSEH who have shown improvement with conservative treatment have also been published. With the invention of MRI, the number of cases diagnosed with SSEH increased. The internal vertebral venous plexus is the most likely source of SSEH. Most hematomas are located in the posterolateral or posterior part of the spinal canal[4].

Epidural haemorrhages can be classified as idiopathic, spontaneous and secondary. SSEH accounts for 0.3-0.9% of spinal epidural hematomas. In 2010, the case of a 42-year-old male patient with SSEH was reported. He used aspirin and warfarin for deep vein thrombosis, and his INR value was 2.2. His spinal MRI revealed an SSEH at the right posterolateral area between the T12 and L1 levels. He was started on FFP, vitamin K and dexamethasone treatment after the discontinuation of the anticoagulant therapy. The patient who presented with myeloradiculopathy showed complete neurological improvement on the sixth day and radiological improvement in the eighth week[3]. This case is interesting because the patient had a complete recovery, both neurologically and radiologically, with conservative follow-up and medical treatment.

In 2017, the case of a 76-year-old female patient with an SSEH between C2 and S5 vertebrae levels was published. The patient had a history of pulmonary embolism. She had developed acute quadriplegia and was intubated while receiving warfarin treatment. Her INR value was 14.04. After normalisation of her INR, neurological recovery began. Although no surgical treatment was performed, complete neurological and radiological improvement was seen at the 3-month follow-up[5]. The spontaneous resolution of SSEH, which extends along almost the entire spinal canal, and both neurological and radiological recovery in a short time raises the question of whether surgical treatment is actually needed.

Another 86-year-old male patient receiving warfarin treatment for chronic atrial fibrillation developed bladder dysfunction and painful paraparesis. An SSEH was detected between C7 and T6 vertebrae levels and showed improvement with conservative treatment[6]. In an article published in 2007, a 70-year-old female patient receiving warfarin treatment developed severe low back pain and paraplegia. Despite surgical treatment, her clinical

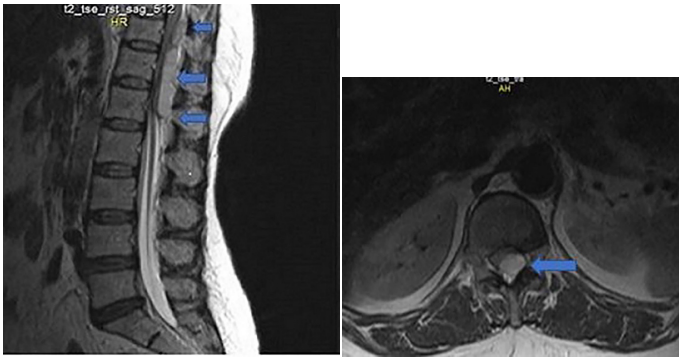

Figure 1. a) Preoperative T2 MRI sagittal section of the thoracolumbar spine shows hyperintense T11-L1 SSEH and cord compression (blue arrows); **b)** Axial view of SSEH in the thoracolumbar spine in a preoperative T2 MRI section (blue arrow)

MRI: Magnetic resonance imaging, SSEH: Spontaneous spinal epidural hematoma

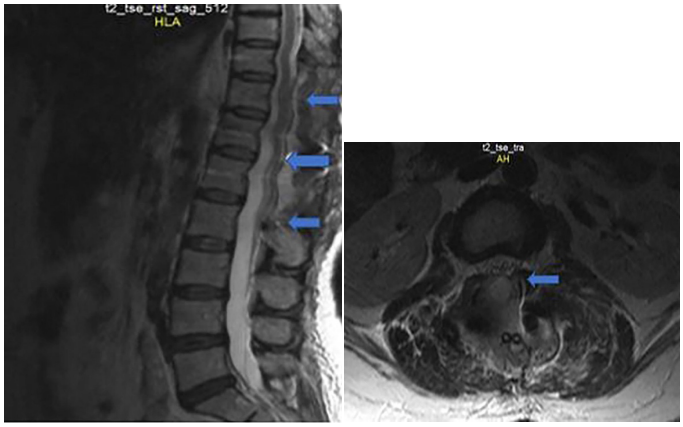

Figure 2. a) Postoperative thoracolumbar T2 MRI sagittal section showed complete evacuation of SSHE and anterior subarachnoid space of the spinal cord was enlarged (blue arrows); **b)** No SSEH is apparent in a postoperative T2 MRI axial section (blue arrow)

MRI: Magnetic resonance imaging, SSEH: Spontaneous spinal epidural haematoma

signs did not improve even after 14 months postoperatively[7]. As illustrated, there have been case reports indicating that the non-surgical approach might be more moderate because of the unsuccessful cases after surgical treatment.

Between 2009 and 2016, a case series of 10 patients with a mean age of 70 years who underwent surgery for SSEH was published. It was reported that 50% of these patients recovered postoperatively. In addition, the time delay from the onset of symptoms to surgery could not be correlated with the outcome[8]. In our case, the time between the onset of symptoms and the surgical procedure was 1 day. However, this article emphasizes that the effect of delayed time on the outcome is not significant.

In a 2004 article, a 60-year-old female patient presented to the emergency department with acute paraplegia. An SSEH extending between T1 and T12 vertebra levels was detected. This was the first report of an SSEH that had an extent spanning the entire thoracic level. The patient recovered completely, both neurologically and radiologically[9]. The authors reported that although the surgical procedure was successful, conservative follow-up may also be an option in neurologically stable cases with SSEH.

In 2018, the authors reported a tumour-like spontaneous lumbar epidural hematoma in a 50-year-old female patient receiving warfarin therapy. The patient underwent surgical treatment. Lumbar MRI performed 1 year later showed that the SSEH was completely absorbed[10]. In this case, the authors argued that surgical intervention should generally be preferred in patients with progressive spinal compression symptoms.

This issue in patients with SSEH who were receiving warfarin treatment is essentially similar to that in our patient. In our case, we achieved successful results with surgical intervention. However, there are several opinions in the literature. Although the clinical evidence is weak, some cases show complete recovery with conservative follow-up. Therefore, although it is said that SSEH treatment requires urgent surgery, a complete consensus has not been formed because of the rarity of cases.

In conclusion; surgical treatment should be given priority in patients with SSEH receiving anticoagulant therapy, such as warfarin, if progressive neurological deficit is noted. However, patients who do not have neurological deficits or those who recover neurologically while being prepped for surgery can be followed up conservatively. In both cases, vitamin K and FFP supplementation should be administered to patients with an INR value above the therapeutic levels.

Ethics

Informed Consent: Informed consent was obtained from the patient and patient's daughter.

Authorship Contributions

Surgical and Medical Practices: Ö.Ö., N.K., 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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C7-T1 DISC HERNIATION TREATED BY POSTERIOR APPROACH: CASE REPORT

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ABSTRACT

C7-T1 disc herniation is a rare condition that constitutes only 4-8% of all cervical disc herniations. Cases have been treated by anterior and posterior approaches. For the anterior approach, there are many limitations and potential complications. The operation area is close to important visceral structures. So, inadvertent traction and/or dissection can lead to several complications, including oesophageal perforations, vertebral artery injury, pneumothorax and laryngeal/tracheal injuries. The cervicothoracic junction is limited by the manubrium and clavicle bone. A manubriotomy or sternotomy may be required to widen the operation area. This procedure causes patients intense pain despite continuous medications, including narcotics. A posterior approach to C7-T1 disc herniations can be performed with a low rate of complications in appropriate cases.

Keywords: C8 radiculopathy, C7-T1 disc herniation, cervicothoracic junction, posterior approach

INTRODUCTION

Most cervical disc herniations are observed between the C3 to C7 disc spaces. C7-T1 disc herniation is a rare condition that constitutes only 4-8% of all cervical disc herniations[1,2]. A detailed neurological examination needs to be supported by magnetic resonance imaging (MRI) and electromyogram (EMG) findings for an accurate diagnosis. Cases have been treated by the anterior[3-6], and posterior approaches[7,8] and both have advantages and limitations. We aimed to demonstrate the C7-T1 disc herniation treated by the posterior approach.

CASE REPORT

A 61-year-old male patient presented to our clinic with severe pain and numbness radiating from his neck to the medial side of his right forearm and right digits 4 and 5. His neurological examination showed hypoaesthesia at both the ulnar side of his right forearm and hand without any motor deficit. His deep tendon reflexes were normal, and Spurling test was positive. His cervical MRI showed a disc herniation that narrowed the right neural foramina at the C7-T1 level (Figure 1). We performed an electrodiagnostic study and confirmed the right C8 radiculopathy. The patient, who had not any benefit from conservative treatment, underwent a "C7 hemilaminotomy with right T1 foraminotomy" for a posterior approach to the nerve root to be decompressed. Postoperatively, his radiculopathy improved, and his cervical MRI displayed nerve root decompression (Figure 2). He was discharged two days later.

DISCUSSION

C7-T1 disc herniation is a rare condition among all cervical disc herniations. Most of these disc herniations occur laterally and cause radiculopathy rather than myelopathy because of the absence of Luschka joint at this level[9]. A detailed neurological examination needs to be supported by MRI and EMG findings

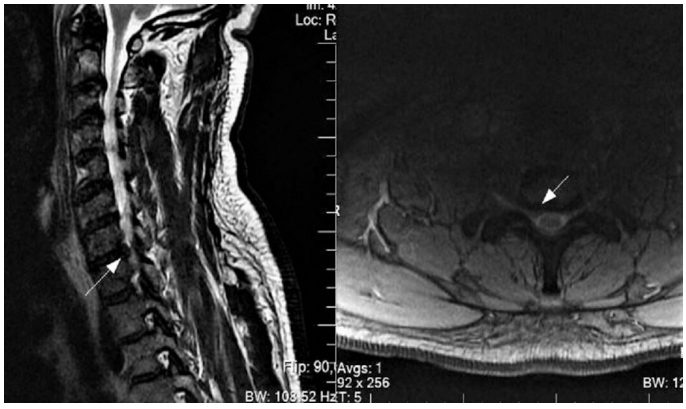

Figure 1. Preoperative cervical MRI showing a disc herniation that narrows the right neural foramina at the C7-T1 level
MRI: Magnetic resonance imaging

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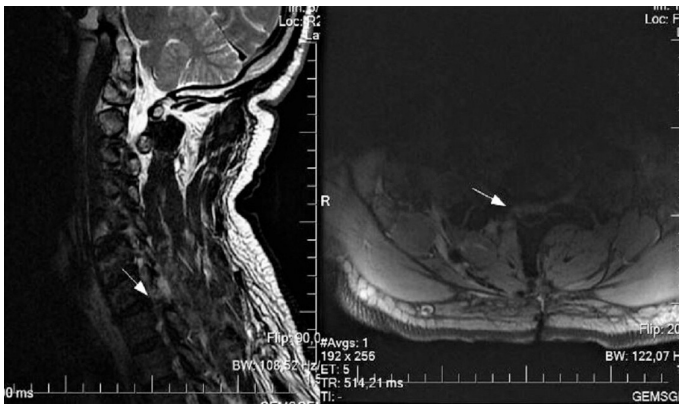

Figure 2. Postoperative cervical MRI displaying nerve root decompression

MRI: Magnetic resonance imaging

for an accurate diagnosis. Surgery can be performed by both an anterior or posterior approach; both techniques have advantages and limitations. The cervicothoracic region can be reached by the anterior approach with the classic supramanubrial Smith-Robinson technique. However, the operation area is close to important visceral structures (trachea, oesophagus, large vessels, ductus thoracicus, sympathetic ganglia) so inadvertent traction and/or dissection can lead to several complications, including oesophageal perforations, vertebral artery injury, pneumothorax, Horner syndrome, dysphagia, dysphonia, hoarseness because of laryngeal/tracheal injuries[7]. The cervicothoracic junction is limited by the manubrium and clavicle bone[3,4]. A manubriotomy or sternotomy may be required to widen the operation area. This procedure causes patients intense pain despite continuous medications, including narcotics[5]. In addition, the cervicothoracic junction is a transition zone from cervical lordosis to thoracic kyphosis, so it is difficult to obtain bone fusion[7]. Anterior fusion has been shown to reduce motion by 50% to 100%, which may improve axial neck pain. This approach, however, may result in increased stress on the adjacent vertebral segments[7,10,11]. As compared with the anterior approach, the posterior approach is a relatively safe procedure with a very low rate of complications (0-4%)[1,12-14]. Most of them are wound infections and serous drainage[13,14]. In conclusion, the posterior approach to C7-T1 disc herniations can be performed with a low rate of complications in appropriate cases.

Ethics

Informed Consent: The patient signed informed consent form.

Authorship Contributions

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

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

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

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A CASE REPORT OF CUTANEOUS MENINGIOMA: UNCOMMON TUMOUR AT THE UNCOMMON REGION

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ABSTRACT

Meningiomas are usually located in the central nervous system and arise from the membranes surrounding the brain and spinal cord. Rarely, they may also be located in the skin and in this case they are known as cutaneous meningiomas. Herein, we report a case of cutaneous meningiomas within the dermal sinus tracts, located in the midline of the lumbosacral junction, the diagnosis of which was confirmed by histopathological examination.

Keywords: Cutaneous meningioma, epidermoid tumour, dermal sinus tracts, surgery

INTRODUCTION

Meningiomas are benign and slowly growing tumours that originate from arachnoid cap cells, which are located on the outer surface of the arachnoid membrane surrounding the brain and spinal cord[1]. They are usually located in the central nervous system (CNS) and tend to occur in any region within the brain and spinal cord[2]. Rarely, they may also be located in the skin and are referred to as cutaneous meningiomas[3]. These tumours originate from ectopic meningothelial cells in the dermis and subcutaneous tissue[3,4]. In addition, they may be found in the skin of patients with neural tube closure defects associated with congenital spinal malformations.

Here, we report a case of cutaneous meningioma within the dermal sinus tracts, located in the midline of the lumbosacral junction, the diagnosis of which was confirmed by histopathological examination.

CASE REPORT

A 35-year-old man presented with a 6-month history of low back and right leg pain. During physical examination, we found dermal sinus tracts with surrounding hyperpigmentation and hypertrichosis in the midline of the lumbosacral junction. His neurological examination was normal. To determine the aetiology of the pain, radiological studies were done, which showed a lumbar spinal lesion. In addition, magnetic resonance imaging (MRI) revealed an intra-dural/intra-medullary space-occupying lesion extending from the L1–L4 vertebrae and a dermal sinus tract in the midline of the lumbosacral junction (Figure 1).

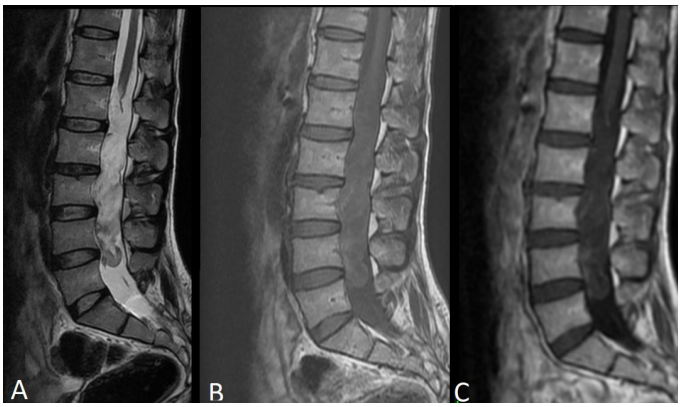

Figure 1. Pre-operative MRI scans revealed an intra-dural cystic lesion between L1 and L5 segments **(A)** lesion has no gadolinium enhancement according to the T1 and **(B)** T1+ contrast **(C)** scans. Dermal sinus tract is depicted using arrows in the lumbosacral junction as observed in FAST STIR MRI scan

FAST: Focussed assessment sonography for trauma, STIR: Short tau inversion recovery, MRI: Magnetic resonance imaging

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The patient was operated on in the prone position. The dermal sinus tract was dissected from the surrounding soft tissues with a fish-mouth incision involving the tract, and the incision was extended to the L1 vertebra. The tract was first excised and then the intra-dural tumour was also excised via L1-L2-L4 hemilaminectomies. The tumour contained cutaneous elements such as hair. Upon discharge, the neurological examination for the patient was normal. The post-operative histopathological examination revealed that the intra-dural tumour contained keratinous materials (dermoid tumour) and that the fistula tract consisted of epithelial tissue and also a cutaneous meningioma with psammomatous calcifications (Figure 2). Post-operative MRI scans showed that the dermal sinus tract had been removed; however, a remnant of the dermoid tumour had persevered (Figure 3). The patient was followed-up for three years and during his last examination, mild numbness was detected in his right leg.

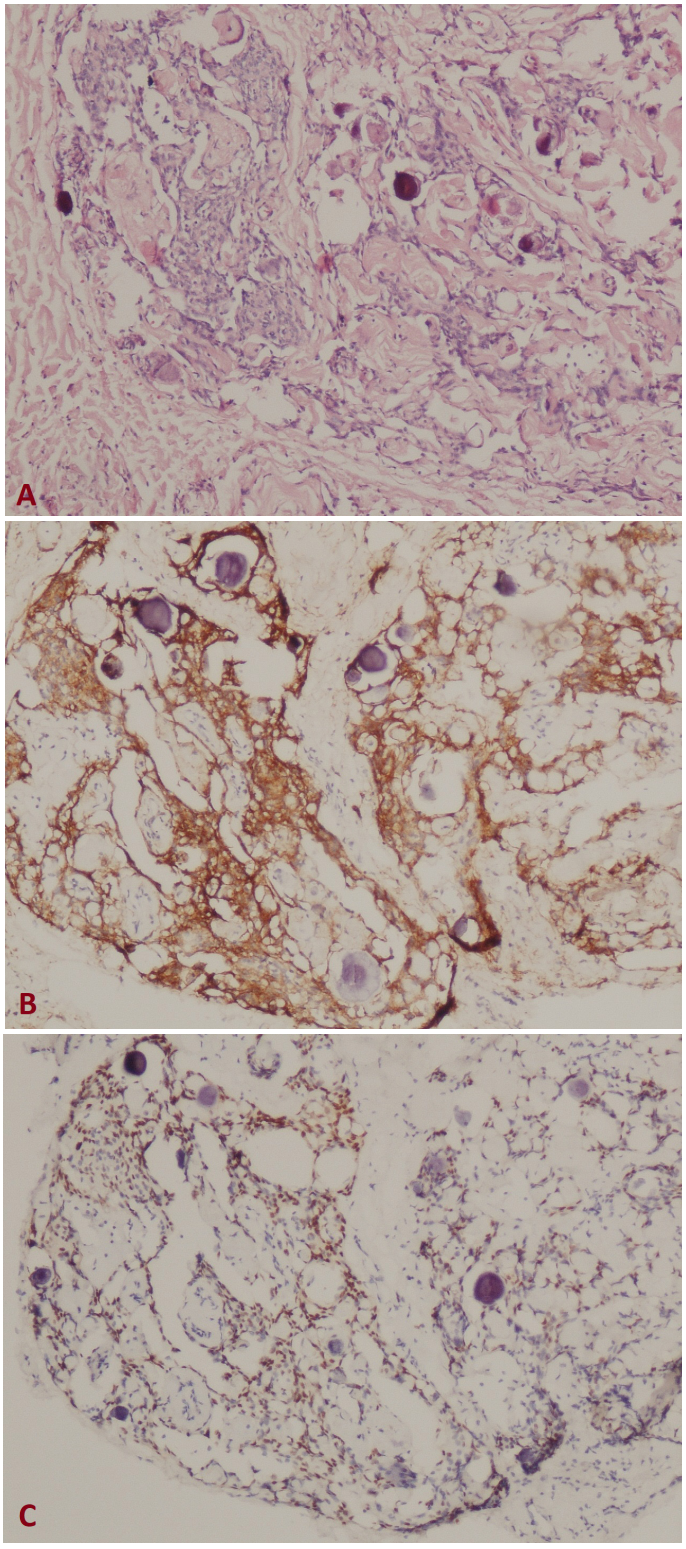

Figure 2. The meningothelial tumour cells are uniform, with oval nuclei, delicate chromatin and eosinophilic cytoplasm. There are whorls and psammoma bodies in the tumour **(A)**. It stains for EMA **(B)** and progesterone receptor **(C)**
EMA: epithelial membrane antigen

DİSCUSSİON

Cutaneous meningioma was first reported in an England-based study[5]. In 1974, Lopez et al. [4] classified these tumours using clinical and histopathological criteria. According to this classification, there are three distinct types of cutaneous meningiomas:

Type 1 cutaneous meningiomas are congenital and are discovered at an older age. They are mostly located in the scalp and paravertebral region, and they originate from ectopic arachnoid cells found between the dermis and subcutaneous layer during embryological development. These tumours may have a connection with the CNS in the form of sinus tracts which may be associated with neural tube defects like meningocele and meningomyelocele without the connection being interrupted[4,6].

Type 2 cutaneous meningiomas originate from ectopic arachnoid cells that extend along spinal and cranial nerves and have no connection with the neural axis. These tumours mostly occur around sense organs, such as ears, nose and eyes[3,4].

Type 3 cutaneous meningiomas occur as a result of the extension of intra-cranial meningiomas into the subcutaneous and dermal layers through bone and skin defects that develop after trauma or surgery[4].

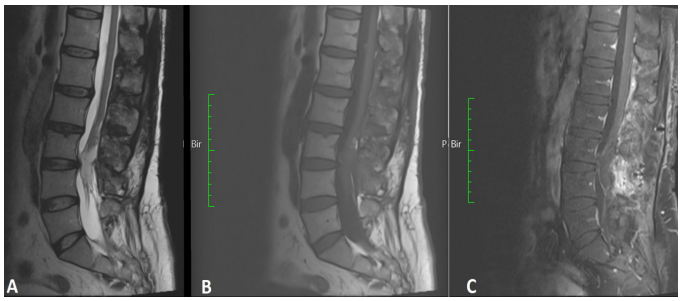

Figure 3. MRI scans showed that the epidermoid cyst lesion was removed sub-totally while the dermal sinus tract was removed totally **(A, B, C)**
MRI: Magnetic resonance imaging

The differential diagnosis of cutaneous meningioma is generally difficult, because they are rare and have non-distinctive characteristic features such as painless subcutaneous nodules and hairless areas or hypertrichosis[3,4,7]. The differential diagnosis should include sebaceous nevus, alopecia areata, dermoid cysts, fibromas, haemangiomas, squamous cell carcinomas, hamartomas, meningocele, myelomeningocele, nasal gliomas, neuroectodermal tumours and metastatic lesions[3,4,6,7].

It should be noted that type 1 cutaneous meningiomas may be associated with congenital tumours, such as epidermoid tumours or lipomas, and atypically located meningiomas in patients with congenital closure defects. Type 1 tumours have a better prognosis than type 2 and 3 tumours and they can be cured by en-bloc excision[3]. However, conservative treatment may be an option in selected patients who are asymptomatic or have a high morbidity burden for surgery[8].

The patient in this study underwent surgery in adulthood after being diagnosed with a cystic tumour in the lumbar region and dermal sinus tracts in the lumbosacral junction. Clinical and histopathological findings were consistent with a type 1 cutaneous meningioma. Complete surgical resection is the gold standard treatment in such cases; thus, the tumour was removed completely from the dermal sinus tract in this case.

In conclusion, meningiomas are common tumours of the CNS and their diagnosis is easy if the tumour occurs in the cranium and/or spinal canal; however, their diagnosis may be complicated when they are atypically located. In addition, because cutaneous meningiomas may occur in the skin, dermis and subcutaneous tissue, the differential diagnosis is important to avoid misdiagnosis. Cutaneous meningiomas should be considered in patients with spinal dysraphism or congenital tumours.

Ethics

Informed Consent: Informed consent was taken.

Authorship Contributions

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

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CASE REPORT
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THORACIC INTRADURAL EXTRAMEDULLAR ARACHNOID CYST IN AN ADULT: CASE REPORT AND REVIEW OF THE LITERATURE

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ABSTRACT

Spinal intradural arachnoid cysts are rare and primarily benign lesions. These cysts are typically located posterior to the spinal cord in the middle to lower thoracic spinal legion. They occur more frequently during adolescence or in early adult life. The true mechanism of arachnoid cysts development is not yet known. Possible mechanisms proposed include congenital, inflammatory arachnoidal adhesions, and, arachnoiditis secondary to subarachnoid haemorrhage, local anaesthetics and contrast agents, injury of the spinal column. Depending on the location, size, and mechanism of origin, the clinical course varies between asymptomatic, incidentally-diagnosed cases to severe myelopathy and/or radiculopathy. The final diagnosis is based on combined imaging, intra-operative, and histopathological findings. In the differential diagnosis cystic tumours, ependymal cysts, neurenteric cysts, teratogenic cysts and epithelial cysts should be considered. Surgical approach is usually indicated for symptomatic patients or progression in size through excision in the epidural space/fenestration in the intradural space. The basic surgical principle is the removal of spinal compression with cyst excision. Shunts may be considered in recurrent cysts. Because of its rare diagnosis mostly case reports have been reported in the literature. Thus, we report an adult patient with thoracic intradural extramedullary arachnoid cyst with a complaint of dorsalgia who responded well to Gabapentin treatment along with literature review.

Keywords: Arachnoid cyst, thoracic, gabapentin, dorsalgia

INTRODUCTION

Spinal intradural arachnoid cysts are rarely diagnosed in patients during adulthood and usually show symptoms before adolescence. They are fenestrated in most cases in order to relieve the spinal cord of tension. Most of the symptoms arise from the compression of the spinal cord, which in turn results in a variety of neurological deficits. Although symptomatic patients undergo surgery, a stable radiological examination of patients with no neurological deficit would allow for a more non-invasive follow-up. Furthermore, there is no evidence of a relationship between dorsalgia and arachnoid cysts.

CASE REPORT

A 48-year-old male patient visited our clinic complaining of a long-lasting upper-back pain. The patient had no significant history of trauma, previous surgery, infection or spinal anaesthesia. He complained of the upper-back pain extending to the neck, which was aggravated by physical activity and alleviated by resting. He had taken multiple non-steroidal anti-inflammatory drugs (NSAIDs) which did not significantly alleviate his pain. The result of his neurological examination was normal. A magnetic resonance imaging (MRI) of his thoracic vertebra without contrast enhancement revealed an arachnoid cyst at T4 level posterior to the spinal cord with cerebrospinal fluid (CSF) (Figure 1, 2). Since no abnormal neurological finding was observed, he was closely observed for other symptoms of neurological deficit; he was orally administered with 300 mg Gabapentin thrice a day and called for a check-up 6 months later. After 6 months, no change was observed in the cyst size in response to Gabapentin. Therefore, he was continued on Gabapentin treatment and called for a check-up in 12 months.

DISCUSSION

Our study presents a case of a patient diagnosed with a spinal intradural arachnoid cyst based on MRI findings. Arachnoid

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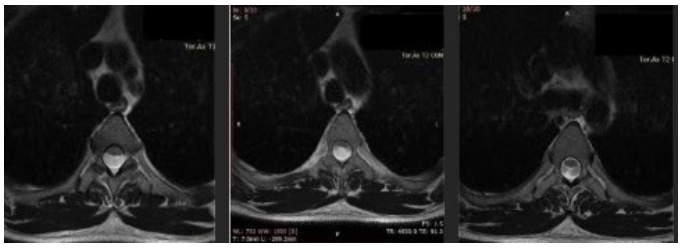

Figure 1. Axial views of T4 level perpendicular to the arachnoid cyst in T2 sequence showing the compression of the spinal cord from the posterior

Figure 2. Sagittal view of the arachnoid cyst in T2 sequence

cysts are characterised as well circumscribed cysts with an imperceptible border, displacing adjacent structures and following a CSF pattern–hyperintense on T2 with FLAIR suppression on the MRI. One of the differential diagnoses of arachnoid cysts is idiopathic spinal cord herniation, which detects a defect in the dura mater; this was not observed in this case. Additionally, neuroradiologists were consulted for their inputs on the case to reach a consensus. Spinal intradural arachnoid cysts may be diagnosed with or without neurological deficit. These pathologies are mostly located anterior to the spinal cord in the cervical region and posterior to the spinal cord in the thoracolumbar region[1]. The arachnoid cysts located in the intradural space of the thoracic region are rarely diagnosed in adults. Surgery is recommended for symptomatic patients, whereas a close follow-up of the neurological status, together with a radiological examination, is a more plausible option for asymptomatic patients.

There are many hypotheses postulating the underlying factors of arachnoid cyst development. Although it is thought to have a multifactorial cause, adhesions in the arachnoid mater after surgery or trauma is believed to disrupt the flow of CSF, leading to its accumulation in a contained space, thus forming an arachnoid cyst. Moreover, patients with coagulation disorders may have an asymptomatic haemorrhage in the intradural space, leading to adhesions in a similar manner[2]. Another hypothesis postulates an arachnoid mater herniation through congenital intradural defects with the pulsation of CSF. However, defects in arachnoid trabeculations may evolve over time following a similar mechanism. Although patients with spinal intradural arachnoid cysts have a strong family history and high rate of developing central nervous system abnormalities, congenital factors are also believed to play a major role[3]. Patients usually complain of pain aggravation as a result of staying in an erect position for a prolonged time. Apart

Table 1. Previous reports of Thoracic Arachnoid Cysts

Author	Average age (years)	Number of cases	Localisation
Mohindra et al.[4]	25 (6-46)	10	C:3, T:5, L:1, S:1
da Conceição et al.[5]	28	1	T1-T12
Wenger et al.[6]	55	1	T5-6
Rao et al.[7]	9	1	T1-5
Novegno et al.[8]	31	1	T11-12
Osenbach et al.[9]	41.5 (5-7)	14	C:3, T:9, L:2
Wang et al.[10]	52 (17-80)	21	C:4, T:14, L:3
Van Nuenen et al.[11]	65	1	T7
Payera and Brühlhart[12]	33	1	T11-L1
Kumar et al.[13]	40&75	2	T3-5&T5-7
Peruzzotti-Jametti et al.[14]	53	1	C1-T11
Endo et al.[2]	54	1	T3-8
Present case	48	1	T4

C: Cervical vertebra, T: Thoracic vertebra, L: Lumbar vertebra

from the pain experienced, most patients experience common symptoms such as hypoesthesia, ataxia and motor weakness as well as urinary symptoms. Myelopathic symptoms may arise due to the compression of the spinal cord. However, it is important to note that the cyst may disturb CSF flow, thus resulting in syringomyelia or similar symptoms where surgery becomes inevitable. Since symptomatic cysts are usually identified during childhood, their diagnosis in adults is usually rare. During the diagnosis of arachnoid cysts, cystic tumours, ependymal cysts, neurenteric cysts and teratogenic cysts, epithelial cysts must be differentiated[3].

Table 1 outlines the literature review of spinal intradural arachnoid cysts diagnosed in the thoracic region. All the patients in the previously reported cases have undergone surgery due to neurological deficits. In this case, the patient underwent a normal neurological examination and a tolerable amount of pain. Myofacial syndrome or radiculopathy in this patient was ruled out; therefore, his alleviation is unlikely to have a different aetiology even though it is unclear how Gabapentin relieved his symptoms. Therefore, no surgery was performed. However, widely used analgesics, such as NSAIDs, did not relieve the patient's pain. Gabapentin is routinely used for the treatment of neuropathic pain. Patients with chronic irritation of the nerve roots or with spondylotic symptoms have greatly benefited from Gabapentin. Although no case has reported the use of Gabapentin in the treatment of stable spinal intradural arachnoid cysts, this patient seemed to benefit from Gabapentin treatment without showing any side effects. Although literature review yields many results for arachnoid cysts, no information regarding the algorithm of diagnosis and follow-up of such patients has been published.

Symptoms such as resistance to conservative treatment, deterioration of the neurological status or increase in the arachnoid cyst size should alert the surgeon of the requirement for an urgent surgical intervention. However, tolerable symptoms and a normal neurological status is an indication of conservative follow-up. An excision through laminectomy or fenestration is the most commonly used surgical technique, whereas a cystoperitoneal shunt is more suitable for recurrent patients.

The literature review of spinal intradural arachnoid cysts reveals symptomatic patients, who underwent surgery, as well as asymptomatic patients, who were only followed up. However, no case has reported any kind of treatment to alleviate the patient's symptoms and improve their quality of life. In this case report, we report an adult patient diagnosed with a spinal intradural arachnoid cyst, who did not undergo surgery but benefited from Gabapentin treatment.

Ethics

Informed Consent: Informed consent was obtained from the patient.

Authorship Contributions

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

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CASE REPORT
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ISOLATED DEGENERATIVE C1 SPINAL STENOSIS: CASE REPORT AND REVIEW OF THE LITERATURE

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ABSTRACT

Cervical spinal stenosis (CSS) is a pathology typically seen in males over the age of 65 years, at C5-6 and C6-7 distances, often due to a decrease in the cervical canal diameter, resulting from the degenerative process and the formation of a secondary neural compression. Although degeneration of the cervical spinal elements is the primary pathologic lesion in CSS, secondary compression of the spinal cord or spinal vascular structures is responsible for the emergence of myelopathy symptoms. Risk factors for normally localised CSS include increasing age, male gender, disc degeneration, loss of vertebral height due to ageing (with trauma or osteoporosis), posterior longitudinal ligament calcification and the presence of a congenital anomaly (Congenital CSC, Klippel-Feil Syndrome). Clinically, progressive myelopathic complaints are prominent depending on the degree of stenosis. Diagnosis is made by measuring the anteroposterior diameter of the cervical canal radiologically. Treatment is by surgical decompression with or without fusion, in patients having progressive clinical symptoms, with radiological evidence of a narrow canal and the existence of neurological compression. In this report, two patients without systemic/rheumatologic concomitant disease and congenital predisposing factors, who were operated for isolated C1 narrow canal were discussed with a review of the literature.

Keywords: Cervical spondylosis, Isolated C1 spinal stenosis, myelopathy

INTRODUCTION

Cervical spinal stenosis (CSS) is a progressive degenerative process which occurs as a result of fragmentation of intervertebral discs, decreased fluid content and collapse and ongoing degeneration of the spine[1]. Although degeneration of the cervical spinal elements is the primary pathologic lesion in the CSS, secondary compression of the spinal cord or spinal vascular structures is responsible for the emergence of myelopathy symptoms[1,2]. CSS is a natural result of ageing. It occurs in 10% and 95% of patients at 25 and 65 years, respectively[3]. Decreased sagittal diameter of the cervical canal is the main factor of the primary degenerative process in CSS. The clinical course is usually insidious and progressive. It often begins with stiffness and axial pain in the neck, progressing with pain and strength loss in the arms, numbness in the hands, loss of dexterity and sensation, gait imbalance, weakness and stiffness in the legs and rarely, sphincter control loss and urinary incontinence over time[4]. Diagnosis is made by the presence of progressive myelopathic complaints and when the anterior-posterior diameter of the cervical canal, which is normally 34.5 mm on average, is less than 10 mm on radiological examination. In patients with radiologically diagnosed progressive deficit and myelopathic complaints, treatment includes surgical decompression with or without fusion. In this case report, two patients without systemic/rheumatologic concomitant disease and congenital predisposing factors, who were operated for isolated C1 spinal stenosis were discussed with a review of the literature.

CASE REPORT

Case 1: A 53-year-old male patient with no systemic concomitant disease was admitted to our clinic with increasing numbness in his hands and gait disturbance for the past 3 years. On neurological examination, the patient had no significant motor sensory deficits, Hoffman positivity was found on the right and his JOA score was 14. The anteroposterior diameter of the cervical canal measured on preoperative cervical magnetic resonance imaging (MRI) was 6.1 mm. The preoperative cervical computerised tomography (CT) and MRI of the patient showed thickening and hypertrophy of the posterior elements at the C1 level and increased cord signal in T2 sequences compatible with myelomalacia (Figure 1, 2). The patient was diagnosed

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with C1 spondylotic canal and administered a C1 posterior decompression, C1-C2 instrumentation and fusion surgery. After 4 years of follow-up, no additional neurological deficit or radiological spondylotic canal was detected (Figure 3, 4, 5).

Case 2: A 67-year-old male patient with no systemic concomitant disease presented to our clinic with complaints of weakness in the hands, feeling of electric shock in the arms, inability to use the hands, inability to walk without support with increasing intensity for the past 2 years and urinary-faecal incontinence for the past 8 months. The patient's neurological examination revealed a marked decrease in fine motor abilities on the right with a strength of 2/5 in the right upper extremity, spasticity, Romberg positivity, hyperactivity in deep tendon reflexes, Hoffman and Lhermitte's signs and clonus positivity on the right; JOA score was 9. The anteroposterior diameter of the cervical canal was 7.2 mm on the patient's preoperative cervical MRI. The preoperative cervical MRI showed increased cord signal in T2 sequences compatible with myelomalacia at the C1-C2 level (Figure 6). The preoperative cervical CT of the patient did not show thickening and hypertrophy of the posterior elements at the C1 level (Figure 7). Upon diagnosis of the C1 spondylotic canal on the preoperative cervical MRI, C1 and C2 posterior decompression, C1-C2 instrumentation and fusion surgery were performed. After 8 years of follow-up, no additional neurological deficit or radiological spondylotic canal was detected (Figure 8, 9, 10).

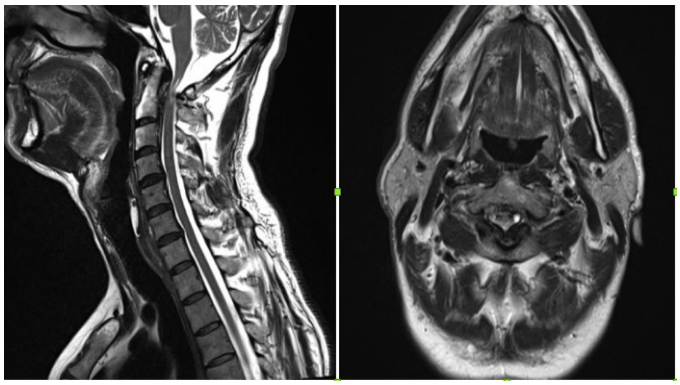

Figure 1. 1st patient Pre-operative MRI
MRI: Magnetic resonance imaging

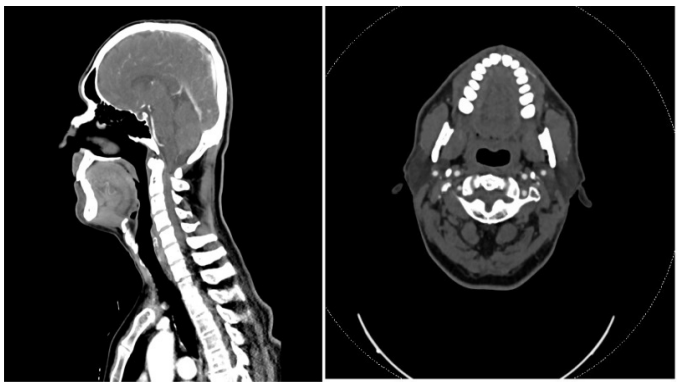

Figure 2. 1st patient pre-operative CT
CT: Computed tomography

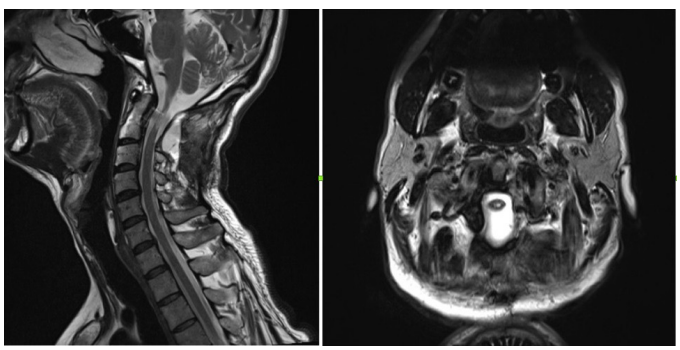

Figure 3. 1st patient post-operative 4th year MRI
MRI: Magnetic resonance imaging

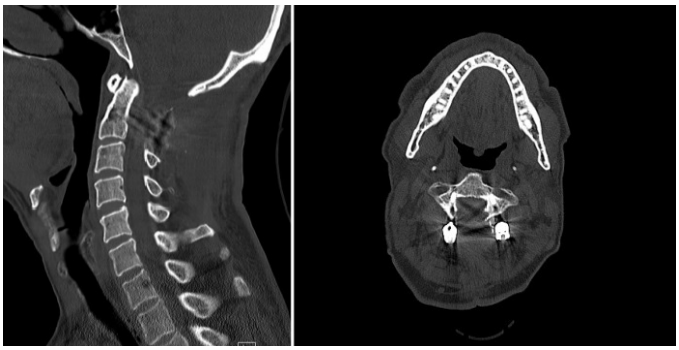

Figure 4. 1st patient post-operative 4th year CT
CT: Computed tomography

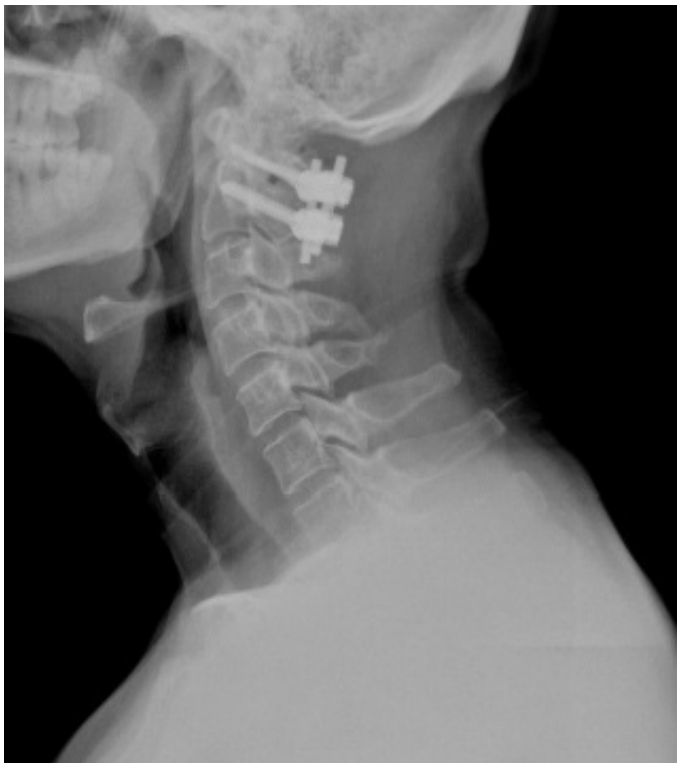

Figure 5. 1st patient post-operative 4th year X-ray

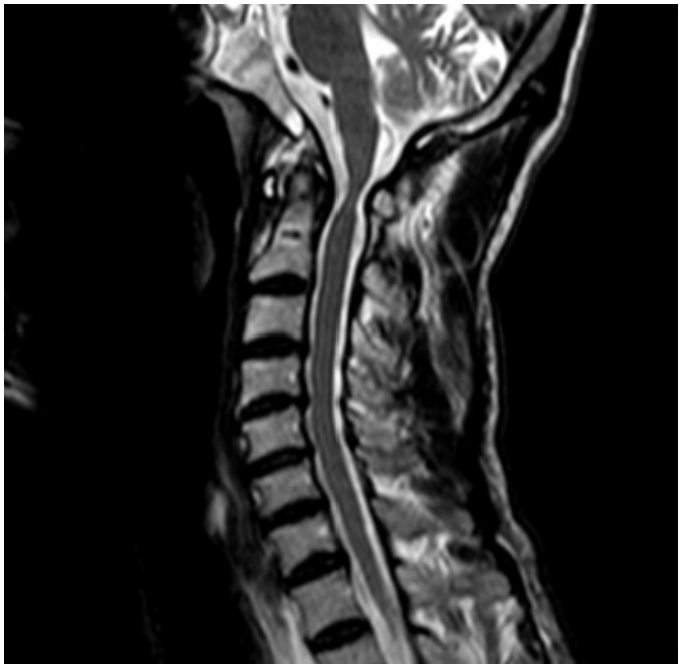

Figure 6. 2nd patient pre-operative MRI
MRI: Magnetic resonance imaging

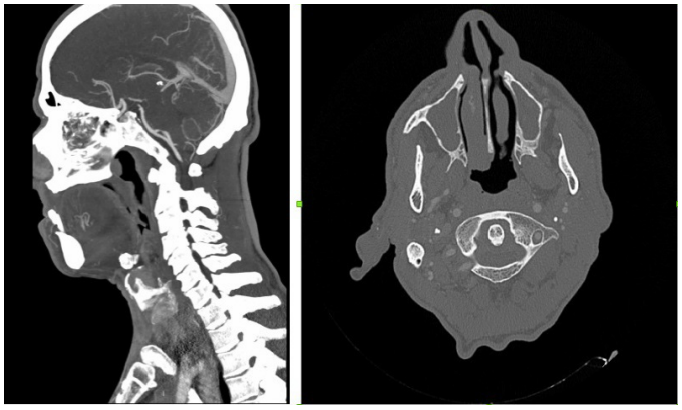

Figure 7. 2nd patient pre-operative CT
CT: Computed tomography

Figure 8. 2nd patient post-operative 8th year MRI
MRI: Magnetic resonance imaging

DISCUSSION

The symptomatic degenerative process begins with the formation of osteophytes at the C5-6 and C6-7 distances, where movement is greater and therefore, CSS is most common[1,5]. Subsequently, C4-5 and C3-4 distances are typically affected[6]. After progressive degeneration, the spinal canal diameter, which normally varies between 17-18 mm from the C3-C7 vertebrae decreases and when it falls below 10 mm as defined in CSC, the clinical picture emerges after neuronal compression[7]. The mean anterior-posterior diameter of the cervical canal at the distance of C1-C2 is 34.5 mm and because of its rarity, there is no clear canal diameter defined in the literature for its clinical

Figure 9. 2nd patient post-operative 8th year CT
CT: Computed tomography

Figure 10. 2nd patient post-operative 8th year X-ray

Table 1. Summary of the literature review on C1 stenosis

	Patient number	Age/ Gender	Clinic	Stenosis level	Radiology	Treatment	Outcome
Komatsu et al.[13]	1	56/M	Cervical myelopathy	C1	Atlas hypoplasia with segmental compression of the spinal cord	Decompressive laminectomy of the atlas	Remarkable neurologic recovery
Yamashita et al.[14]	1	73/F	Progressive cervical myelopathy	C1	MRI: Hypoplasia of the atlas associated with a retro-odontoid pseudo-tumour X-ray: Narrowing of the spinal canal at the level of the atlas and severe osteoarthrosis of the atlantoaxial joint without atlantoaxial subluxation	Decompressive laminectomy of the atlas with posterior occipitocervical fusion	Remarkable neurologic recovery
Phan et al.[15]	2	80/M 75/M	Progressive cervical myelopathy	C1	Hypoplastic posterior C1 arch	Posterior decompression with removal of both posterior arches of C1	Clinical improvement
Okamoto et al.[16]	1	77/M	20-year history of progressive gait disturbance and paresis of both the upper and lower extremities	C1	Severe canal stenosis at the level of the atlas	Resection of the posterior arch of the atlas	Clinical improvement
Benitah et al.[17]	2	78/M 41/F	Progressive cervical myelopathy	C1	1st patient: Unilateral osteophytes on the left C1-2 joint 2nd patient: Congenital hypertrophy of the laminae of C1 and C2	Laminectomy and ligamentum flavum resection of the atlas and axis	Clinical improvement
Nishikawa et al.[18]	3	82/M 72/M 42/F	Cervical myelopathy	C1	Congenital hypoplasia of the atlas	Laminectomy of C1	Clinical improvement
Urasaki et al.[19]	1	12/M	Cervical myelopathy	C1	Atlas hypoplasia with complete posterior arch	Decompressive laminectomy of the atlas	Clinical improvement
Atasoy et al.[20]	1	30/M	Neck and left arm pain	C1	MRI: Osodontoideum, marked stenosis of the spinal canal at the level of the atlas, with cord compression and evidence of myelopathy CT: Hypoplasia of the posterior arch	Patient declined surgical treatment	
Connor et al.[21]	1	8/UNS	Progressive upper and lower limb neurological symptoms	C1	Medial posterior hemiarches of a bifid C1 to be in-turned and compressing the cervical cord, severe C1 stenosis	Laminectomy of the posterior arch of C1	Clinical improvement
Sato et al.[22]	1	38/M	Progressive cervical myelopathy	C1	Atlas hypoplasia associated with non-traumatic retro-odontoid mass and hypertrophy of the transverse ligament of the atlas	Decompressive laminectomy of the atlas	Clinical improvement
Bokhari and Baeesa[23]	1	68/F	Progressive cervical myelopathy	C1	Hypoplastic intact posterior arch of C1 and concomitant ossified transverse ligament	Laminectomy of C1	Clinical improvement
Pascual-Gallego et al.[24]	1	5/M	Down syndrome with cervical myelopathy	C1	An anomaly of the atlas leading to stenosis	Laminectomy of C1	Clinical improvement
Nehete et al.[25]	20	8 Adults (mean age 22.85) 12 paediatric	Syndromic association with cervical myelopathy	C1	C1 arch stenosis	Laminectomy of C1	Improvement in symptoms

MRI: Magnetic resonance imaging, CT: Computed tomography, F: Female, M: Male, UNS: Unspecified

formation in this distance. When the diameter of the spinal canal falls below 10 mm irrespective of the distance, an absolute narrow canal is considered and myelopathic complaints are observed. Consistent with the literature, both cases had severe myelopathic complaints secondary to decrease in the canal diameter, which were of greater intensity in the second case.

When the affected cervical segments are examined in CSS, spondylotic changes occurring in the cervical spine alone, most commonly observed between the C3 and C7 cervical vertebrae, have a frequency of 15%, whereas the frequency of spondylotic changes occurring at multiple levels is 60-85%[8]. The presented cases had a rare C1 segment and single level involvement, without any predisposing factor and there was no case with similar features when the literature was reviewed.

Risk factors for normally localised CSS include increasing age, male gender, disc degeneration, loss of vertebral height due to ageing (with trauma or osteoporosis), posterior longitudinal ligament calcification and the presence of a congenital anomaly (Congenital CSC, Klippel-Feil Syndrome)[9,10]. Upper distance (C1-C2) cervical region involvement is typically seen in association with the presence of systemic connective tissue diseases such as rheumatoid arthritis. Spinal canal diameter is narrowed and myelopathic complaints develop following extension of the pannus formation, which occurs after recurrent acute synovitis attacks, from around the dens into the spinal canal[11]. In post-mortem examinations conducted on these patients, the upper cervical region was involved at a rate of 59-80% and it was found that the cause of death was spinal cord compression in seven (63.6%) of 11 cases[12].

We performed a literature search in the PubMed Database for "C1 Stenosis" and also cross-referenced articles. There are some predisposing factors of C1 spinal stenosis and Table 1 outlines the literature review of CSS diagnosed in the upper segment (C1). Isolated pure atlas hypoplasia is rare, while fissures and segmentation defects are relatively common. Arch anomalies of the atlas rarely causes compression, since they usually increase the canal space. Another anomaly that may be associated with hypoplasia and canal stenosis is an ossified transverse ligament, leading to chronic and progressive myelopathy. Some syndromic diseases that may be associated with hypoplasia of the atlas include Down syndrome, Turner syndrome, Morquio disease, ankylosing spondylitis, achondroplasia, gonadal dysgenesis and congenital spondyloepiphyseal dysplasia. A congenital malformation presents with clinical symptoms relatively later in life (as opposed to at birth or during childhood). Symptoms generally indicate superimposed age-related degenerative changes, such as ligamentum flavum buckling, pannus behind the dens or synovial cyst formation. Due to this reason and depending on the degree of congenital stenosis, the age of presentation of C1 stenosis may vary from small children to older adults.

When the predisposing risk factors for CSS were examined, there were no significant findings except for male gender and advanced age in the cases discussed. There was no congenital narrow canal or connective tissue disease.

In conclusion, new clinical and radiological narrow canal findings were not present after 4 and 8 years of follow-up. The cases are considered as rare cases due to both the development without the presence of predisposing factors and the distance involved being limited to the C1 level. As a result, it should be borne in mind that CSS can also be seen at the C1 level in the absence of predisposing factors, although rare.

Ethics

Informed Consent: Informed consent was obtained from the patient.

Authorship Contributions

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

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