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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.

Journal of Turkish Spinal Surgery is indexed in TÜBİTAK ULAKBİM TR Index, EBSCO, J-Gate, GALE, ProQuest, Türkiye Atıf Dizini, Index Copernicus and Europub.

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

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PEER REVIEW

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

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

AUTHOR'S RESPONSIBILITY

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

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

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

CONFLICTS OF INTEREST

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

ARTICLE WRITING

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Journal article:

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

Book chapter:

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

Entire book:

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

Book with volume number:

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

Journal article in press:

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

Book in press:

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

Symposium:

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

Papers presented at the meeting:

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

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

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

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

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

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

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

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

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

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

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

- Practical Tips:

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

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

3. Avoid references and statistical values in the Abstract.

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

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

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

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

7. Regularly count words from the Introduction through Discussion.

TABLE-1. LEVELS OF EVIDENCE

LEVEL- I .

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

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

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

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

5) Multi-center, randomized, prospective studies

LEVEL –II.

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

2) All Level-I studies with no randomization

3) Randomized retrospective clinical studies

4) Meta-analysis of Level-II studies

LEVEL– III.

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

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

3) Meta-analysis of Level III studies

LEVEL- IV.

1) Case presentations

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

LEVEL – V.

1) Expert opinion and review articles

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

TABLE-2. CLINICAL AREAS

Anatomy

Morphometric analysis

Anesthesiology

Animal study

Basic Science

Biology

Biochemistry

Biomaterials

Bone mechanics

Bone regeneration

Bone graft

Bone graft sustitutes

Drugs

Disc

Disc Degeneration

Herniated Disc

Disc Pathology

Disc Replacement

IDET

Disease/Disorder

Congenital

Genetics

Degenerative disease

Destructive (Spinal Tumors)

Metabolic bone disease

Rheumatologic

Biomechanics Cervical Spine

Cervical myelopathy

Cervical reconstruction

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

Fractures

Dislocations

Spinal cord

Spinal Cord Injury

Spinal stenosis

Cervical

Lumbar

Lumbosacral

Tumors

Metastatic tumors

Primary benign tumors

Primary malign tumors

APPLICATION LETTER EXAMPLE:

Editor-in-Chief

Journal of Turkish Spinal Surgery

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

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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.

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

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Dear Colleagues,

I feel very fortunate to be the person responsible for publishing this, the 4th issue, of our professional journal this year. Once again, it includes several clinical research studies, a couple of case reports, and a review article. I apologize for the fact that it's late this month, but there were technical issues beyond our control. I hope that each of you will review this issue very carefully, and add the insights contained herein, to your already extensive knowledge of your field of expertize.

The Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spine Society. Our publication is currently indexed in Ulakbim, Atıf Dizin, J-Gate, Europub and Ebsco host. However, we are very happy to announce that, in addition, our journal has also been indexed by three international indexes, Proquest, Index Copernicus and Gale Cengage Learning. We would like to remind you that, should you choose to submit a manuscript to the Turkish Journal of Spinal Surgery, it is free of charge, and the Pleksus system is being used.

In this issue, there are ten clinical research studies, two case reports and one review article. The first study is a study concerning the "Evaluation of the Preferences of Turkish Spine Society Members Toward Adolescent Idiopathic Scoliosis Treatment." The second is a basic science study on a Bipedal c57bl6 Mice Model, and the "Radiological Analysis of the Effects of Raloxifene, Nitric-oxide and Estrogen on Scoliosis." In the third, one can read a retrospective clinical study entitled, "A Surgical Error Resulting in Proximal Junctional Kyphosis in Treatment of Adolescent Idiopathic Scoliosis." The fourth article is "A Prospective Cohort Study About Effectiveness of Patient Specific Thoracolumbar Brace Treatment for Adolescent Idiopathic Scoliosis." The authors of the fifth study examined "The Efficacy of Surgical Techniques for Cervical Spondylotic Myelopathy on Functional Outcome, Recovery, and Patient Satisfaction." The sixth study compares "Sequestrectomy and Aggressive Discectomies in Terms of Recurrence in Lumbar Disk Hernia Surgeries" while, in the seventh, the authors wrote about "Adjacent Segment Degeneration after Decompression and Fusion surgery for Degenerative Lumbar Spinal Stenosis" in a retrospective comparative study. The eighth article gives a clear answer to the question: "Does Lumbosacral Transitional Vertebrae Cause Low Back Pain?" The ninth article is "A Quality Control Study That Answers the Question: Can Endoscopic Lumbar Discectomy Videos Shared on YouTube be Used as a Patient Education Tool?" The tenth study is about the importance of subcutaneous tissue thickness, in the development of surgical site infection, after lumbar disc surgery. The eleventh and twelfth articles are case reports about thoracic dynamic instrumentation, and Atlantoaxial Subluxation in a Patient with Psoriatic Arthritis respectively. The thirteenth is a review of Complex Regional Pain Syndrome Following Spinal Diseases and Surgeries.

I hope you found this issue thought-provoking and edifying. It's my goal to provide you with the latest, and most up-to-date information in our field. My mission is to increase our awareness so that we are all abreast of the latest cutting-edge developments in our field.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

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EVALUATION OF THE PREFERENCES OF TURKISH SPINE SOCIETY MEMBERS TOWARDS ADOLESCENT IDIOPATHIC SCOLIOSIS TREATMENT

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ABSTRACT

Objective: Controversies exist in the follow-up and treatment of adolescent idiopathic scoliosis (AIS). Thus, it is important to identify the attitudes of physicians from a national perspective to determine the status and problems associated with AIS treatment.

This study aimed to evaluate the preferences of the Turkish Spine Society (TSS) physicians towards AIS treatment by investigating differences in AIS monitoring and treatment through a web questionnaire survey.

Materials and Methods: This cross-sectional observational study employed a simple questionnaire focusing on AIS, which was created using Survey Monkey. Twenty questions, which were deemed as the most controversial topics of AIS, were constructed by the authors. A consensus was considered when 70% of the respondents provided the same answer.

Results: A consensus was obtained among TSS physicians for using brace as conservative treatment and the brace was used 22 hours daily. Most TSS physicians agreed about the surgical indication of AIS; however, there was a disagreement about the indication of brace treatment.

Conclusion: TSS physicians had a consensus on using brace in AIS treatment. However, there was a disagreement towards the indication of the brace treatment. The results demonstrated a consensus about surgical management and surgical experiences. However, a disparity existed about the time by which activities and contact sports are allowed.

Keywords: Adolescent idiopathic scoliosis, brace, surgery, spine, survey

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) occurs in 3% of the general population for curves between 10° and 20° and 0.3% for curves >30°. Of those affected, 10% warrant some treatment, and only 0.1% require surgical intervention[1,2]. Suh et al.[3] conducted a study over a 9-year period of school-based screening to investigate the scoliosis prevalence in the Korean population, and they found that AIS affected 3.26% of 1,134,890 school children. Curves >30° are up to 10 times more prevalent in girls than in boys. Men and women are equally likely to have minor scoliosis of approximately 10°, but in women, the condition is 5-10 times more likely to progress to a more severe disease, possibly requiring treatment[2,4].

The Turkish Spine Society (TSS), which is a national association of healthcare professionals (orthopaedic surgeon, neurosurgeon, physical therapy physicians, etc.) working in spine diseases, has been carrying out scientific activities for 28 years. Many controversial topics exist in the follow-up and treatment of AIS. Thus, it is important to identify the attitudes of physicians from a national perspective to determine the state and problems associated with AIS treatment. Therefore, this study aimed to evaluate the preferences of TSS physicians towards AIS treatment by investigating differences in AIS monitoring and treatment through a web questionnaire survey.

MATERIALS AND METHODS

In this cross-sectional observational study, which performed between August 2016 and October 2016, a simple questionnaire focusing on AIS was created using Survey Monkey (Table 1). Twenty questions, which were considered the most controversial topics of AIS, were constructed by the authors.

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Table 1. The 20 question survey fullfilled by the Turkish Spine Society members.

1. What is your limit of Cobb angle for surgery indication for thoracic AIS ?

40 degrees
45 degrees
50 degrees

2. What is your limit of Cobb angle for surgery indication for lumbar AIS?

35 degrees
40 degrees
45 degrees

3. What is your instrumentation preference for thoracic AIS surgery?

Hook + screw
Monoaxial screw
Polyaxial screw
Mono + poliaxial screw

4. What is your rod preference for thoracic AIS surgery?

Ti
Stainless steel
Chrome-cobalt

5. What is the post-operative infection rate of thoracic AIS surgery?

1%
2%
3%
4%
5%

6. What is the rate of paraplegia in thoracic AIS surgery?

1/100
1/1000
1/5000
1/10000
1/20000

7. Are the swimming, pilates, yoga or exercise involved in AIS conservative treatment?

Yes
No

8. Do you use brace at conservative treatment of AIS?

Yes
No

9. AIS , while M: 0 R: 0, if the curvature is less than 35 degrees, do you start the brace treatment without 5 degree progression?

Yes
No

10. What is your daily use time preference for brace treatment?

22 hours
16 hours
only night

Table 1 contiuned

11. How do you explain benefit of the brace treatment to the patients family?
May reduce the progression of AIS curve
May stops the progression of AIS curve
May reduce of AIS curve
12. M:+1 year , R: 3-5 , 45°- 60° Thoracic AIS . Surgical treatment should be performed in .... year?
1
2
3
4
13. M:+2 year , R:5 , AIS. Which cobb angle will occur the life threatening problems?
45
60
70
80
100
14. How many weeks after surgery can the patients begin to school?
3 weeks
4 weeks
6 weeks
8 weeks
15. How many months after surgery can the patients begin to cycling?
1.5 months
3 months
6 months
9 months
16. How many months after surgery can the patients begin to contact sports (football, basketball)?
2 months
4 months
6 months
9 months
17. How many hours the operation time of T2 to L3 instrumentation? (start and end of the anesthesia)
3 hours
4 hours
5 hours
6 hours
7 hours
18. Do you perform the operation with wake up test without neuromonitoring?
Yes
No
19. If there is 60% flexibility in the thoracic AIS (between 45 and 60 degrees), how many percentage of correction can be expected?
70%
80%
90%
100%
20. What is the most important things for the patient after surgery?
Image in the mirror
Radiology

The responses were arranged as multiple choices. A unique link to the survey was provided in the e-mail and sent to TSS physicians. The TSS members who fulfilled the questionnaire were included in the study. A progress bar that stated the percentage of successfully finished pages was included, and progress to the next page was only possible when all questions were answered. All questions included the option "no answer". The questionnaire could only be filled in once and only within 14 days. After 7 days, a reminder e-mail was sent to all non-responders. A consensus was attained when 70% of the respondents provided the same answer. We did not use any statistical analysis in the study.

RESULTS

A total of 103 respondents who completed the survey were included in this study. The respondents were orthopaedic surgeons, neurosurgeons and physical therapy physicians (82%, 17% and 1%, respectively).

Majority of the respondents answered 45° (43%) as the surgical indication for thoracic AIS, while it was 40° (52%) for lumbar AIS. Many respondents preferred to use polyaxial screws (68%) over monoaxial screws or hybrid constructs, and they preferred titanium rods (64%).

The postoperative infection rate was mostly responded as 1% (51%), while the paraplegia rate was responded as 1/1,000 (52%). We did not find a consensus among TSS physicians about the effect of swimming, Pilates, yoga or exercises on the conservative management of AIS (yes/no; 48% vs 52%). However, brace treatment was the most commonly used conservative treatment method for AIS (78%). Most respondents believed that brace treatment may stop the curve progression (73%) in AIS, and they used brace treatment for 22 hours a day (74%). Nevertheless, no consensus was found among respondents about beginning brace treatment in a Risser grade 0 patient with curve <35° without 5° progression (yes/no; 60% vs 40%).

We also asked some case examples (questions 12 and 13). Most respondents believed that in a Risser grade 3-5 patient with 45° to 60° thoracic Cobb angle, surgical treatment should be performed within 1 year (80%). By contrast, we did not observe a consensus about the degree of Cobb angle, which may result in life-threatening problems (question 13).

TSS physicians usually allow their patients to go to school at 3, 4 or 6 weeks after surgery (36%, 23% and 30%, respectively). In addition, no consensus was noted about the time of beginning cycling or contact sports, but most physicians allow their patients to begin cycling and contact sports 3 and 6 months after surgery, respectively.

Most respondents prefer using neuromonitoring during surgery (69%). The operation time for a T2 to L3 instrumentation varies between 4 and 6 hours. For a patient with 60% flexibility and 45° to 60° thoracic Cobb angle, majority of the surgeons expected an 80% correction rate (60%). In the last question, majority of the respondents declared that one's reflection in the mirror is the most important thing for the patients after surgery compared with radiology (94% vs 6%).

DISCUSSION

The most important study finding was observing a general consensus about the surgical treatment of AIS while detecting some disagreements about the conservative management of AIS. The general indications for thoracic and lumbar AIS as well as fixation method and rod materials did not differ among respondents. The rates of postoperative infection and paraplegia were also similar among respondents. However, our results demonstrated a disagreement about the preferences of conservative management. Most respondents believed that brace treatment is an effective non-operative management of AIS. Nevertheless, there was no consensus about beginning the brace treatment; for example, in a patient with Risser grade 0 and curve <35° with <5° progression, 60% of the respondents choose to start brace treatment, while 40% did not choose this treatment.

In 2013, Lehman et al.[5] created a survey about the treatment of AIS among 23 expert surgeon-researchers who are members of the spinal deformity study group. This study concluded that modern posterior instrumentation allows surgeons to recommend earlier return to sports after fusion for AIS, with the majority allowing running by 3 months and noncontact (gym class, swimming) and contact sports (basketball, volleyball) by 6 months[5]. Our results showed that TSS physicians mainly allowed cycling 3 weeks after AIS surgery, while they allow beginning contact sports at 6 months after surgery. However, we did not encounter a consensus about the exact time of beginning sports activities and contact sports among TSS physicians. TSS physicians similarly allow patients to begin cycling in 3 or 6 months and to begin contact sports in 6 or 9 months.

Most investigators who have studied the impairment of pulmonary function in scoliosis generally agree that a Cobb angle >90° greatly predisposes to cardiorespiratory failure, and lung function abnormalities are detectable when a Cobb angle is >50° to 60° and lung function abnormalities are mainly of the restrictive type[4,6-8]. In our study, the responses vary between 60°, 70°, 80° and 100° (20%, 20%, 31% and 27%, respectively).

Scoliosis is also an image problem for young people. Self-image, as measured by patient responses on a validated questionnaire scored from 1 (best) to 6, was significantly worse for scoliosis patients than controls[9]. Self-image is decreased during the treatment period for both patients who used brace and underwent surgery. After brace treatment, patients' condition returned to normal. At an average of 7 years after surgery, small differences persisted for patients who underwent surgery, and the differences were characterised as probably "more statistical than practical"[9]. Moreover, respondents agreed that one's reflection in the mirror is more important than that in the radiological view.

Spinal cord complications occurred in 18 patients in the SRS series, all of which were incomplete spinal cord injuries. The posterior (0.21%) and combined (1.12%) groups each had nine complications. No spinal cord complications were noted in the anterior group. The differences in spinal cord complication rates between the combined and anterior procedures, as well as combined and posterior procedures, were statistically significant, but not between anterior and posterior procedures. On the contrary, wound infection was found in 0.17% and 1.37% of the patients following anterior and posterior spinal fusion surgery, respectively, according to the SRS series. In the present, TSS physicians also reported similar infection and paraplegia rates after AIS surgery.

Piantoni et al.[10] reported the results of their survey in which 497 National Spine Society members in Argentina were evaluated. They observed that 95.5% of the surgeons prescribed TLSO and indicated wearing of brace 20.6 hours daily[10]. In the present study, most respondents agreed (78%) to using brace treatment and 73% used brace for 22 hours.

Study Limitations

The main limitation of this study was its small sample size. To reach a more relevant consideration about the preferences of surgeons towards AIS in Turkey, all physicians interested and working in spine diseases should be evaluated. However, it is difficult to conduct such survey, as the present study only aimed to evaluate TSS physicians' preferences towards AIS. As the main study strength, this study is the first to have evaluated preferences of TSS physicians towards AIS treatment.

CONCLUSION

In light of the study results, TSS physicians agreed on using brace as AIS treatment. However, there was a disagreement towards the indication of the brace treatment. Our results demonstrated a consensus about surgical management and surgical experiences. However, a disparity also existed about the time of allowing activities and contact sports.

Ethics

Ethics Committee Approval: Since our study is a survey study which is evaluated according to the answers doctors who answer the questions, ethics committee approval was not required.

Informed Consent: Since our study is a survey study which is evaluated according to the answers doctors who answer the questions, informed consent was not necessary.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: K.T., U.A., Design: K.T., U.A., Data Collection or Processing: G.K.K., İ.Y.Ç., Y.O.K., Y.U., Analysis or Interpretation: G.K.K., İ.Y.Ç., Y.O.K., Y.U., Literature Search: K.T., U.A., İ.Y.Ç., G.K.K., Y.O.K., Y.U., Writing: İ.Y.Ç., Y.O.K., Y.U.

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

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THE RADIOLOGICAL ANALYSIS OF THE EFFECTS OF RALOXIFENE, NITRIC-OXIDE AND ESTROGEN ON SCOLIOSIS: A BIPEDAL C57BL6 MICE MODEL

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ABSTRACT

Objective: Raloxifene (RLX), estrogen and nitric oxide (NO) medications were showed to be related to scoliosis, but the complex mechanism has not yet been elucidated. The prevention and non-surgical treatment of scoliosis may be achieved with these drugs since they are safe for use in humans. We aimed to investigate the effects of oestrogen, RLX and NO on scoliosis progression, bone mineral density and sagittal plan deformities.

Materials and Methods: One hundred and fifty-two C57BL6 mice were grouped into bipedal Estrogen, bipedal RLX, bipedal NO, bipedal control and quadrupedal control groups. All of the animals' forelimbs and tails were amputated, except for the quadrupedal group (n=28), and followed-up for five weeks. Estrogen, NO and RLX groups received orally administered Estrogen, NO and RLX after the 5th week for 35 weeks. Anteroposterior and lateral X-ray imaging were done at the 5th, 20th and 40th weeks and bone mineral density measurements were done at the 20th and 40th weeks.

Results: There was no significant difference in mean Cobb angles between the groups at the fifth, 20th and 40th weeks (p=0.917, p=0.066, p=0.562, respectively). In contrast, a significant increase in mean Cobb angles was found in the quadrupedal group between the 20th and 40th weeks. In addition, no significant difference was found between the groups in terms of scoliosis incidence at the fifth and 20th weeks (p=1.000, p=0.132, respectively). However, when the scoliosis progression was investigated, a decreasing tendency was found in the RLX group compared to the other groups. Although there was a decreasing tendency in terms of the thoracic kyphosis angles and pelvic incidence between the 20th and 40th weeks in all groups, no statistical difference was found. Spinosacral angles increased significantly between the 20th and 40th weeks in all groups, except the quadrupedal group. There was a significant increase of the bone mineral density in the RLX group (p=0.041).

Conclusion: RLX may decrease scoliosis progression in a C57BL/6 mice model and increase the bone mineral density. Unlike previous studies, the quadrupedal mice group had a tendency to increase scoliosis progression between the 20th and 40th weeks.

Keywords: Scoliosis, raloxifene, nitric oxide, oestrogen, C57Bl6 mice, sagittal plan deformities

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a spine deformity due to unknown causes for which preventive treatments does not exist. Therefore, patients with this disease usually require intensive brace therapy or surgery[1]. Possible aetiological mechanisms of AIS have been investigated, but the factors leading to AIS have not yet been completely elucidated[2-4]. As an experimental model, chicken pinealectomy was shown to produce scoliosis in previous studies[5,6]. Further studies showed that scoliotic deformity was produced in rats when they were forced to survive in a bipedal posture by amputation of the forelimbs and tails[7]. C57BL6 mice, inbreed species without melatonin synthesis, were also used for the animal scoliosis model such that pinealectomy was not needed. When these mice gained the bipedal posture via the amputation of their forelimbs and tails, scoliosis was observed at 20 weeks[8]. Based on these studies, a clinical study showed that children with progressive scoliosis have lower blood melatonin levels compared to children without scoliosis[9]. During the investigation of the effects of melatonin, Acaroglu et al.[10] found that there was no difference in melatonin levels, but calmodulin levels in the paravertebral muscles on the convex side of the scoliotic patients were found to be higher compared to the control

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group. Further studies showed that calmodulin antagonism is beneficial for the prevention of scoliosis progression[2,11-13]. Calmodulin antagonism with a Selective Estrogen Receptor Modulator (SERM) like tamoxifen showed that tamoxifen decreases the scoliosis progression rate[2]. Raloxifene (RLX) is another SERM that is used for the prevention and treatment of osteoporosis in postmenopausal women[14]. In a study with ovariectomised mice, it was shown that RLX was effective in preserving the bone microstructure[15]. In another study, RLX and tamoxifen treatment of bipedal C57Bl6 mice showed that RLX is as effective as tamoxifen[13].

Estrogen is thought to be an aetiologic factor involved in AIS pathogenesis[16]. Experiments with bipedal rat models demonstrated that estrogen promotes the onset and development of idiopathic scoliosis[17]. Despite contrary publications[18,19], previous studies performed on girls with AIS showed that there may be differences in serum oestradiol concentrations and determination of the estradiol levels may be useful in detecting spinal pathologies in AIS[20,21].

nitric-oxide (NO) is another molecule that may be involved in the aetiology of the idiopathic scoliosis. NO levels on the concave side of the paraspinal muscles in idiopathic scoliosis patients were found to be higher compared to the convex side[22,23].

Due to these complex findings in the aetiology of idiopathic scoliosis, further studies investigating the effects of the drugs on scoliosis progression are required. We aimed to investigate the effects of RLX, NO and estrogen on scoliosis incidence and progression in a scoliotic mice model.

MATERIALS AND METHODS

The study was conducted in an animal research laboratory with a total of 180 melatonin deficient, 3 weeks old, 15 grams weighted, C57BL6/NCrl mice. Approval was obtained from the local ethics committee of Hacettepe University Animal Experimentations Ethics Board (date: 12.07.2011, decision no: B.30.2.HAC.0.05.06.00/59). All subjects, except quadrupedal group (n=28), forelimbs and tails were amputated and rendered bipedal under general anaesthesia to obtain scoliosis model as previously described[8]. Twenty-two mice died during amputation process. All mice receive pain-control and antibiotics prophylaxis following surgical procedure. The remaining 158 mice were followed for 5 weeks without an intervention. Six mice died during this 5-week follow-up. At the fifth week follow-up, 152 mice were alive and they were randomly separated into five groups. There were 28 mice in quadripedal group (group 1), 42 mice in bipedal group (group 2), 27 mice in bipedal estrogen group (group 3), 29 mice in bipedal RLX group (group 4) and 26 mice in bipedal NO group (group 5). For the baseline evaluation, anteroposterior and lateral spinal radiographs were obtained from 10 mice in the quadripedal group and 14 mice in the bipedal group and following radiographic evaluation, they were sacrificed for histological evaluation. Medications were given to subjects starting from the 5th week and administered as follows: Mice in group 1 (n=18) and group 2 (n=29) received no medication. Mice in group 3 (n=27) received estrogen (0.5 mg/kg/day). Mice in group 4 (n=28) received RLX (1 ml/kg/day). Mice in group 5 (n=26) received NO (0.2 mg/kg/day). All medication was prepared by smashing the tablet form of the drugs and dissolving in distilled water. All medication was administered orally to the subjects through drinking water. Doses of medications were adjusted based on previous literature[13]. Medications were continued on a daily basis for 40 weeks.

Between the 5th and 20th week follow-up, 27 mice (one in quadripedal group, two in bipedal control group, 15 in estrogen group and nine in NO group) were dead. Anteroposterior and lateral spinal radiographs were taken, pelvic and spinal bone mineral density were measured in all groups at 20th week follow-up; and then, 49 mice (eight in quadripedal group, 13 in bipedal group, seven in estrogen group, 13 in RLX group and eight in NO group) were sacrificed for histological evaluation. None of the mice died between the 20th and 40th weeks follow-up. The remaining mice were initially evaluated with anteroposterior and lateral spinal radiographs, bone mineral density (pelvic and spinal) and later sacrificed for histological examination. All the mice were kept in 22 °C ±2 environmental conditions with 12 hours light/darkness cycles. The position of the water bottle and nutrition was set in a way that mice had to stand-up over two feet to reach them.

Radiographs and bone mineral density measurements were obtained under ether anaesthesia. Based on a previous study, coronal plane deformity analysis was performed[13]. Sagittal plane deformity analysis was made based on thoracic kyphosis, spinosacral angles and pelvic incidence[22]. Bone mineral density values were given with g/cm^2. Subjects having a Cobb angle above 5 degrees were considered as being scoliosis. An example of anteroposterior and lateral spinal radiograph of a mouse is shown in Figure 1.

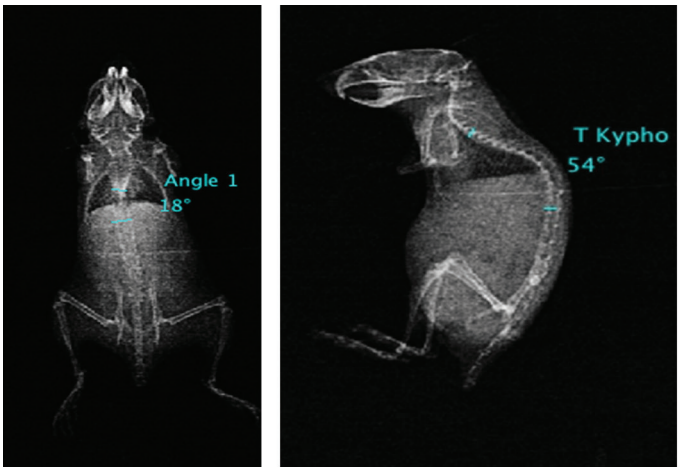

Figure 1. An anteroposterior and lateral spinal radiograph of a bipedal mouse

Statistical Analysis

Kolmogorov-Smirnov test was used to perform the normality analysis of the data. Kruskal-Wallis test was used to evaluate the mean of the variables, while categorical variables were compared with chi-square test. Continuous variables are presented as mean ± standard deviation, whereas categorical variables are given as frequencies. IBM SPSS Statistics 23.0 (IBM Corporation, Armonk, NY, USA) program was used to perform analysis on the data. The results were considered statistically significant when the p value was <0.05.

RESULTS

Mean Cobb angles at 5th, 20th and 40th weeks are given in Table 1. There was no significant difference in mean Cobb angles between the groups at the 5th, 20th and 40th weeks (p=0.917, p=0.066, p=0.562, respectively). There was a significant increase in mean Cobb angles in the quadrupedal group between the 20th and 40th weeks (Figure 2).

The incidences of scoliosis according to the weeks are shown in Figure 3. There was no significant difference between the groups in terms of the scoliosis incidence at the 5th and 20th weeks (p=1.000, p=0.132, respectively). No statistical comparison was performed at the 40th week due to the small sample size (Table 2).

The mean thoracic kyphosis angles, spinosacral angles and pelvic incidence according to the weeks are shown in Table 3. Although there was a tendency to decrease the thoracic kyphosis angles (Figure 4), and pelvic incidence (Figure 5) between the 20th and 40th weeks in all the groups, no statistical difference was found. Except in the quadrupedal group, spinosacral angles had a significant increase between the 20th and 40th weeks in all the groups (Figure 6).

Table 1. Mean Cobb angles at the 5th, 20th and 40th weeks

	5th week		20th week		40th week	
Bipedal group	12±8.1		11.9±9.0		16.5±12.8	
Quadrupedal group	9±5.5		18.8±10.4		23.3±10.2	
Estrogen group	-		22.9±18.0		25.2±18.8	
Raloxifene group	-	p=0.917	12.4±7.3	p=0.066	18.7±16.1	p=0.562
Nitric-oxide group	-		17.3±14.4		18.4±13.0	

Table 2. Scoliosis incidences at the 5th, 20th and 40th weeks

	5th week		20th week		40th week	
Bipedal group	41.6%		64.2%		66.6%	
Quadrupedal group	55.6%		88.2%		100%	
Estrogen group	-	p=0.528	91.6%	p=0.132	80.0%	
Raloxifene group	-		79.3%		68.7%	N/A
Nitric-oxide group	-		64.7%		77.8%	

N/A: Not available

Table 3. Mean thoracic kyphosis, spinosacral angle, pelvic incidence at the 5th, 20th and 40th weeks

Thoracic kyphosis Spinosacral angle Pelvic incidence	5th week		20th week		40th week	
Bipedal group	56.8±12.7 82.2±32.7 14.3±7.1	p=1.000 p=0.346 p=0.120	48.5±14.0 46.6±7.8 15.4±8.0		45.5±8.4 56.5±11.2 12.3±9.2	
Quadrupedal group	57.8±12.4 78.1±19.3 9.6±6.9		45.8±12.3 60.1±9.7 20.8±4.9		44.6±8.8 67.6±7.9 16.9±5.4	
Estrogen group	-		58.8±9.8 47.1±8.8 18.7±7.1		48.8±8.7 57.3±7.5 13.8±10.6	
Raloxifene group	-		54.6±15.3 42.8±9.9 14.8±6.1	p=0.001 p<0.001 p=0.016	48.6±10.3 59.8±12.0 13.6±8.4	p=0.562 p=0.523 p=0.523
Nitric-oxide group	-		61.1±10.2 49.2±8.0 13.4±7.8		52.7±9.8 63.1±17.0 11.9±6.5	

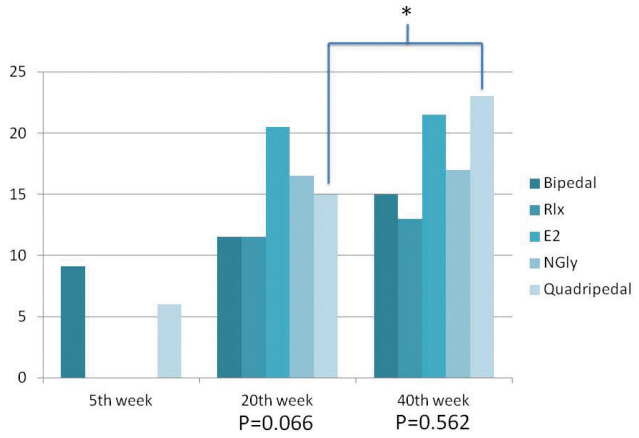

Figure 2. Mean Cobb angles in all groups at 5th, 20th and 40th weeks. There was a significant increase in mean Cobb angles in quadripedal group between 20th and 40th week (p=0.035)

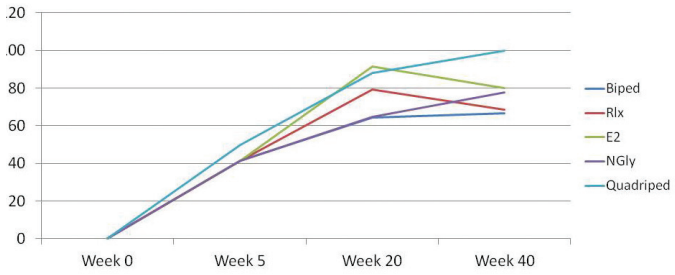

Figure 3. The incidences of scoliosis according to the weeks

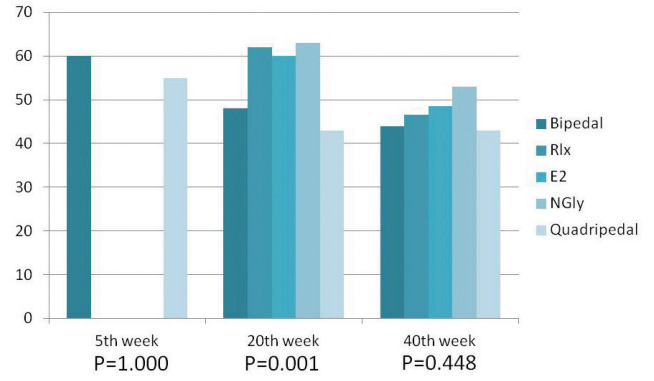

Figure 4. The mean of thoracic kyphosis angles in all groups at 5th, 20th and 40th weeks

The course of the bone mineral density between the 20th and 40th weeks are shown in Table 4. There was a significant increase in the RLX group (p=0.041) (Figure 7).

The results of the histological evaluation of the sacrificed mice did not show any significant finding.

DISCUSSION

Our primary goal in this study was to investigate the effects of RLX (calmodulin antagonist), estrogen and NO on the aetiology of scoliosis using a C57BL6 mice model. Calmodulin is an important mediator of cellular calcium metabolism and

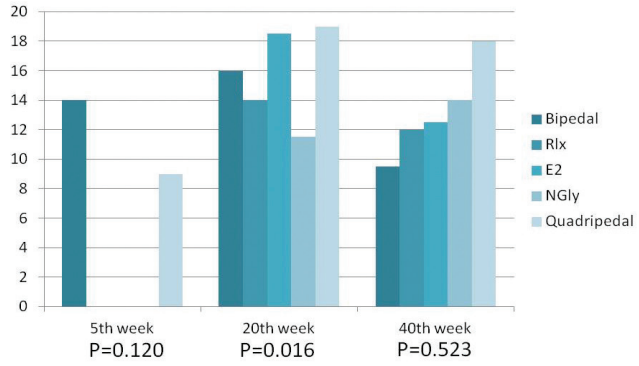

Figure 5. The mean of pelvic incidence angles in all groups at 5th, 20th and 40th weeks

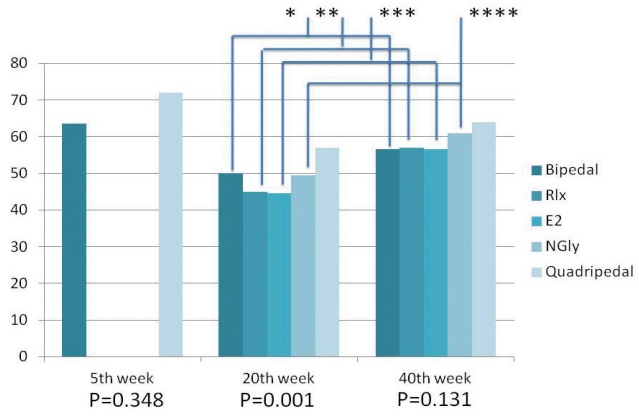

Figure 6. The mean of spinosacral angles in all groups at 5th, 20th and 40th weeks

Table 4. Mean pelvic bone density values at the 20th and 40th weeks

	20th week		40th week	
Bipedal group	0.051±0.005		0.053±0.007	
Quadrupedal group	0.053±0.007		0.052±0.008	
Estrogen group	0.053±0.007	p=0.224	0.058±0.006	p=0.461
Raloxifene group	0.049±0.007		0.053±0.009	
Nitric-oxide group	0.048±0.006		0.051±0.006	

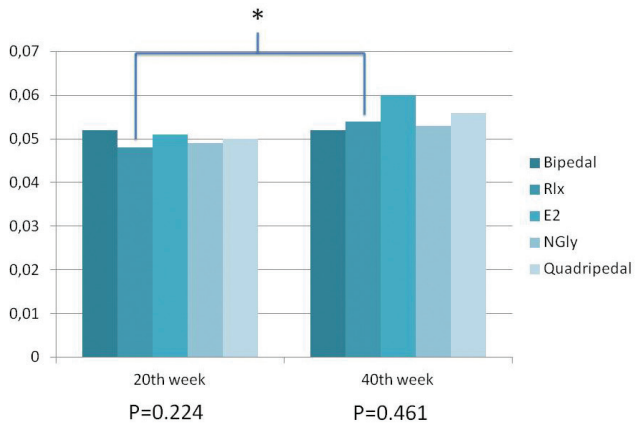

Figure 7. The mean of bone mineral density in all groups at 20th and 40th weeks

calmodulin antagonism was found to decrease the incidence and magnitude of scoliosis in pinealectomised chicken[24]. In studies using the C57BL/6 mice model, calmodulin antagonism with tamoxifen was successful at inhibiting the progression and decreasing the magnitude of the curves[2], and this finding was supported by further studies[11]. Another selective estrogen modulator, RLX, was also found to be as effective as tamoxifen in decreasing the magnitude of the spinal deformities on the C57BL/6 mice model[12], and both RLX and tamoxifen were found to be effective in improving the osteopenia and scoliotic deformity[13]. Our results demonstrated that at the 5th, 20th, and 40th weeks, there was no statistically significant difference in mean Cobb angles between the groups. However, when the scoliosis progression was investigated, there was a decreasing tendency in the scoliosis progression of the RLX group compared to the other groups, which was consistent with the previous studies[12,13]. However, our results with RLX's inhibitory effect is not as powerful as those of previous studies. In addition, contrary to our hypothesis, estrogen and NO were not found to be effective in the treatment of the scoliosis in bipedal mice model. RLX has multiple effects in the vertebra through calmodulin receptors and also with estrogen receptors, leading to the prevention of osteopenia. The reason for the inhibitory effect of RLX on scoliosis progression may be due to these complex functions, unlike its isolated effects of estrogen and NO donors. However, when the number of animals in all the groups were compared, a small number of mice remained in the estrogen and NO groups due to unexpected deaths during the study, which may affect the result.

It is not clear if estrogen and selective estrogen receptor modifiers act through the calmodulin receptors to decrease the osteopenia. The association between osteopenia and scoliosis was shown in previous studies[25,26], and animal models[27]. Treatment of osteopenia resulted in decreased curvatures in C57Bl6 mice models[13,28], and in our study, the RLX group demonstrated increased bone mineral density, which supported previous studies. RLX is clinically used in breast cancer and osteopenia treatment, but the effect of RLX on scoliosis progression requires further evaluation.

Mouse and rat spine is being used as a mechanical model of the human spine[17,29]. However, there are arguments about using quadrupedal animal lumbar spines as models of bipedal human spine. In quadrupedal models, due to the absence of axial gravitation force, a mechanical asymmetry along the spine is required to initiate a scoliosis; on the other hand, bipedal models can mimic the human posture and are under the effect of similar forces due to gravity, which is thought to be a contributing factor to the development of scoliosis[30]. In quadrupedal animals, the spine is in the horizontal plane such that the loads on the vertebral bodies or discs are not on the axial compression. In the quadrupedal group, contrary to previous studies[8,31], there was a statistically significant increase in scoliosis incidence when the results in the 20th and 40th weeks were compared. This result may be supported with further studies and may show that bipedality is not mandatory in studies with C56BL/6 mice.-

During growth, the sagittal profile of the spine changes, and scoliosis may develop either due to lateral asymmetry of the spine or a primary rotational problem[31]. Idiopathic scoliosis is a three-dimensional deformity presenting with hypokyphosis in the sagittal plane[27]. The incidence of vertebral rotation and degree of kyphoscoliosis was increased in bipedal rats following the contralateral ilium tethering procedure[32], and selective brain stem damage in the quadrupedal rats[33]. Kyphoscoliosis was also seen in SHP2-deficient mice[34], but we failed to find any investigation about hypokyphosis in scoliotic mice. It was thought that kyphosis may be a factor for scoliosis progression[35]. In this study, we aimed to investigate the sagittal plane analysis of the spine and pelvis based on these findings. There was a decreasing tendency in terms of thoracic kyphosis and the pelvic incidence in all the groups, but we were unable to demonstrate any statistically significant difference. However, there was a significant increase in the spinosacral angle between the 20th and 40th weeks in all the groups, except the quadrupedal group, which may be due to adaptation to bipedality.

Study Limitations

Our study has some limitations and shortcomings. The number of mice in each group was not equal due to deaths. It may not possible to extend this study to humans because of the unknown effects of estrogen, RLX and NO. However, with the utility of estrogen, RLX and NO could reveal the possible mechanisms of AIS. On the basis of the current study, new medications for conservative treatment of AIS may be planned.

CONCLUSION

RLX may decrease scoliosis progression in a C57BL/6 mice model and increase bone mineral density. Unlike previous studies, the quadrupedal mice group had a tendency to increase scoliosis progression between the 20th and 40th weeks.

Ethics

Ethics Committee Approval: This study was approved by Hacettepe University Animal Experimentations Ethics Board (date: 12.07.2011, decision no: B.30.2.HAC.0.05.06.00/59).

Informed Consent: Experimental study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: R.E.A., H.G.D., Design: R.E.A., H.G.D., Data Collection or Processing: C.E.B., H.G.D., Analysis or Interpretation: C.E.B., İ.A., H.G.D., R.E.A., Literature Search: C.E.B., İ.A., Writing: C.E.B., İ.A., H.G.D.

Conflict of Interest: DePuy Synthes, Medtronic, AO Spine, Cotrel Foundation (REA).

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A SURGICAL ERROR RESULTING IN PROXIMAL JUNCTIONAL KYPHOSIS IN TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: The study aimed to investigate the incidence of painful proximal junctional kyphosis (PJK) after posterior fusion surgery in patients with adolescent idiopathic scoliosis (AIS) and their clinical results.

Materials and Methods: A total of 220 patients diagnosed with AIS (180 females and 40 males) were reviewed retrospectively. PJK was defined as the development of kyphosis more than 10 degrees between the upper instrumented end vertebra and the proximal adjacent vertebra. Visual analogue score (VAS) and the Scoliosis Research Society (SRS)-24 questionnaire were used for clinical evaluations. Thoracic kyphosis (TK) and lumbar lordosis (LL) were measured on the sagittal spinal radiograph pre and postoperatively. Computed tomography (CT) and magnetic resonance imaging (MRI) were performed on patients with pain and worst disability scores.

Results: The mean age was 15±2.4 years and the mean follow-up period was 24.27±11.69 months. PJK was detected in 20 of the 220 patients. TK changed from 35.5°±13.6° to 25°±7.3° postoperatively (p=0.001) while on observation, LL decreased from 53°±10° to 44.4°±7.8° postoperatively (p=0.001). The average score of the VAS average score was 3.2 (3-8), the mean SRS-24 pain was 2.5 and the self-image score was 4.1 in patients with PJK. In three of the 20 patients with PJK, the pain was severe (VAS=8), SRS-24 pain was on average 5 and the self-image score was three in patients who had disc penetration. CT and MRI evaluations in these three patients manifested severe disc degeneration and disc space collapse caused by pedicle screw penetration through the endplate and disc.

Conclusion: Upper disc penetration with pedicle screw at the upper instrumented end vertebra leads to symptomatic disc degeneration and development of PJK. The proper placement and perfect trajectory of the most proximal pedicle screw is crucial and mandatory.

Keywords: Proximal junctional kyphosis, posterior fusion, pedicle screw, adolescent idiopathic scoliosis

INTRODUCTION

Proximal junctional kyphosis (PJK) is defined as the development of kyphosis proximal to the instrumentation in the sagittal plane. It is regularly encountered after surgeries treating kyphosis, and there are reports in the literature about its occurrence after adolescent idiopathic scoliosis surgery[1-7]. PJK is an adjacent segment problem in the upper proximal region of the instrumentation level, and the incidence rate of PJK has been reported to be between 26% and 46% in the literature[1-7]. Howbeit, there is a controversy regarding the definition of PJK, the most commonly accepted definition is a sagittal angulation of more than 10 degrees between the upper instrumented level and the proximal adjacent vertebra.

The risk factors in PJK development include, increased kyphosis before the operation, thoracoplasty, autogenous grafting for early fusion, use of pedicle screws and the level of the distal fusion being lower than L2. Studies in the literature on PJK secondary to adolescent idiopathic scoliosis (AIS) emphasise that PJK development does not have a negative effect on the quality of life, and by itself does not indicate a revision. Kim et al.[2] have explained this with having mild adjacent segment degeneration in young patients. There is no adequate data on the indications for revision in patients with secondary PJK.

The aim of the study was to investigate the incidence of painful PJK after posterior fusion surgery patients with AIS and clinical results of these patients.

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MATERIAL AND METHODS

This study protocol was approved by the institutional review board of our institution. A retrospective study of patients with AIS who operated at a single institution was conducted. Inclusion criteria included; patients diagnosed with AIS, patients treated with posterior instrumentation and fusion using pedicle screw, had no previous spine surgery, full sets of preoperative and follow-up standing full-length anteroposterior, and lateral spinal radiographs including femoral heads and available medical records. Whereas patients who had previous spinal surgery, inadequate time for follow-up (minimum 12 months), had additional congenital deformities, diagnosed with neuromuscular disease, patients who underwent anterior spinal surgery, or osteotomy were excluded.

A total of 220 patients (180 females and 40 males) were included in the study. In all patients, the posterior ligamentous complex, facet capsule and soft tissue were preserved at the proximal end of the instrumentation. The proximal end pedicle screw was locked after correction without applying any correction force.

Concerning the sagittal plane analysis, a sagittal spinal radiograph was used to measure the thoracic kyphosis (TK), lumbar lordosis (LL) and central sagittal vertical line (CSVL). The development of kyphosis, more than 10 degrees, between the upper proximal instrumented level and the adjacent proximal vertebra was defined as PJK. Visual analogue score (VAS) and SRS-24 questionnaires were used to determine the correlation of clinical complaints. Computed tomography (CT) and magnetic resonance imaging (MRI) were performed on patients with pain and worst disability scores.

Statistical Analysis

All statistical analyses in this study were performed using SPSS version 24.0 (IBM Corp., Armonk, NY). Study data were evaluated using descriptive statistical methods. Test for normality of distribution done using the Shapiro-Wilk test. The significance level was set at 5%. Pre- and postoperative clinical and radiological results were compared using paired t-test.

RESULTS

Out of the 220 patients involved in this study, one hundred eighty patients were female and forty patients were male. The mean age was 15±2.4 years and the mean follow-up duration was 24.27±11.69 (12-80) months.

After surgery, TK changed from 35.5±13.6 degrees to 25±7.3 degrees on average (p=0.001), LL decrease from 53±10 degrees to 44.4±7.8 degrees on average (p=0,001) and CSVL was 11.89±43 mm and 11.4±34 mm on average, pre and postoperatively (p=0.727).

Although 5 degrees of PJK was seen in 30 patients, PJK defined as the development of the kyphosis angle more than 10 degrees was seen in 20 patients. The average VAS score was 3.2[(3-8)], the mean SRS-24 pain was 2.5 and self-image was 4.1 points. Three of those 20 patients had severe pain (VAS=8), and the mean SRS-24 pain and self-image were 5 and 3 points, respectively. CT and MRI evaluation in these three patients revealed severe disc degeneration and disc space collapse caused by pedicle screw penetration through the endplate and disc **(**Figure 1). These patients were noted to have acquired severe restriction of active range of motion of the cervical spine.

These three patients were advised to extend the fusion one segment up proximally under fluoroscopic control (Figure 2). Six weeks after surgery, the patients' complaints were resolved and their average VAS score was 2.7 points. However, the active range of motion of the cervical spine improved gradually three months after surgery.

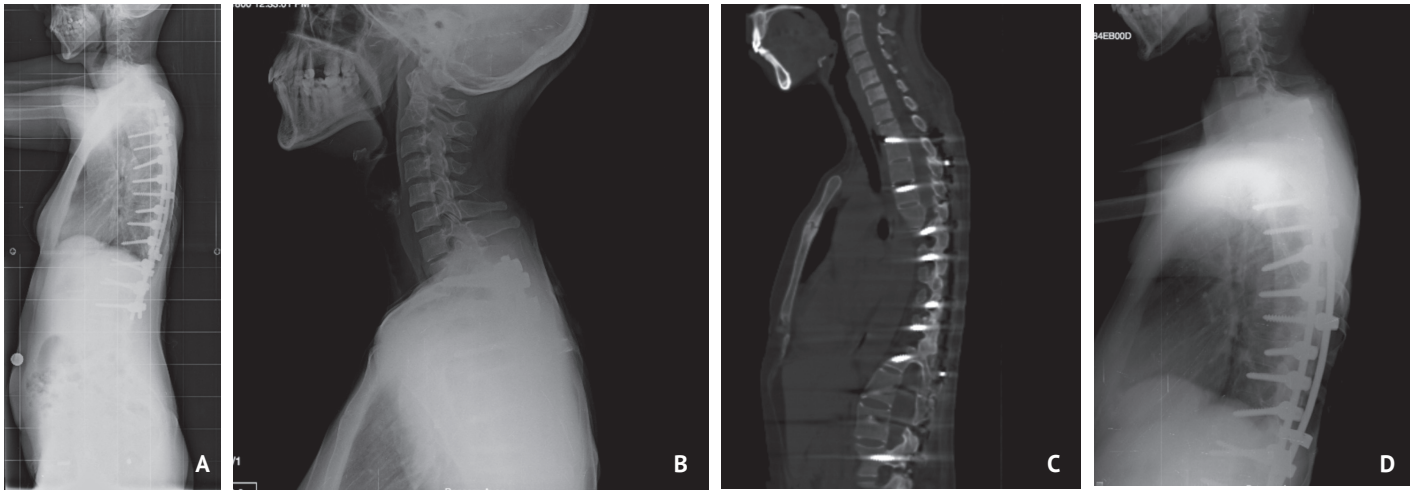

Figure 1. Patient underwent posterior fusion surgery that has pain at the cervicothoracic junction. The sagittal spinal radiograph showed proximal disc degeneration and kyphosis **(A, B).** CT examination showed disc space collapsed and pedicle screw penetration **(C).** Instrumentation was revised and lengthened one level above **(D)**

CT: Computed tomography

DISCUSSION

For the correction of spinal deformities, instrumentation through a posterior approach and fusion yielded successful outcomes. Nevertheless, the development of PJK in the vertebrae adjacent to the instrumented vertebra in rigid systems has emerged as a severe problem. In the literature, there is no established consensus on the diagnosis and incidence of PJK.

Lee et al.[7], in their study, have reported an incidence of 46% while the latest studies report it to be 26%[2,5,7,8]. PJK after surgery for AIS has been defined by Lee et al.[7], to be the development of kyphosis more than 5 degrees proximal to the implant. Whereas, Glattes et al.[6] defined it as the angle between the first instrumented vertebra endplate and the adjacent proximal vertebra upper endplate being more than 10 degrees. Helgeson et al.[5] recommend that the threshold should be 15 degrees, and the measurement should be performed between the endplates of two proximal vertebrae. The reported rates of PJK differ depending on the definition. Considering the published spectrum of PJK definition in AIS, in our series of patients, the incidence of PJK after surgery was determined to be 13%.

PJK development after adult spine deformities was investigated in more detail, and risk factors were determined. These factors included patients older than 55 years of age with combined anterior and posterior surgery, independent of surgical errors[9], increased kyphosis before the operation, thoracoplasty, autogenous grafting for early fusion, use of pedicle screws and the level of the distal fusion being lower than L2[1-7]. In our series, patients who needed revision surgery did not have any of the risk factors reported in the literature, but PJK was developed based on disc degeneration and loss of disc height.

Disc degeneration and penetration of the pedicle screws into the disc were demonstrated with MRI scans. Although the literature suggests that revision is not needed in patients with secondary PJK; however, revision surgery is necessary for pain relief when PJK is accompanied by disc degeneration and collapse. Surgical inclusion of the degenerated and painful proximal disc and segment into the fusion area resulted in significant relief of the patients' complaints.

Meter et al.[10] have shown in their cadaveric studies that in order for the pedicle screws inserted, especially at the lumbar area, not to cause endplate damage, the tip must lie at least 3 mm from the endplate. In their anatomic study, Melrose et al.[11] have demonstrated disc degeneration with mechanic destabilisation through injuring annulus fibrosis. Notwithstanding, although Meter et al.[10] have advised that pedicle screws cause centripetal

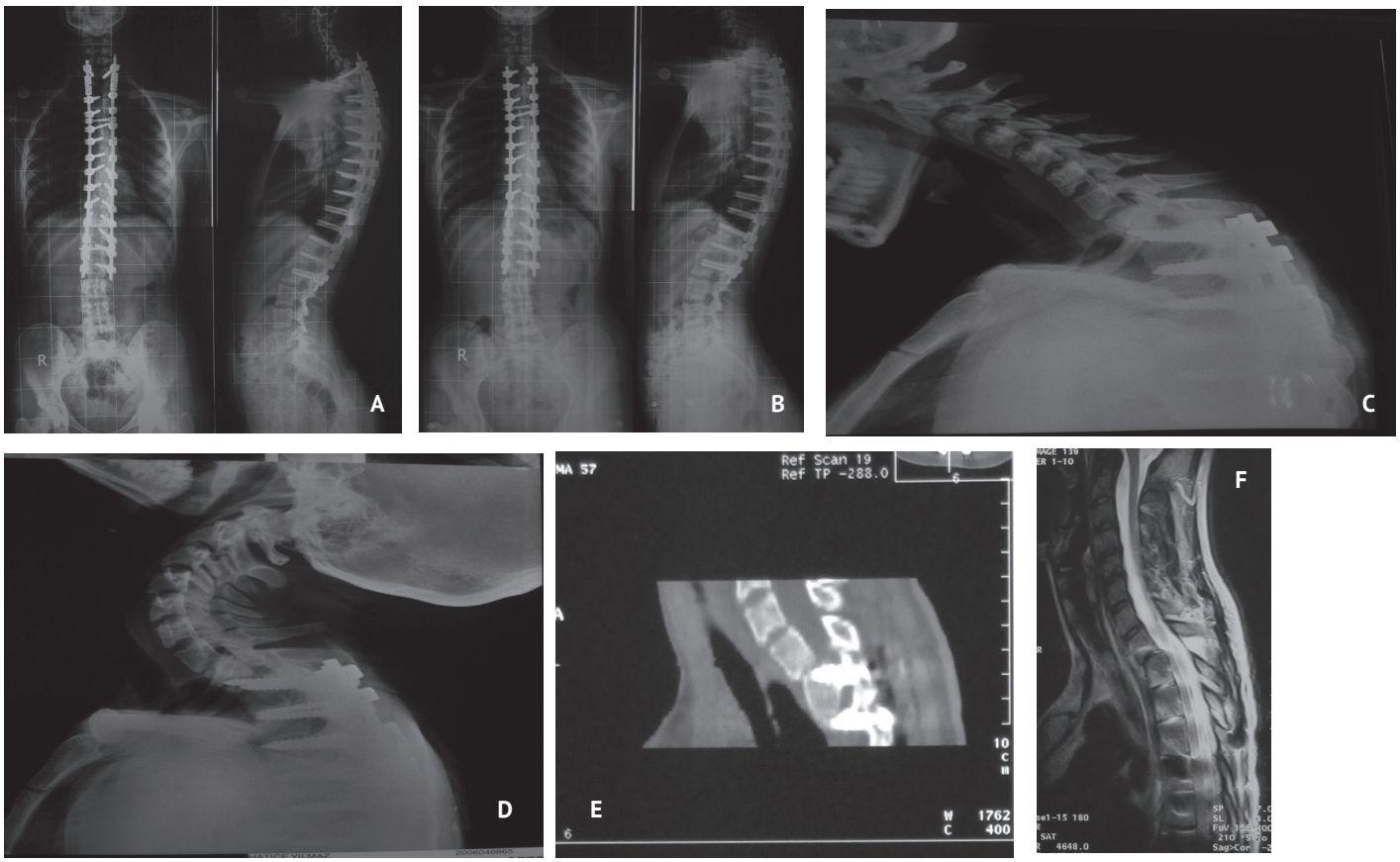

Figure 2. Another patient with PJK and cervical pain diagnosed at follow-up visit **(A)**. Lateral flexion and extension radiographs of cervical spine showed no major instability at the PJK side **(B,C).** CT and MRI showed disc space collapsed and screw penetration at most proximal side **(D, E).** Patient who underwent revision surgery **(F)**

PJK: Proximal junctional kyphosis, CT: Computed tomography, MRI: Magnetic resonance imaging

damage and in turn prevents the release of phospholipase located in the nuclear substance, and the presence of a metallic screw inside the disc causes damage to it, the consequences of these in the mobile discs could not be clearly understood. In our study, pedicle screws penetrating the endplate and the disc consistently resulted in symptomatic degeneration and loss of height. Even if centripetal, the presence of metallic materials in the disc causes disc degeneration characterised by pain.

Study Limitations

There were some limitations in the study. Firstly, it is a retrospective study with a small number of patients. Secondly, other sagittal spinal measurements, such as pelvic tilt, sacral slope and cervical lordosis, were not investigated pre and postoperatively. Thirdly, the follow-up period was shorter. Patients may develop the PJK for a long time after the surgery. And finally, we did not classify our patients according to the Lenke classification system; thus, our cohort was not homogeneous.

CONCLUSION

We emphasised that, utmost care should be taken while using the pedicle screws to ensure a perfect placement and trajectory of it at the uppermost vertebra to avoid penetration of proximal adjacent endplate and disc, to prevent the development of painful PJK and the need for revision surgery. The use of proper imaging is crucial during the insertion of these specific pedicle screws.

Ethics

Ethics Committee Approval: Since the nature of our study was retrospective, study was conducted with institutional review board approval, not ethics committee.

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: T.A., Design: S.B, Data Collection or Processing: Ş.K., M.A., Analysis or Interpretation: C.G, Literature Search: Y.Z, T.A, U.T, Writing: T.A., S.B.

Conflict of Interest: The authors declare that they have no conflict of interest.

Financial Disclosure: There is no funding source.

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EFFECTIVENESS OF PATIENT-SPECIFIC THORACOLUMBAR BRACE TREATMENT FOR ADOLESCENT IDIOPATHIC SCOLIOSIS: A PROSPECTIVE COHORT STUDY

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ABSTRACT

Objective: The efficacy of bracing for patients with adolescent idiopathic scoliosis (AIS) remains controversial. We aimed to evaluate the effectiveness of patient-specific thoracolumbar brace treatment in patients with AIS who met the Scoliosis Research Society inclusion criteria and the factors affecting success rate.

Materials and Methods: From April 2015 to February 2018, 25 patients diagnosed with AIS treated with patient-specific thoracolumbar brace were asked to participate in this study. The initial brace correction rate and clinical outcomes of the main curvature was evaluated. The clinical course of bracing was considered progression if there was ⩾6° curvature increase and improvement if there was ⩾6° curvature decrease. The success rate was correlated with age, sex, Lenke classification, Risser grade, initial Cobb angle and rotation grade.

Results: The curvature progressed and improved in 13 and two cases, respectively, and the curve remained unchanged in 10 cases. A success rate of 48% (12/25) was achieved. Moreover, only three of 25 cases with Cobb angle of 45° were considered candidates for surgery. The mean pre-brace Cobb angle of the main curvature was 27.9°±6.7°, which ranged from 20° to 37°. The duration of bracing was 37.2 (6-76) months. The mean Cobb angle at the end of the treatment was 32.1°±8.2°, which ranged from 15° to 45°. No correlation was found between age, Risser grade and brace treatment success. However, treatment success was significantly correlated with initial Cobb angle, rotation grade and Lenke classification (main thoracic) ($p<0.001$, $r=0.680$; $p=0.028$, $r=-0.458$; $p=0.020$, $r=0.481$, respectively).

Conclusion: Patient's age, Risser grade and sex were not related with successful results of brace treatment. However, the initial Cobb angle, rotation of the apical vertebra and Lenke classification were significantly correlated with successful brace treatment.

Keywords: Brace treatment, patient-specific thoracolumbar brace, adolescent idiopathic scoliosis, conservative treatment

INTRODUCTION

The treatment for scoliosis remains debatable, especially for patients with adolescent idiopathic scoliosis (AIS) with Cobb angle of 10°–25°. Rehabilitative activity and bracing are accepted in various studies as conservative treatment protocol[1-3]. Bracing is initiated for patients with curvature of 20°–30° and ⩾5° improvement of the curvature occurs during subsequent visits. Notwithstanding, when a patient is skeletally immature (Risser grade ⩽2) and presented with a 30°–45° curve, bracing is suggested at the first visit[4]. At the Osaka Medical College, several braces have been recommended, such as Boston, Milwaukee, Wilmington, soft braces (SpineCor/TriaC) and night-time braces (Providence/Charleston)[3]. The implementation of orthopaedic braces could be propitious for restraining curvature progression in patients with AIS[5]. As regards bracing, the percentage of in-brace correction and brace wearing time can affect the outcome of bracing[6]. Each brace should be assessed separately because various kinds of braces yield different results[7,8]. It was thought that brace treatment success is related to patients' compliance and usage time. In the literature, patient-specific thoracolumbar brace was reported to have satisfying outcomes. However, the success rate depends on the patients' compliance. In this study, we aimed to evaluate the effectiveness of the patient-specific thoracolumbar brace treatment in patients with AIS and the factors influencing the success rate.

MATERIALS AND METHODS

This prospective therapeutic study was conducted at our clinic from April 2016 to February 2018. Patients with diagnosis of progressing idiopathic scoliosis were asked to participate in this study. Ethics committee approval was acquired for this research from the ethics board of İstanbul University, İstanbul Faculty of Medicine (2018/1500). Written informed consent was obtained from patients and parents of children who participated in

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this study. A prospective cohort study was then performed to evaluate the effectiveness of patient-specific thoracolumbar brace in the treatment of AIS.

The inclusion criteria were as follows: patients who met the Scoliosis Research Society (SRS) inclusion criteria which consist of age ⩾10 years upon prescription of the brace, Risser 0–2, primary curve angles of 25°–40°, no prior treatment and, if female, either premenarche or less than 1 year postmenarche[9], and a minimum of 2 years follow-up.

The exclusion criteria were history of brace treatment and comorbidities that change the course of AIS such as genetic defects, neuromuscular disorders, metabolic disorders, and history of severe trauma.

Patient-specific thoracolumbar braces were fabricated, and functions that consisted of pressure pad placements were ensured by the same certified orthotist. A plaster cast was taken to capture the body shape of each patient with an underarm position. In addition, standing anteroposterior (AP) X-ray images were used to confirm in-brace correction and full spinal alignment, including the pelvis, while the brace was being worn (Figure 1). The correction magnitude threshold was >50% reduction of the initial Cobb angle. At the beginning of bracing, patients were instructed to wear the brace for a minimum of 23 hours per day. Bracing was stopped at 1 year after skeletal maturity was reached. Skeletal maturity was achieved if all of the following three criteria were fulfilled: Risser stage 4, at least 2 years after the onset of menstruation (for girls) and two consecutive visits for at least 1 year with no more than a 1-cm increase in height.

Figure 1. The photo was showed that the patient treated with patient specific thoracolumbar brace

At the beginning of the treatment, 25 patients with AIS (22 girls and three boys) aged 11.4±1.19 years (range: 10–14) were analysed. X-ray imaging was done before the start of treatment, while the brace was worn, before and after each use of subsequent braces and at skeletal maturity (after brace wearing). In-brace X-ray images were taken 6 weeks after the start and 6 months after the bracing period to determine 'skeletal maturity' values. All Cobb angle analyses were done by the senior author (TA). After combining curve types into main thoracic and main lumbar, 10 patients were considered to have main thoracic curves (Lenke I, II, or III), and the remaining 15 patients were ascertained to have main lumbar curves (Lenke V or VI). The rotation of the apical vertebra was also measured using the Nash and Moe method, which was based on the relationship between the vertebral pedicles and the centre of the vertebral body in the AP X-ray view[10]. Rotation was classified in five degrees according to the removal of the pedicles. No vertebral rotation was identified if the pedicles are halfway to the lateral margins of the vertebral bodies and considered at 0°. As the projection of the pedicle of the apical vertebra moves towards the median line in the AP view, the rotational degree progresses in the evaluation scale, reaching the most significant value (degree IV) when it crosses that line. The clinical outcome was assessed based on the SRS criteria. According to the Cobb angle on standing AP spine X-ray images, which obtained with the patients not wearing the brace, were classified as follows: (1) improved, decrease in the Cobb angle by ⩾6°; (2) stable, no more than 5° of progression or improvement; (3) progressed, increase in the Cobb angle by ⩾6° and (4) progression with Cobb angle ⩾45° was considered candidates for surgery.

Statistical Analysis

Statistical analysis was conducted using the SPSS statistics version 24.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean, standard deviation, median, frequency, ratio, minimum and maximum) were used to evaluate the study data. Student's t-test was used to differentiate two groups of quantitative data with normal distribution, and the Mann-Whitney U test was used to compare two groups of data with non-normal distribution. Pearson chi-square test, Fisher-Freeman-Halton exact test and Fisher's exact test were used to compare qualitative data; with a significance level set a priori at $p<0.05$ A p value less than 0.05 was deemed to be statistically notable.

RESULTS

The first series involved 25 patients (three boys, 22 girls). Three patients underwent scoliosis surgery. The curvature type were main thoracic (n=8), thoracolumbar (n=10), lumbar (n=5), double major (n=1) and double thoracic (n=1). Risser stage was grade 1 in eight, grade 2 in eight and grade 2-3 in nine cases. The apexes of the main curves were higher than T7 in four patients (T6 in four patients) and lower than T7 in 11 patients (T8 in four, T9 in three, T10 in one, T11 in one, T12 in two, L1 in two, L2

in five and L3 in three cases). The mean pre-brace Cobb angle of the main curves was 27.9°±6.7°, which ranged from 20° to 37°. The duration of bracing was 37.2 (range: 16-76) months. The mean Cobb angle at end of the treatment was 32.1°±8.2°, which ranged from 15° to 45°. According to Nash and Moe classification, 12 patients had grade 1, six had grade 2, two had grade 3 and four had grade 4 rotation.

At the last follow-up, the curve progressed in 13 cases, improved in two cases and remained unchanged in 10 cases (Figure 2 A, B and Figure 3 A, B). A success rate of 48% (12/25) was accomplished. Furthermore, only three of 25 cases that progressed beyond Cobb angle of 45° were admitted as candidates for surgery.

No correlation was found between age, Risser grade and thriving brace treatment outcome. However, successful treatment was significantly associated with the initial Cobb angle, rotation grade and Lenke classification (main thoracic) ($p<0.001$, $r=0.680$; $p=0.028$, $r=-0.458$; $p=0.020$, $r=0.481$, respectively).

DISCUSSION

In this study, we used age and simple morphologic classifications (Cobb, Lenke classification and Risser grade) and demonstrated successful treatment of AIS using patient-specific thoracolumbar brace and the relationship between uncomplicated parameters and brace benefit. Thompson et al.[11] reported a comprehensive series managed with thoracolumbosacral orthosis brace in 168 patients. In their study, the rate of surgery or improvement to ≥50° was 35.8% (43 of 120) in patients with persistent main thoracic curves, 20.0% (6 of 30) in patients with persistent main lumbar curves, 12.5% (1 of 8) in patients with main thoracic curves that converted to main lumbar curves, and 0% (0 of 9) in patients with main lumbar curves that became main thoracic curves ($p=0.0383$). The thoracic curves are at higher risk for brace failure than the lumbar curves regardless of the comparable primary curve magnitudes and average daily duration of wearing brace. Our study found a notable distinction between the main thoracic and main lumbar curves, that is, patients with thoracic curves had a higher success rate. We observed that rotation is also correlated with a thriving rate.

Previous clinical studies have highlighted that curve progression is associated with younger age[12,13]. Nevertheless, various studies have found no relationship between age and curve improvement. Cheung et al.[13] presented a large series of 586 patients with mean brace-wear duration of 3.8±1.5 years and a post-wearing follow-up duration of 2.0±1.1 years. They found that curve progression was correlated with younger age [odds ratio (OR): 0.71 (95% confidence interval (CI): 0.55 to 0.91];

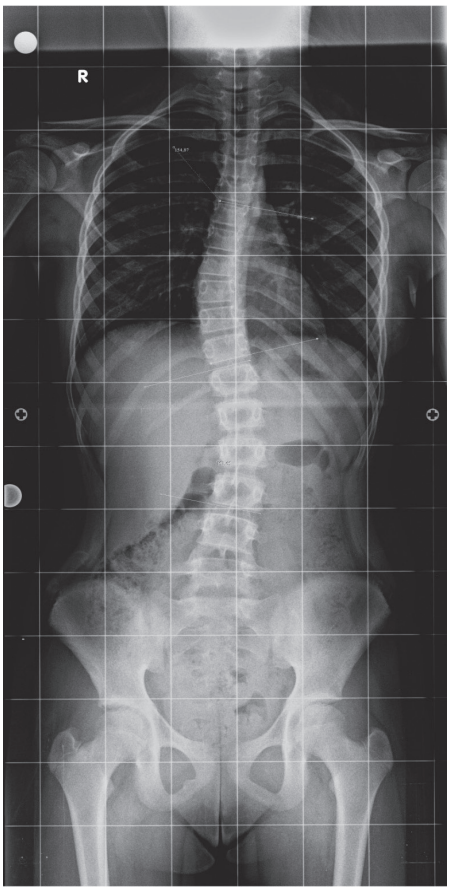

Figure 2A. Standing anteroposterior radiograph of the patient before beginning of the patient specific thoracolumbar brace

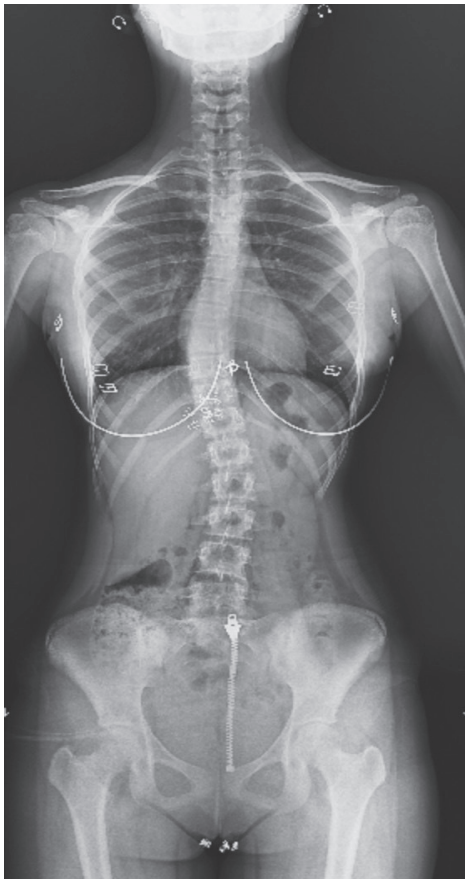

Figure 2B. The brace has been removed. The patient was successful treated with patient specific thoracolumbar brace

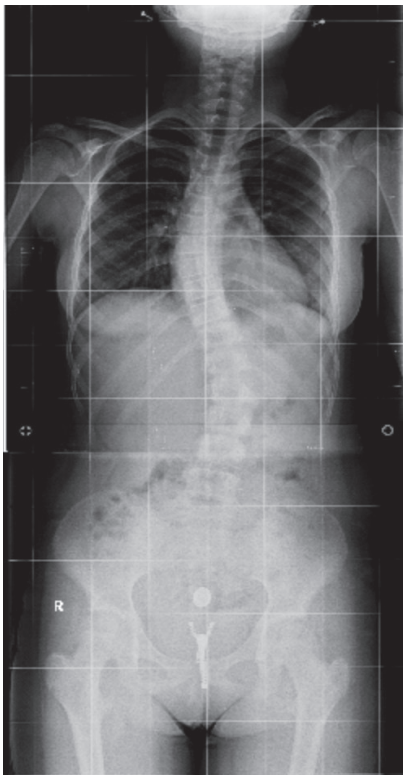

Figure 3A. Standing anteroposterior radiograph of the patient before beginning of the patient specific thoracolumbar brace

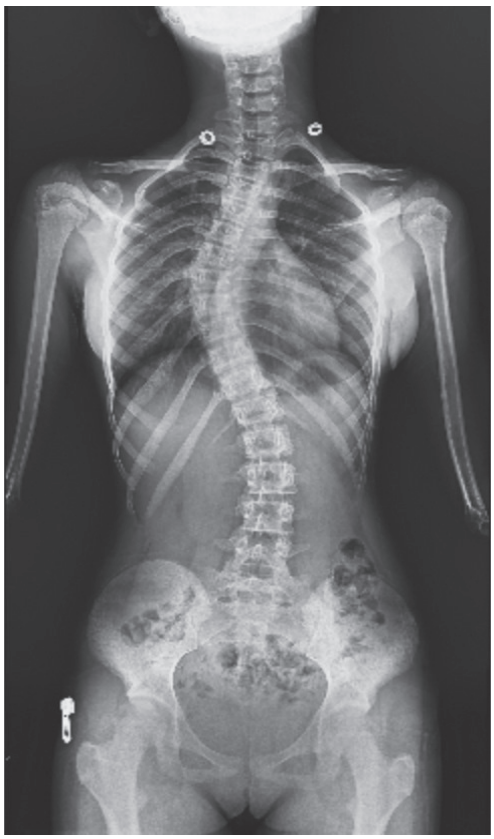

Figure 3B. The brace has been removed. The curve was progressed in this patient

p=0.008]. Yrjönen et al.[14] described 102 patients with AIS using Boston brace and reported that patient's age, curve pattern, or curve magnitude did not have a statistical influence on the risk of progression. Peltonen et al.[15] examined 107 patients with idiopathic scoliosis using Boston brace and average follow-up of 3 years. In their analysis, no correlation was found between patients' age at the start of the treatment and outcome. In our study, we have not obtained a relationship between age and curve increase.

Another main factor on the treatment AIS using brace is the initial curve. First, Emans et al.[16] advised that a Boston brace with a higher primary curve magnitude enhanced the potential for surgery. Katz and Durani et al.[17] found that double curves, with an initial thoracic curve >35°, are more likely to progress. On the contrary, Ovadia et al.[18] reported that low baseline Cobb angle values are linked to a more limited progression rate, but they did not find a statistically significant correlation. Kuroki et al.[19] found that Cobb angles of 20°–30° were not significantly associated with lower success rate than angles >30°, so they reported that curve magnitude is not associated with treatment success. Van den Bogaart et al.[20] performed a systematic review of moderate scientific evidence that the initial Cobb angle was not related with treatment failure and inadequate evidence of treatment success. In the present study, we found a notable correlation between the primary Cobb angle and successful treatment.

Study Limitations

This study has several limitations. First, this study has a small sample size. Second, the follow-up time was relatively short. Third, the number of male patients was higher than that of female patients to correlate sex with brace success. Given our small sample size, we did not measure the Risser stage, which has been shown to influence brace success. Finally, the average hours of daily wearing of brace were not assessed, which was considered to influence brace compliance and success.

CONCLUSION

The patient-specific thoracolumbar brace treatment for AIS in skeletally immature patients could significantly decrease the increase in curve angle to the threshold for surgical intervention. Patient's age, Risser grade and sex were not related to optimum brace treatment outcomes. The initial Cobb angle, rotation of the apical vertebra and Lenke classification were significantly correlated with the spread of brace treatment.

Ethics

Ethics Committee Approval: Ethics committee approval was acquired for this research from the ethics board of İstanbul University, İstanbul Faculty of Medicine (2018/1500).

Informed Consent: Written informed consent was obtained from patients and parents of children who participated in this study

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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

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

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THE EFFICACY OF SURGICAL TECHNIQUES FOR CERVICAL SPONDYLOTIC MYELOPATHY ON FUNCTIONAL OUTCOME, RECOVERY AND PATIENT SATISFACTION

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ABSTRACT

Objective: Cervical spondylotic myelopathy is a neurological condition that develops due to degenerative changes of the spine resulting in compression of the spinal cord and its vascular structures. It is the most common form of spinal cord injuries in adults; however, its diagnosis is often delayed due to the insidious progression of the disease. We investigated the functional outcome, recovery and satisfaction of patients undergoing surgical treatment in our clinic.

Materials and Methods: The study included patients who were operated for spinal stenosis caused by cervical spondylosis. The patient's age, sex, admission complaint, duration of complaint, comorbidities, neurological examinations and gait performances were evaluated, measured by the Nurick Scale. The spinal cord was examined with the preoperative Magnetic Resonance imaging. The operative times, surgical techniques, complications, post-discharge follow-up durations, functional outcomes and long-term complaints of the patients were analysed. We divided the patients into four groups according to the surgical technique.

Results: A total of 50 patients were operated, of which 38 were males and 12 were females (M/F=3.16), with a mean age of 68.8 years. Of these patients, 24 (48%) underwent only laminectomy (group 1), six (12%) underwent laminectomy and fusion (group 2), 17 (34%) underwent corpectomy and anterior fusion (group 3) and three (6%) underwent combined surgery (group 4). Recovery was seen in 60% of all the patients, while 6% had deterioration in myelopathy. The patients in group 1 had the shortest operative time and length of hospital stay, while those in group 2 had the highest satisfaction and recovery rate (83.33%).

Conclusion: Age, duration of symptoms and neurological condition at admission are the most important determinants of the response to treatment. Patients who are clinically and radiologically diagnosed should be treated with surgery as soon as possible, and restoration of cervical alignment, decompression and if necessary, fusion should be effectively performed in the surgery.

Keywords: Cervical spondylotic myelopathy, corpectomy, laminectomy, stenosis, spinal cord

INTRODUCTION

Cervical spondylotic myelopathy (CSM) is a poor neurological condition that develops due to degenerative changes of the spine resulting in compression of the nearby spinal cord over time. The most common cause of spinal cord dysfunction in adults worldwide is CSM[1,2], and it typically presents with decreased hand skills, gait and balance difficulties caused by dysfunction in fine motor movements. In the progression of the disease, slow, gradually increasing upper and lower extremity sensorimotor dysfunction and sphincter dysfunction occur; yet, in very few cases, rapid neurological deterioration may occur[3]. The incidence of CSM is likely to increase with increasing age in accordance with its degenerative aetiology.

It is well known that in CSM, an effective treatment option is surgical decompression of the spinal cord, as it does not only halts the progression of symptoms, but also shows a significant functional improvement in a considerable proportion of individuals treated[4,5]. Pathologies located in the anterior or posterior spinal canal can be the cause of spondylotic spinal compression and accordingly, surgical decompression can be performed using an anterior or posterior surgical approach. Anterior surgery is typically performed in the form of anterior cervical discectomy and fusion or corpectomy and fusion. Posterior surgery refers to laminoplasty or laminectomy with or without fusion[3].

Although it is generally safe and effective, 11-38% of CSM patients treated surgically develop complications[6,7]. These include dysphagia, C5 radiculopathy, wound infection, axial pain

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and postoperative (post-op) kyphosis[8]. Today, it remains unclear as to whether multi-level spondylotic cervical spinal stenosis can best be treated with the anterior or posterior surgical approach and whether each of these surgical approaches is superior in terms of patient outcomes or complication rates. The aim of this study is to investigate the effects of the surgical techniques used in patients with CSM operated in our clinic on complication, recovery and patient satisfaction.

MATERIALS AND METHODS

Our study included only patients who were operated for spinal stenosis caused by cervical spondylosis. The exclusion criteria in our study involved patients with spinal stenosis who were operated for trauma, tumour and other aetiologies. The patients' age, sex, admission complaint, duration of complaints, systemic diseases and neurological examinations were evaluated. Their gait performances were evaluated according to the Nurick scale. Stenosis levels and the presence of myelomalacia were examined with the preoperative (pre-op) magnetic resonance imaging (MRI) examinations of the cervical vertebra. The operative times, surgical approaches, number of decompressions, peroperative (per-op) and post-op complications, post-discharge follow-up durations, functional outcomes and long-term complaints of the patients were analysed. In addition, the post-op length of hospital stay, complications, functional outcomes and long-term complaints of the patients were analysed according to surgical approaches. The patients were divided into four groups according to the surgical technique: group 1 (laminectomy without fusion), group 2 (laminectomy and fusion), group 3 (anterior corpectomy and fusion) and group 4 (combined surgery).

This study was approved by Başkent University Medicine and Health Sciences Research Committee (94603339-604.01.02/845).

Selection of the Surgical Technique

When CSM is diagnosed, the type of treatment is discussed. The treatment of CSM should be with surgery or conservatively. CSM is generally considered a surgical disease, because symptoms tend to worsen in natural course. Therefore, in our clinic, all cases of CSM with clinical and radiological consistency were treated with surgery.

The surgical treatment of CSM is performed by anterior, posterior or combined approach, depending on the specific pathology. The patients with 1 to 2 vertebral level kyphosis or ossification of the posterior longitudinal ligament were generally operated with an anterior approach. The patients with >3 levels of cervical stenosis, posterior compression or congenital stenosis, laminectomy and posterior fusion were generally performed.

Statistical Analysis

Statistical analysis was performed using the statistical package SPSS software (Version 17.0, SPSS Inc., Chicago, IL, USA). If the continuous variables were normal, they were described as the mean ± standard deviation [$p>0.05$ in Shapira-Wilk ($n<30$)], and if not normal, they were described as the median. Comparisons between groups were applied using Kruskal-Wallis test, used for data not normally distrubited. The chi-square test or Fisher's exact test. Test was used to analyse the catagorical variables between the groups. Values of $p<0.05$ were considered statistically.

RESULTS

A total of 50 patients were operated in our hospital between 2014 and 2019 of which 38 were male and 12 were female (M/F=3.16). The mean age was 68.8 years (43-85). The most common admission complaints were simultaneous weakness in the arms and legs, difficulty in walking, arm pain, weakness only in the legs, weakness only in the arms, weakness on one side of the body and spasticity. The mean time from onset of symptoms to presentation was 8.8 months (2 days-60 months). The patients' personal history evaluated revealed that the most common systemic disease was diabetes mellitus (DM) with 34% of the patients (n=17), followed by coronary artery disease (n=15), and hypertension (n=15).

The neurological examinations of the patients revealed that 35 patients (70%) had pathological reflex (Hofmann, Clonus and Babinsky), while 23 (46%) patients had quadriparesis, eight (16%) patients had paraparesis, eight (16%) patients had monoparesis, four patients (8%) had hemiparesis and two patients (4%) had spastic paraparesis. Of the patients, 10% were grade 0, 16% were grade 1, 8% were grade 2 and 66% were grade 3 and 4 according to the Nurick scale. None of the patients was grade 5 (Table 1). During the outpatient clinic

Table 1. Our patients were evaluated according to the Nurick scale (Evaluation 0 to 5 Points) preoperatively. Of the patients, 10% were grade 0, 16% were grade 1, 8% were grade 2 and 66% were grade 3 and 4 according to the Nurick scale. None of the patients was grade 5

Grade	Description	Our cases
0	Signs and symptoms of root involvement without spinal cord disease	10%
1	Signs of spinal cord disease without difficulty in walking	16%
2	Slight difficulty in walking that does not prevent full-time employment	8%
3	Difficulty in walking that prevents full-time employment or daily life without requiring assistance with walking	
4	Ability to walk only with assistance	66%
5	Chair bound or bedbound	-

admission of the patients, the MRI of the cervical vertebra performed showed that 32 (64%) patients had myelomalacia of the spinal cord. Of the patients, 25 (50%) had spinal stenosis at 2 levels, 20 (40%) at 3 levels and 5 (10%) at 1 level. Spinal stenosis was most commonly observed at C4-5 (80%), followed by C5-6 (64%), C3-4 (48%) and C6-7 (34%).

Of the patients, 24 (48%) underwent laminectomy without fusion (group 1), six (12%) underwent laminectomy and fusion (group 2), 17 (34%) underwent corpectomy and anterior fusion (group 3), three (6%) underwent anterior and posterior decompression and fusion (group 4) (Figure 1). Decompression was performed at 2 levels in 19 patients, 1 level in 17 patients and 3 levels in 14 patients. The mean operative time of the surgical groups was examined in minutes (min). The mean operative time was 102.5 minutes in group 1, 210 minutes in group 2, 175.2 minutes in group 3 and 220 minutes in group 4 (Table 2). There was a statistically significant difference (p=0.001) in the mean operative time of the surgical groups. In addition, the shortest post-op length of hospital-stay (3.66 days) was found in group 1, although this was not statistically significant (p=0.572). Considering the per-op and post-op complications of all the patients, this rate was 10%. Two of the patients who underwent only laminectomy were re-operated due to spinal cord oedema and haematoma at the operation site after post-op 24 hours, and two of the patients who underwent corpectomy and anterior instrumentation were re-operated due to hematoma at the operation site (post-op 2nd day) and corpectomy cage shift (post-op 4th day). Moreover, one of the patients who underwent laminectomy and fusion peroperatively developed dural tear, which was repaired in the same session (Table 2). Complication rates were not statistically significant (p=0.978).

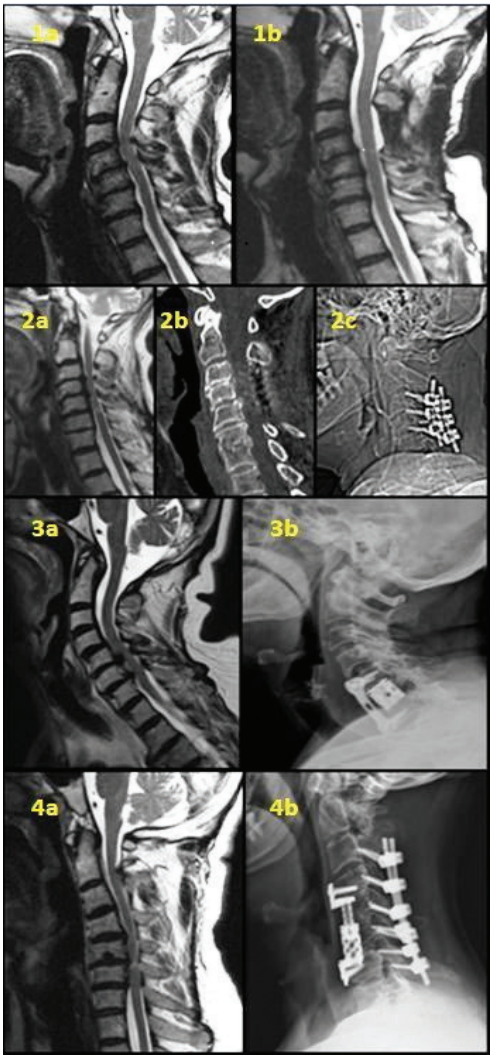

Figure 1. Case samples from groups; **1a, b:** Preoperative and post-operative MRI images of one patient who underwent laminectomy (group 1), **2a, b, c:** Preoperative MRI and postoperative CT control of a patient who underwent laminectomy and posterior fusion (group 2), **3a, b:** Preoperative MRI and postoperative X-ray control of a patient who underwent anterior corpectomy and fusion (group 3), **4a, b:** Preoperative MRI and postoperative X-ray control of a patient who underwent anterior and posterior decompression and fusion (group 4)

MRI: Magnetic resonance imaging, CT: Computed tomography

The mean post-discharge follow-up period of the patients was 12.82 (1–48 months) months. The post-discharge follow-up analysis of all the patients with CSM revealed that, of the patients, 30 (60%) achieved complete recovery, nine (18%) achieved partial recovery and 5 (10%) got worse compared to the preoperative period (increase in motor loss in three patients, spasticity in two cases), while six (12%) had no change compared to the pre-op period. The complete recovery rates of the surgery groups were as follows, 83.33% of group 2 and 70.58% of group 3 showed complete recovery, while this rate in group 1 was 41.1% (Table 2). There was no significant difference of recovery rates between surgical groups in this context (p=0.657). One patient died of acute coronary syndrome (ACS) 7 days after discharge. We determined that nine (18%) patients developed neuropathic pain complaints in our long-term follow-up, more than half of whom (five patients) were in the group treated with only laminectomy, and appropriate medical treatment was given to these patients.

DISCUSSION

The most common cause of spinal cord dysfunction in individuals older than 55 years is CSM[9]. Cervical spondylosis is a progressive disease characterised by degenerative changes affecting the vertebrae, intervertebral discs, facets and associated ligaments. These changes accelerate CSM by causing narrowing of the canal vertebralis diameter and direct compression of the spinal cord and/or surrounding blood vessels[10]. Disruption in blood supply to the spinal cord tissue, further increasing neuronal injury is caused by the vascular involvement. The disease can result in long-term disability and severe neurological disorders. Early and effective treatment before irreversible spinal cord injury develops is important to maintain the quality of life of these patients.

Table 2. Operative times, complications, post-op length of hospital stay and treatment outcomes of patients by surgeries

	Number of patients (n)	Operative time (min) (p=0.001)	Complication (n) (p=0.978)	Length of stay (day) (p=0.572)	Outcome (%) (p=0.657)
Group 1	24	102.5	2	3.66	Complete recovery: 41.66 Partial recovery: 25 No change: 20.83 Worsening: 12.5
Group 2	6	210	1	5.16	Complete recovery: 83.33 Partial recovery: - No change: - Worsening: 16.66
Group 3	17	175.2	2	4.58	Complete recovery: 70.58 Partial recovery: 11.76 No change: 5.88 Worsening: 5.88
Group 4	3	220	-	6.33	Complete recovery: 66.66 Partial recovery: 33.33 No change: - Worsening: -

post-op: Postoperative

The progression of cervical myelopathy is often insidious although it is seen only in a small portion of patients with spondylosis. The natural course of CSM is variable. Some patients show a gradual worsening, while others have a long silent period. Minor and major traumas that may occur in the presence of cervical spondylosis can cause acute clinical deterioration and central cord syndrome. The symptoms of some of the patients in this study had started within 1 month, and their condition had worsened within days.

Patients usually present gait disturbance and fine motor dysfunction since the spinocerebellar and corticospinal pathways are affected in the first place[11]. Therefore, patients exhibit hand numbness and hand motor dysfunctions, a wide-based and ataxic gait and inability to perform tandem standing during the initial assessment. Neurological examination shows lower motor neuron findings at the highest stenosis level and upper motor neuron findings at lower levels. Positive Hoffman, Clonus and Babinski reflexes and motor weakness are frequently encountered[12]. In this study, the most common admission complaints of the patients were weakness in the arms and legs and walking difficulties, while pathological reflexes such as motor weakness with 78%, Hoffman, Clonus and Babinski reflexes with 70% were observed.

Nurick[13] in 1972 published the original symptom severity scale for CSM and was based only on gait disturbance. In recent years, this scale has been considerably replaced by a more holistic rating system, called the Japanese Orthopaedic Association Myelopathy Evaluation Questionnaire (JOA scale) [14]. The Nurick scale is still very much in use to assess the effect of gait dysfunction on daily life activities however, the JOA scale has become the preferred rating scale to assess overall patient weakness. We found out using the Nurick scale that, 66% of the patients were grade 3 and 4 in the pre-op period.

Neurological changes developing with DM cause axonal damage in the spinal cord. Sensory findings usually include proprioceptive loss and loss of glove-like sensations in the hands that can be confused with DM or concomitant peripheral neuropathy[10]. The JOA scale scores of those with DM were lower than those of other patients was the discovery of a study evaluating patients with CSM who were recently treated surgically[15]. In our study, 34% of the patients had DM. Nine of the patients had neuropathic pain in post-op course and three of these patients had DM previously. Complaints such as neuropathic pain and sensory loss can be of DM origin. Electromyography (EMG) can be used to confirm this, but some patients in our study did not have EMG examination.

A very important method to confirm the diagnosis of CSM by imaging. Plain radiographs, computed tomography (CT) and MRI with or without myelography can be used to evaluate spinal canal narrowing and pathological vertebral changes. Plain radiographs are usually taken before advanced modalities because they are cheaper, faster and expose the patient to less radiation. However, due to the non-invasive nature, high resolution and ability to show soft tissues in detail of MRI, it is preferred for precise evaluation[16]. Sometimes, an increased T2 signal is visualised in the spinal cord on MRI. This condition, which we call myelomalacia, suggests spinal cord injury and permanent damage due to spinal cord compression or recurrent trauma[12]. In our study, pre-op MRI examination was performed in all the patients, and myelomalacia was visualised in 64% of the patients. Pre-op CT examination was also performed in patients who were considered to have posterior longitudinal ligament ossification (PLLO), osteophyte formation and facet hypertrophy to evaluate these patients.

The most important risk factors for disease progression and worsening are age and duration of symptoms[10,17]. In addition,

preoperative neurological function along with these factors are the most important prognostic indicators of surgical treatment success. The best treatment option should be decided taking into account these factors[12]. Indeed, the acceptable mean duration of symptoms (8.8 months) and mean age (68.8 years) of the patients we operated may be the cause of the good neurological condition at discharge and during the follow-up of the patients. In severe cases of CSM, surgery is often considered the best treatment option. Some studies have shown that 23-54% of patients who are initially treated with conservative treatment before surgery are later treated surgically[18].

The most accurate surgical approach is not always clear. The goals of surgery for patients with CSM are decompression of the spinal cord, restoration of the cervical alignment and treatment of the instability, if any[19]. An AO Spine North America CSM study showed that cervical decompression halted worsening in patients regardless of the disease severity and the improved neurological outcomes, functional status and quality of life[20]. The anterior approach is preferred when the number of affected levels is 1 or 2. Discectomy and fusion or corpectomy and fusion can be included in the procedures performed during the anterior surgical approach. The anterior approach has been preferred by many spinal surgeons in recent years due to its advantages such as direct decompression of pathologies located in the anterior cervical spine (osteophyte, PLLO, disc herniations), the ability to resolve radiculopathy, muscle-preserving dissection to minimise post-op pain, low infection rates and correction of cervical kyphosis[10].

The risk of complications of the anterior approach increases in the case of three or more levels and thus, the posterior approach should be considered in such cases. However, the posterior approach should not be used in the case of kyphosis. The extension of the spinal cord along the kyphotic spine causes neural injury, which can be exacerbated by posterior decompression. In our study, we found that combinations with the posterior approach were performed on all the patients with three levels of spinal stenosis, and the anterior approach alone was not performed on any of them. In the past, laminectomy without fusion was widely used for the treatment of CSM; however, due to the identification of post-laminectomy kyphotic deformities, the use of this technique has reduced[3]. Therefore, although the idea of adding fusion to the posterior approach has gained importance, restricted cervical mobility, neck stiffness and adjacent segment degeneration are its important handicaps[9]. In our study, we found that 48% of the CSM patients underwent laminectomy without fusion; this surgical approach was preferred more in high-risk patients due to advanced age and systemic diseases, and complaints such as neuropathic pain in the post-op long-term follow-up were most commonly observed in these patients. Although no post-laminectomy kyphotic deformity was observed in the follow-up of any patient, this group had the shortest operative time and post-op length of hospital-stay of 102.5 minutes and 3.66 days, respectively.

In our study, we found that the group in which only the anterior approach was preferred had one of the highest satisfaction rates (70.58%), and only 1 or 2 levels of corpectomy were performed in this group. However, it was noted that 5.88% of the patients in this group and 12.5% of the patients who underwent laminectomy without fusion had post-op worsening. In addition, although the number of patients (n=3) in the group in which the anterior and posterior approach was combined was small, the satisfaction rate of these patients (66.66%) was better than that of the group (41.66%) who underwent laminectomy without fusion. However, the patients treated with the combined approach had the longest length of hospital-stay. The group treated with laminectomy and fusion was found to be the best in terms of patient satisfaction and functional recovery (83.33%).

Lawrence et al.[3] reviewed five studies and compared the success of their CSM surgical techniques. They found that a better functional improvement was observed after the anterior surgical treatment in two studies. More success was achieved after the posterior surgery approach in two studies. In one study, no difference was found between the anterior and posterior approaches. Only one of them was statistically significant. Thus, in the current literature, the anterior and posterior neurological outcome is insufficient for explaining the best surgical approach. We found that laminectomy and fusion was the most successful surgical method. However, the anterior approach is also a successful treatment option.

In the literature, post-op early and late complication rates have been reported as 15.6% and 4.4%, respectively[20]. The more common complications are cardiopulmonary problems (3.3%), dysphagia (3.0%), superficial infection (2.3%), pseudoarthrosis (1.8%), C5 radiculopathy/palsy (1.7%), worsening myelopathy (1.3%), epidural/wound hematoma (1.0%) and dural tear (1.0%). Wound infection is more common in the posterior approaches (4.7% posterior, 0.6% anterior), while C5 radiculopathy/palsy is equally common in both approaches (1.9% posterior, 1.7% anterior), and dysphagia is slightly more common in the anterior approach (0.9%)[16,20]. The complication rate of all the patients in our study was 10%. The rate of worsening myelopathy was 6%, followed by hematoma at the operation site with 4%, and per-op dural tear with 2%. One patient who underwent laminectomy and fusion and recovered completely died of ACS approximately one week after discharge. Our complication rates were different compared to those of larger studies, since our sample size was small.

CONCLUSION

CSM is a degenerative disease that can be easily overlooked by clinicians, often leading to a delay in diagnosis and an irreversible spinal cord injury. Therefore, it should be treated as soon as possible. Laminectomy without fusion has the advantages of having the shortest length of hospital-stay and operative time. However, we recommend that laminectomy without fusion only

be performed on high-risk patients due to comorbidities with 1 or 2 level involvement and no kyphosis, since it has more side effects such as neuropathic pain, lower functional recovery and patient satisfaction rates compared to other approaches. It will be useful to add fusion to multi-level laminectomies. We are of the opinion that laminectomy and fusion may be more successful in eligible cases in terms of patient satisfaction and functional recovery, and may cause fewer complications. When deciding on the surgical technique, it will be best to make a decision by evaluating the patient's age, clinical condition and radiological characteristics all together. Yet, there is a need for series with a larger sample size.

Ethics

Ethics Committee Approval: This study was approved by Başkent University Medicine and Health Sciences Research Committee (94603339-604.01.02/845).

Informed Consent: Informed consent was obtained from all patients.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: E.D., Design: K.T., M.Ö., Data Collection or Processing: Ö.K., A.G.Y., Analysis or Interpretation: H.İ.S., S.Ç., Literature Search: H.İ.S., S.Ç., A.G.Y., Writing: H.İ.S.

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COMPARISON OF SEQUESTRECTOMY AND AGGRESSIVE DISCECTOMIES IN TERMS OF RECURRENCE IN LUMBAR DISC HERNIA SURGERIES

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ABSTRACT

Objective: Lumbar disc herniation (LDH) is a disease that seriously affects people's social and work life. LDH recurrence is a condition that occurs after lumbar microdiscectomy and is characterised by findings of failed lumbar surgery syndrome. Recurrent disk herniation may develop due to demographic factors, obesity and limited discectomy. Therefore, this study aimed to compare the recurrent disk herniations that develop following aggressive discectomy (AD) and sequestrectomy.

Materials and Methods: Seventy patients diagnosed with extruded LDH at a single level who underwent sequestrectomy (S) and 70 patients with the same diagnosis who underwent AD at Başkent University Zübeyde Hanım Hospital were enrolled in this study. In the study groups, age, gender, comorbidity characteristics, disk herniation level, duration of surgery, blood loss, hospitalisation duration and complications including recurrence rate, reoperation rate, low back pain postoperatively and visual analogue scale for radicular pain during the last evaluation and analgesic application results were collected in addition to the perioperative information.

Results: In the comparison S and AD, recurrence (62.50%) and reoperation rates (57.10%) were found to be higher in patients who underwent sequestrectomy. Although surgical site infection (50.00%) occurred at the same proportion in both groups, the rate of dural tear (66.70%) was found to be higher in those who underwent sequestrectomy.

Conclusion: Although several noninvasive procedures have been defined as an alternative to microsurgery, surgical discectomy remains an effective treatment method for LDH. We suggest that for cases of LDH recurrence, AD is more preferred over other surgical methods.

Keywords: Seguestrectomy, aggressive discectomy, disc herniation

INTRODUCTION

In lumbar disc surgery, less invasive interventions have been developed since Mixter and Barr[1] completed the first successful lumbar herniated disc resection, including extensive laminectomy, in 1934. Two procedures have been discussed since microsurgery (MC) became the gold standard for lumbar disc herniation (LDH). One of these procedures involves resection of the herniated disc fragment from the spinal canal and aggressive curettage of the normal disc[2]. Disc distance curettage leads to intervertebral instability and disc height collapse, thus contributing to the "failed lumbar surgery syndrome"[3]. The other procedure is sequestrectomy alone with disc fragment resection from the spinal canal. This intervention is thought to maintain disc height and minimise intervertebral instability[4,5]. Both interventions are widely used in clinical practice. Therefore, this study aimed to describe the clinical and preoperative results and complication and reherniation rates in patients operated by different surgeons in two separate hospitals with a review of the literature.

MATERIALS AND METHODS

Participants

Perioperative information including age, gender, magnetic resonance imaging (MRI) and diagnosis, level rates, surgery duration, intraoperative blood loss, hospitalisation duration, complications and results including recurrence rates, reoperation rates, low back pain, visual analogue scale (VAS) for sciatica pain at the time of the final evaluation and analgesic use postoperatively were collected from patient files and by

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phone follow-up. A total of 140 patients diagnosed with LDH at a single level on the caudal and cranial vertebrae or with extruded LDH on the disc level in lumbar MRI were divided into two groups and studied retrospectively.
Group A: Underwent sequestrectomy
Group B: Underwent aggressive discectomy (AD)
Patients aged 20-75 years with a single-level extruded disc between L1 and S1 in an MRI were included in the study. Patients with two or more extruded discs or spondylolisthesis were excluded.

Surgical Technique

Surgical treatment was performed under general anaesthesia and with the use of a surgical microscope. In group A patients, only sequestered fragments on the disc level with caudal and cranial migration were resected. A ruptured posterior longitudinal ligament and annulus fibrosus were observed. In group B patients, sequestered fragments were resected, and disc fragments located at the intervertebral distance were resected through the "+"-shaped incision made in the annulus. The disc distance was cleaned until the anterior longitudinal ligament was observed in front of the distance and the amount of resected disc was measured. Patients were discharged on the first postoperative day and resumed their daily activities in the 3rd postoperative week without corset use and movement restrictions.

Statistictical Analysis

Statistical analysis was done using SPSS 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical package programme. Variables were expressed as mean ± standard deviation, percentage and frequency values. Variables were analysed after checking for normality and homogeneity of variance preconditions (using the Shapiro-Wilk and Levene test). During the data analysis, Independent 2 group t test (Student's t-test) was used to compare the two groups, and Mann-Whitney U test was used when prerequisites were not met. Categorical data were analysed using the Fisher's exact test and chi-square test. In cases where expected frequencies were <20%, analysis was done using the "Monte Carlo Simulation Method" to include these frequencies in the analysis. For the significance level of the tests, $p<0.05$ and $p<0.01$ values were accepted.

RESULTS

Preoperative Neurological Results

In the preoperative period, particularly during the 2-year follow-up period, patients presented to the outpatient clinic with pain similar to sciatalgia that radiates to the right and left lower limbs, weakness on foot dorsoflexion or weakness in the toes and muscle atrophy (Table 1). The American Society of Anaesthesiologists (ASA) classification results for preoperative anaesthesia assessment were 100% ASA (1) in group A and 93.8% ASA (1) and 6.2% ASA (2) in group B.

Preoperative Lumbar MRI Results

In the lumbar MRI of group A patients, extruded disc was detected on the left L3/L4 (60%), L4/L5 (59.50%) and L5/S1 (60.00%) levels and on the right L4/L5 (65.90%) and right L5/S1 (53.60%) levels in group B patients. A statistically significant difference was observed between right L3/L4, right L4/L5 and right L5/S1 extrusion categories in patients who underwent limited and ADs (p=0.003) (Table 1).

Postoperative Back and Leg Pain and Analgesic Use

In this study, symptom relief and patient satisfaction were also analysed. Although postoperative VAS results indicating low back and leg pains were found to be lower in patients who underwent sequestrectomy (66.70%) and moderate in those who underwent AD, no significant statistical difference was observed between the two groups (p=0,819). In addition, the frequency of postoperative analgesic use in the sequestrectomy group was significantly lower in both the short-term (<1 year) and long-term (>1 year) follow-ups (48.00%) (Table 2). Therefore, better functional recovery and satisfaction occurred in the sequestrectomy group.

Recurrence Results

All patients were followed-up for 24 months. Recurrence was reported in 16 of 140 patients, including 10 group A patients (14,28%) and six group B patients (8,57%). In this study, recurrence rates were higher in the sequestrectomy group (p=0.288) (Table 3).

Reoperation Results

With regard to the follow-up of the patients using MRI, one group A patient had recurrence in the first 6 months, four in the 1-2-year follow-up, one in the 2-3-year follow-up and 2 after the 3-year follow-up; all of them were reoperated and two patients recovered by responding to a conservative treatment. Conversely, in group B, recurrence occurred in one patient at one month (during the first 10 days), one in 6-12 months, one in 2 years and three after 3 years; all of them were also reoperated. Regarding the follow-up of both groups, recurrence was more frequently observed in the 1-2 years postoperative in group A patients, but either as early as 10 days postoperative or after 3 years in group B patients. While infection was equally observed in both groups, dural tear was higher in group A (66.70%) (Table 3).

Peroperative Results

Although no difference was observed in intraoperative blood, the duration of surgery and length of hospitalisation between group A and B patients, a statistically significant difference was observed in the disc amount (p=0.001) and follow-up time (p=0.040) variables between patients who underwent sequestrectomy and AD (Table 4).

Table 1. Demographic, clinical and MRI results of patients with limited and aggressive discectomy

Preoperative			Sequestrectomy	Aggressive discectomy	Total	p
Age			50.2±16.39	50.44±12.07	-	0.920
Sex	F	n	36	37	73	0.866
		%	49.30%	50.70%	100.00%	
	M	n	34	33	67	
		%	50.70%	49.30%	100.00%	
Symptom	R muscle hypotonia	n	1	0	1	0.526
		%	100.00%	0.00%	100.00%	
	L muscle weakness	n	9	14	23	
		%	39.10%	60.90%	100.00%	
	R muscle weakness	n	8	11	19	
		%	42.10%	57.90%	100.00%	
	R muscle atrophy	n	2	1	3	
		%	66.70%	33.30%	100.00%	
	R sciatalgia	n	25	28	53	
		%	47.20%	52.80%	100.00%	
	L muscle atrophy	n	1	1	2	
		%	50.00%	50.00%	100.00%	
	L sciatalgia	n	24	15	39	
		%	61.50%	38.50%	100.00%	
Lumbar MRI	L L2/3 extrusion	n	2	2	4	0.03
		%	50.00%	50.00%	100.00%	
	L L3/4 extrusion	n	3	2	5	
		%	60.00%	40.00%	100.00%	
	L L4/5 extrusion	n	22	15	37	
		%	59.50%	40.50%	100.00%	
	L L5/S1 extrusion	n	9	6	15	
		%	60.00%	40.00%	100.00%	
	R L2/3 extrusion	n	1	1	2	
		%	50.00%	50.00%	100.00%	
	R L3/4 extrusion	n	6	2	8	
		%	75.00%	25.00%	100.00%	
	R L4/5 extrusion	n	14	27	41	
		%	34.10%	65.90%	100.00%	
	R L5/S1 extrusion	n	13	15	28	
		%	46.40%	53.60%	100.00%	

MRI: Magnetic resonance imaging, F: Female, M: Male, L: Left, R: Right, n: Number

DISCUSSION

LDH is a disease characterised by low back pain radiating to the legs and sensory and motor deficits. Its incidence was reported to be 1-2% in the general population and 4.86 per 1,000 person-years in the younger population[6-8]. This study aimed to determine the role of the surgical technique used in the first discectomy in the reduction of the recurrence risk. Recurrence is one of the common complications occurring after lumbar discectomy. Although several procedures may increase the recurrence risk, a high risk of recurrence has been observed after a limited disc resection and the disc degeneration risk increases after an aggressive disc resection[8-10].

Table 2. Preoperative and postoperative results of patients with limited and aggressive discectomy

Sequestrectomy / Aggressive discectomy			Group		Total	p
ASA	0.06-0.08	n	53	54	107	0.17
		%	49.50%	50.50%	100.00%	
	0.27-0.4	n	17	13	30	
		%	56.70%	43.30%	100.00%	
	1.8-4.3	n	0	3	3	
		%	0.00%	100.00%	100.00%	
Postop VAS	0	n	52	54	106	0.819
		%	49.10%	50.90%	100.00%	
	1	n	6	3	9	
		%	66.70%	33.30%	100.00%	
	2	n	5	4	9	
		%	55.60%	44.40%	100.00%	
	3	n	2	4	6	
		%	33.30%	66.70%	100.00%	
	4	n	2	3	5	
		%	40.00%	60.00%	100.00%	
	5	n	3	2	5	
		%	60.00%	40.00%	100.00%	
Postop analgesia	0	n	48	52	100	0.523
		%	48.00%	52.00%	100.00%	
	1	n	7	5	12	
		%	58.30%	41.70%	100.00%	
	2	n	6	6	12	
		%	50.00%	50.00%	100.00%	
	3	n	8	5	13	
		%	61.50%	38.50%	100.00%	
	4	n	0	2	2	
		%	0.00%	100.00%	100.00%	
	5	n	1	0	1	
		%	100.00%	0.00%	100.00%	

ASA: The American Society of Anaesthesiologists, Postop: Postoperative, VAS: Visual analogue scale, n: Number

The symptomatic recurrence rate was 4% in all series, and the reoperation rate was 6.4% in the first year, which increased by 10% after the first year[11]. In this context, in a recent meta-analysis, aggressive disc resection, large annulotomy and curettage of the disc interspace (AD) were compared with a more conservative resection of the disc fragment (sequestrectomy), and the recurrence incidence was reported to be higher in the sequestrectomy group than in the aggressive technique group[12,13].

Results of 12 previous studies showed that when AD and sequestrectomy were compared, shorter surgical duration, lower postoperative VAS, lesser postoperative analgesic administration and higher satisfaction rates were reported. However, the recurrence rate, complication rate, reoperation rate and intraoperative blood loss were reported as being equivalent for both methods[13]. Although publications before 2009 showed that the recurrence rate is higher after sequestrectomy, Ran et al.[13] and Fakouri et al.[14] reported that the recurrence rate was equal after both discectomy and sequestrectomy. In our study, when comparing both groups, the recurrence rate was found to be higher (62.50%) after sequestrectomy; however, the difference was not statistically significant (p=0.28).

Additionally, annulus fibrosus openness should be considered in lumbar disc surgery, because patients with small annulus defects during surgery and free disc in the spinal canal are suitable for sequestrectomy. Recurrence rate has been reported to be lower in patients with <6-mm annular defects. Thomé et al.[9] reported that in patients with a large annular defect

Table 3. Complications in patients with limited and aggressive discectomy

Complications Sequestrectomy Aggressive discectomy			Group		Total	p
Recurrence	-	n	60	64	124	0.288
		%	48.40%	51.60%	100.00%	
	+	n	10	6	16	
		%	62.50%	37.50%	100.00%	
Reoperation	-	n	62	64	126	0.573
		%	49.20%	50.80%	100.00%	
	+	n	8	6	14	
		%	57.10%	42.90%	100.00%	
Infection	-	n	69	69	138	-
		%	50.00%	50.00%	100.00%	
	+	n	1	1	2	
		%	50.00%	50.00%	100.00%	
Dural rupture	-	n	66	68	134	0.404
		%	49.30%	50.70%	100.00%	
	+	n	4	2	6	
		%	66.70%	33.30%	100.00%	
Total		n	70	70	140	
%		50.00%	50.00%	100.00%		

n: Number

Table 4. Surgical results and follow-up of patients with limited and aggressive discectomy

	Group		p
	Sequestrectomy	Aggressive discectomy	
Blood loss	45.21±8.05	44.86±7.61	0.790
Duration of surgery	54.57±10.03	55.93±9.72	0.420
Amount of disc	6.18±0.97	12.33±1.68	0.001
Length of hospitalisation	1.27±0.72	1.27±0.66	0.990
Follow-up time	2.26±0.47	2.11±0.32	0.040

after limited microdiscectomy (LMD), the risk of symptomatic recurrence and reoperation was higher. In contrast to this study, the reoperation rate of the sequestrectomy group was higher (57.10%), but without a statistical difference between the two groups, although the annular defect width was higher in the aggressive group (p=0.573). In addition, recurrence rates were reportedly lower in patients with large annular defects repaired after microdiscectomy[9]. The regenerative capacity of the anulus fibrosus is very limited. Due to the intradiscal tension force, repair mechanisms of the annulus were also unsuccessful. Several strategies such as repair, regeneration and replacement of the herniated nucleus pulposus have not been clinically confirmed[15,16].

In this study, although hemilaminotomy and flavectomy were performed as standards in lumbar MC, the free fragment formed by the annulus fibrosus or posterior longitidunal ligament rupture in the spinal canal was resected in sequestrectomies; therefore, the disc distance was maintained and the back wall of the ligament and the annulus were preserved. However, most patients also had segmental disc segments at the intervertebral distance. These residual disc fragments have also been observed to migrate from the annular defect and ligament rupture into the spinal canal due to intradiscal tension. The free fragment, subligamentous sequester and degenerated disc fragments at the intervertebral distance were resected and the anterior longitudinal ligament was detected. Fragments located in the

middle line or at opposite side of the disc interspace were also resected. Although blood loss (p=0.790), surgical duration (p=0.420) and length of hospitalisation were equal (p=0.990) in both groups, the difference in the amount of disc resected during surgery (p<0.05) and in the length of hospitalisation was statistically significant (p<0.01). Complications such as recurrence and reoperation rates and dural tear were also higher in the limited discectomy group. Schmid et al.[17] reported that the clinical results and reoperation rates were equal in both the sequestrectomy and total discectomy groups.

In the literature, the incidence of dural tear is 1.8-2.7% in LMD and 3-5.7% in open discectomy[11,18-20]. In this study, although the dural tear was observed to be more common in the sequestrectomy group, no statistically significant difference was observed between the two groups in terms of the dural tear frequency. Although wound infection rate was reported as 3.3% in patients with sequestrectomy[20], equal and lower rates (1.4%) were observed in both groups in this study. Although the hospitalisation duration was between 1 and 12[21-23] days, it was the same in the limited discectomy (1.27±0.72 days) and AD groups (1.27±0.66 days), without statistical difference (p=0.990). In a study conducted by Schick and Elhabony[15], the patient group who underwent LMD with sequestrectomy was reported to have better duration of hospitalisation and postoperative VAS results in one group; however, return to daily activities, rate of labour loss due to low back pain and recurrence rates were equal.

Schmid et al.[17] investigated 500 patients with and without a surgical microscope and reported that reoperation and complication rates were equal in two groups, the surgical duration was longer in the microscope group and the length of hospitalisation was longer in the non-microscope group[22]. In addition, the surgical duration is expected to be longer in the AD group because it involves entering the intervertebral distance and attempting to resect the residual discs located at a disc interdistance. Minimally invasive procedures have been increasingly performed in recent years. Grasso et al.[12] reported that when an LMD and a radiofrequency system were used together, the reherniation rate was lower, and analgesic use, compliance with social life and other results were better than that of the LMD (sequestrectomy) only group.

CONCLUSION

Although many noninvasive procedures have been defined as an alternative to MC, surgical discectomy remains an effective treatment method for LDH. We suggest that AD should be preferred over other surgical methods due to its lower recurrence.

Ethics

Ethics: Since this study was written as a retrospective study before 2020, and patient records were used in this study, ethics committee approval was not obtained.

Informed Consent: Before the procedure, consent forms were obtained from the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

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

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ADJACENT SEGMENT DEGENERATION AFTER DECOMPRESSION AND FUSION SURGERY FOR DEGENERATIVE LUMBAR SPINAL STENOSIS: A RETROSPECTIVE COMPARATIVE EVALUATION

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ABSTRACT

Objective: The information available on the association between transforaminal lumbar interbody fusion (TLIF) surgery and adjacent segment degeneration (ASD) in lumbar spinal stenosis (LSS) patients is extremely limited. To explore the risk factors involved in the development of ASD after decompression and fusion surgery for LSS.

Materials and Methods: This study subjects were patients who underwent lumbar posterior segmental instrumentation and spinal decompression surgery for degenerative LSS, in L4-5 or L5-S1, during 2010-2015. These patients were classified into two groups based on their stage of ASD development. The diagnosis of ASD was based on magnetic resonance imaging findings. The study groups were compared to determine the risk factors for ASD.

Results: A total of 162 patients (68 men, 94 women) of a mean age 60.76±6.4 years (age range: 37-89 years) were evaluated. The mean follow-up period for these patients was 67.42±5.6 months. Decompression surgery with TLIF was applied to 67 patients, while decompression surgery without TLIF was applied to 95 patients. Overall, ASD developed in 40 patients (24.7%). The type of stenosis was found to be a risk factor for ASD.

Conclusion: Our results suggested that, although instrumentation and fusion applied to the surgical area caused an increase in stress and degeneration in the adjacent segment owing to immobilisation and stiffness in this area, the rate of increase did not rise with TLIF cage. Furthermore, the type of stenosis was determined to be a risk factor for ASD in our study.

Keywords: Adjacent segment, degenerative spine, fusion surgery

INTRODUCTION

Lumbar spinal stenosis (LSS) is a common clinical condition that is characterised by chronic lower back pain, radiculopathy and neurogenic claudication due to narrowing of the lumbar spinal central canal, lateral recess or foramen regions of the lumbar spine[1]. Lumbar decompression surgery has been indicated in patients with severe symptoms, and different surgical approaches have been previously described for this purpose[2]. In this context, lumbar decompression with posterior fusion has been demonstrated to be a valid and effective surgical approach[3]. Nevertheless, adjacent segment degeneration (ASD) is a challenging condition that is defined as degenerative changes occurring at the disk level adjacent to the operation site, comprising of disk/facet degeneration, instability and deformity[4]. Some supporting biomechanical and clinical data exists that suggest creation of a significant compensatory increase in the motion of the adjacent segment in spinal fusion as a result of increased rigidity of the fused segment. Consequently, the development of adjacent segment disease has been considered as a potential long-term complication after spinal fusion surgery[5]. ASD is considered as a cause of failed-back surgery; hence, the incidence and risk factors associated with ASD development warrant further investigation[4].

Transforaminal lumbar interbody fusion (TLIF) has been recommended for patients undergoing decompression surgery and posterior instrumentation so as to provide circumferential arthrodesis and better stabilisation to decrease the risk of recurrence[5,6]. However, the available data are limited to the association between TLIF surgery and ASD in patients with posterior segmental instrumented LSS[7-10]. Therefore, the effect

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of TLIF cage applied in LSS decompression and fusion surgery on the development of ASD has been discussed in the present study.

MATERIALS AND METHODS

Study Design and Participants

This retrospective and comparative study was approved by the Adana City Training and Research Hospital Ethics Committee. (56-858/05.2020). We enrolled patients who underwent lumbar posterior segmental instrumentation and/or spinal decompression, without or with TLIF surgery for degenerative LSS in L4-5 or L5-S1 at our tertiary hospital during 2010-2015. In order to obtain a more homogeneous group, the L4-5 and L5-S1 levels were included in the study. Patients who underwent revision surgery or dynamic stabilisation; had LSS due to disc herniation, cancer, inflammatory changes, lumbarisation or sacralisation; had significant spondylolisthesis or scoliosis and kyphosis; had incomplete data or did not attend follow-up examination visits and patients with both the types of stenosis (i.e. central and foraminal) were excluded. The patients were accordingly divided into two groups based on the status of ASD development. The clinical and demographic data of both the groups were comparatively evaluated.

Surgical Procedure

All patients were operated by the same surgical team (the same senior surgeon). All patients were preoperatively examined in detail with magnetic resonance imaging (MRI) and plane radiographs. The surgical approach in the prone position on the surgical table was applied to the groups of patients using posterior instrumentation (L4 to S1) with pedicle screws, total laminectomy, decompression and posterolateral fusion with iliac-crest auto-graft. In addition, discectomy and peek TLIF cage were applied to eligible patients. However, during the surgery, TLIF cage could not be applied to some of the patients due to certain incompatible situations (such as perioperatively deteriorated hemodynamic) or resistance to TLIF cage insertion (as a result of narrow gap of the disc that prevented cage insertion or insufficient imaging due to epidural bleeding). At this stage, auto-graft was placed in the anterior region of the TLIF cage as well as into the cage in the disc space. Then, compression was applied to ensure a tight attachment of the TLIF cage to the vertebral endplates. The procedure was completed by controlling all the patients with two planned (anteroposterior and lateral) fluoroscopy images.

Evaluation of the ASD

The diagnosis of ASD was based on MRI findings (preoperative and postoperative) with reference to the Pfirrmann classification of lumbar intervertebral disc degeneration[11]. According to this classification system, the comparative progress in the extent of degeneration at postoperative follow-up compared to that before the operation was accepted as ASD.

Statistical Analysis

SPSS software (SPSS 16 Inc., Chicago, IL, USA) was used for statistical analyses. The Kolmogorov-Smirnov test was applied to assess conformity of data to the normal distribution pattern. Descriptive data were expressed as mean ± standard deviation or median (interquartile range) values. Categorical variables were compared using the chi-square test or Fisher's exact test. Student's t-test or Mann-Whitney U test was applied for comparisons between the groups. Binary logistic regression analysis was used to determine the associated risk factors. The presence of ASD was accepted as a dependent variable. $P<0.05$ was considered to be statistically significant.

RESULTS

A total of 162 patients (68 men, 94 women) of mean age 60.76±6.4 years (age range: 37-89 years) were evaluated. The mean follow-up period was established at 67.42±5.6 months. Decompression surgery with TLIF was applied to 67 patients, while decompression surgery without TLIF was applied to 95 patients. Overall, ASD developed in 40 patients (24.7%). Comparisons between patients without and with ASD is provided in Table 1. Central stenosis was found to be more common in ASD-positive patients.

The presence of ASD was determined to act as a dependent factor, while age (<65 years and ≥65 years), gender, body mass index [(BMI); <25, ≥25-30 and ≥30 kg/m^2], type of stenosis (central or foraminal), TLIF application and the level of TLIF (L4-5 and L5-S1) acted as independent factors. The type of stenosis was found to be a risk factor for ASD. Central stenosis increased the risk for ASD by 2.7 times (Table 2).

DISCUSSION

The main goal of spinal fusion surgery is to maintain a solid arthrodesis of the spinal segments[12]. TLIF is a common surgical method administered along with decompression methods to offer several advantages, including preservation of the inter-spinous ligaments with minimal retraction of the dural sac, which causes less neurological injury and provides anterior support and 360° fusion[13-15]. However, spinal fusion can induce ASD owing to biomechanical changes in the adjacent segment, such as increased movement and mechanical stress[5]. As mentioned in the literature, spinal fusion alone is ineffective in this condition[15]. The present finite element analysis indicated that decreased spinal lordosis may evoke overstress in the adjacent segment and predispose a patient to an increased risk of the pathological development of ASD. From this perspective, TLIF should be considered while planning spinal fusion procedures[15]. Due to ASD, clear symptoms requiring failed-back syndrome and revision surgery can be observed[16,17]. Previous studies have demonstrated reoperation rates due to ASD of 10-30%[16,17]. As such, concerns about the pathophysiology and prevention of adjacent segment pathologies are indisputably

Table 1. Comparison of patients with and without adjacent segment disease

Variables	ASD + (n=40)	ASD – (n=122)	p value
Age (years)	62.12±4.0	60.31±7.0	0.090
Gender			
Male	15 (37.5)	53 (43.4)	0.509
Female	25 (62.5)	69 (56.6)	
BMI (kg/m²)	25.60±3.0	25.53±3.4	0.913
Follow-up (months)	67.73±3.8	66.99±6.0	0.063
Type of stenosis			
Foraminal	11 (27.5)	59 (48.4)	0.021
Central	29 (72.5)	63 (51.6)	
TLIF	17 (42.5)	50 (41.0)	0.866
Without-TLIF	23 (57.5)	72 (59.0)	-
Level of TLIF			
L4-5	29 (72.5)	75 (61.5)	0.207
L5-S1	11 (27.5)	47 (38.5)	

ASD: Adjacent segment disease, BMI: Body mass index, TLIF: Transforaminal interbody fusion, n: Number
The data are given as n (%) or mean ± standard deviation.

Table 2. Regression analysis to determine the risk factors for the development of adjacent segment degeneration

Variables	B	SE	Wald	Sig	Exp (B)
Age	0.446	0.453	0.971	0.325	1.562
Gender	0.478	0.427	1.255	0.263	1.613
BMI	-0.035	0.321	0.012	0.913	0.966
Stenosis type	1.006	0.424	5.638	0.018	2.734
TLIF	0.100	0.402	0.061	0.804	1.105
TLIF Level	-0.637	0.439	2.102	0.147	0.529

BMI: Body mass index, TLIF: Transforaminal interbody fusion, B: Unstandardized beta, SE: Standard error, Sig: Significance, Exp: Exponential

of great importance[12,18]. There is also a concern that posterior spinal fusion enhanced by intramuscular fusion can induce greater stiffness and present with potentially higher ASD rates[16,17]. Although different surgical techniques have been compared in terms of ASD after degenerative lumbar diseases, the data on the association between TLIF and ASD development are scarce.

This study aimed to explore the association between TLIF and ASD development after decompression surgery on a selected group of patients with degenerative LSS only. Our findings revealed an overall frequency of ASD of 24.7% for this series of patients, which is consistent with previous clinical and biomechanical outcomes. ASD frequency was similar in patients who underwent TLIF surgery (25.4%) in comparison with patients who did not (24.2%). However, there is no consensus yet on the status of ASD developed or its relationship with the older age factor. While considering these points, it should be remembered that rigid and immobile areas created in the fusion area increases the stress and mobilisation on the adjacent segment. In a comprehensive meta-analysis, the occurrence of ASD after spinal fusion surgery was found to be consistent with a prevalence rate of 26%[7]. For instance, 94 studies with 34,716 patients from 19 countries were included in this study to reveal that the incidence of ASD on radiography was 4.8-92.2%. In order to better analyse the development time of ASD, they performed subgroup analysis by ASD diagnosis time. In the 0.5- to ⩽2-, >2- to ⩽5- and >5- to ⩽20- year periods, the respective radiograph ASD prevalence rates were 21.8% (16.0-27.6%), 33.6% (21.8-45.4%) and 37.4% (10.7-64.1%). In another study of 112 patients with a mean age of 57 years (range: 15-85 years), the ASD rate with radiographic evidence of 20% was reported at a 2-year follow-up[8]. The number of studies need to be increased for the better understanding of age and follow-up time in this situation. Hilibrand and Robins[19] and Levin et al.[20] argued that longer time is required for managing complications of ASD. In another study, although no significant difference was reported after a 1-year follow-up period, radiographic and clinical degeneration in the adjacent segments were detected in 43% and 24% of the patients after TLIF, respectively, after a minimum of 5-year follow-up[9], which is supported by some

other studies[16]. Chen et al.[10] investigated ASD after single-segment posterior lumbar interbody fusion to report a 22% rate of ASD in patients with lumbar degenerative instability. In our study, no correlation was noted between the clinical outcomes and ASD after a single-level TLIF.

On the other hand, some previous studies have highlighted a significant association of ASD incidence with increased age[21,22]. Harrop et al.[23] systematically reviewed 27 articles and found that higher odds of radiographical ASD were associated with older patients. Cheh et al.[9], Yamashita et al.[24] and Sears et al.[25] reported the age definition, which is a risk factor at the end of 5-year follow-up, as >50, >60 and >65 years, respectively (9,24,25). However, some other studies have reported no correlation between ASD incidence and age[26,27]. In fact, it has been argued that ASD is a normal degenerative process[17]. In this study, we did not detect any association between age and ASD.

Another factor that may contribute to ASD development is BMI. A higher incidence of ASD in patients with BMI ≥25 has been reported[28]. In contrast to the general literature, no significant difference was determined in this study between ASD-positive and ASD-negative groups, which can be attributed to the mean BMI of <25 kg/m^2 of the patients in both the groups (ASD-positive and negative), which is also supported by some past studies[29].

The results of the present study also suggest that central stenosis is more common in ASD-positive patients and that central stenosis is a risk factor for ASD. There exists controversy about whether the level and number of fusion in lumbar degenerative diseases increase the incidence of ASD. In a study on the fusion level, spinal canal narrowing noted in the adjacent segment was considered as a risk factor for ASD following lumbar fusion surgery at a rate of ≥47%. In this study, 3- or 4-level fusions were reported to increase the risk of ASD-related revision surgery by 3-fold in comparison to single-level fusion[30]. In the present study, all patients showed single-level fusion, with no significant difference noted between the TLIF and non-TLIF fusion groups.

The main strength of the present study was that large and homogeneous patient groups with degenerative LSS alone facilitated better interpretation. However, the retrospective design of the present study and the difference in the surgical procedure between the two groups were the main study limitations. Nevertheless, the results of this study are noteworthy and can be considered to provide an insight into the mechanism of ASD after LSS surgery.

CONCLUSION

TLIF cage is used to generate fusion while performing decompression surgery in the degenerative spine. In the light of our study, although instrumentation and fusion applied to the surgical area can cause an increase in the level of stress and degeneration in the adjacent segment due to immobilisation and stiffness in this area, this rate does not increase with TLIF cage. In order to avoid revision due to implant failure and pseudo arthrosis, we believe that TLIF cage application does not have a negative effect when considering future ASD incidence. Further studies are recommended in prospective designs with larger patient series, including different levels of spinal stenosis.

Ethics

Ethics Committee Approval: This retrospective and comparative study was approved by the Adana City Training and Research Hospital Ethics Committee (56-858/05.2020).

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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ORIGINAL ARTICLE
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DOES LUMBOSACRAL TRANSITIONAL VERTEBRAE CAUSE LOW BACK PAIN?

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ABSTRACT

Objective: Lumbosacral transitional vertebra (LSTV) is the most common congenital anomaly of the lumbosacral area. Its prevalence varies between 4% and 35.9%, and its relationship with back pain is controversial. In this study, we aimed to investigate the relationship of LSTV with low back pain by comparing the prevalence of LSTV between nonspecific low back pain and abdominal pain.

Materials and Methods: A total of 411 radiographs from patients with nonspecific low back pain (group 1) and 520 radiographs from patients with abdominal pain (group 2) were included in the study. Data were evaluated according to Castellvi's radiographic classification, and the prevalence of LSTV was reported.

Results: According to Castellvi's classification, the prevalence of LSTV was 27.5% and 36.7% in groups 1 and 2, respectively. LSVT types Ia, Ib and IIIb were the most common types.

Conclusion: In abdominal pain group (group 2), which was used as the control group in our study, statistically significantly ($p<0.05$) more LSTV was found compared to the nonspecific low back pain group (group 1). Therefore, no correlation was found between LSTV and nonspecific low back pain.

Keywords: Lumbosacral transitional vertebra, sacralisation, lumbalisation, low back pain

INTRODUCTION

Lumbosacral transitional vertebra (LSTV), which is a congenital vertebral anomaly, is a condition in which the last vertebra in the lumbosacral transitional area exhibits both sacral and lumbar morphology. LSTV is the most common malformation of this region, and its incidence in the general population varies between 4% and 35.9%[1-3].

LSTV anomalies, which include sacralisation or lumbalisation, are often detected accidentally[4,5]. The fusion of the fifth lumbar vertebra with the first sacral segment in varying degrees is called sacralisation, and the sacral segment having transverse processes similar to the morphology of the lumbar vertebra is called lumbalisation. Awareness of these conditions guides physicians in the differential diagnosis of idiopathic low back pain and in determining the vertebral level indicated for surgery[1]. The relationship between LSTV and low back pain has been the subject of many studies[1,4,6]. Although some studies have advocated that LSTV causes low back pain, some have not found a positive correlation between LSTV and mechanical low back pain[7,8].

In this study, we aimed to investigate the frequency of LSTV between a group of patients who presented to our clinic with nonspecific low back pain and a control group with abdominal pain.

The classification of LSTV was made in 1984 by Castellvi et al.[7] based on some features in radiological images. Accordingly, the condition has four types (Table 1, Figures 1-7).

Table 1. Castellvi's radiographic classification of lumbosacral transitional vertebra

Type Ia	Unilateral, TP height equal to or greater than 19 mm
Type Ib	Bilateral, TP height equal to or greater than 19 mm
Type IIa	Presence of unilateral articulation of TP and sacrum
Type IIb	Presence of bilateral articulation of TP and sacrum
Type IIIa	Unilateral fusion of TP with sacrum
Type IIIb	Bilateral fusion of TP with sacrum
Type IV	Fusion of Type IIa on one side and Type III on the contralateral side

TP: The lowest lumbar transverse process

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In light of the current literature, no standard imaging method is used to detect LSTV[8]. In addition, an important referential finding in the differentiation of sacralisation from lumbalisation has been reported as the location of the iliolumbar ligament at the L5 level in axial computed tomography sections and magnetic resonance imaging (MRI)[9]. Although LSTV anomalies are common in the general population, their role in low back pain is still controversial[10].

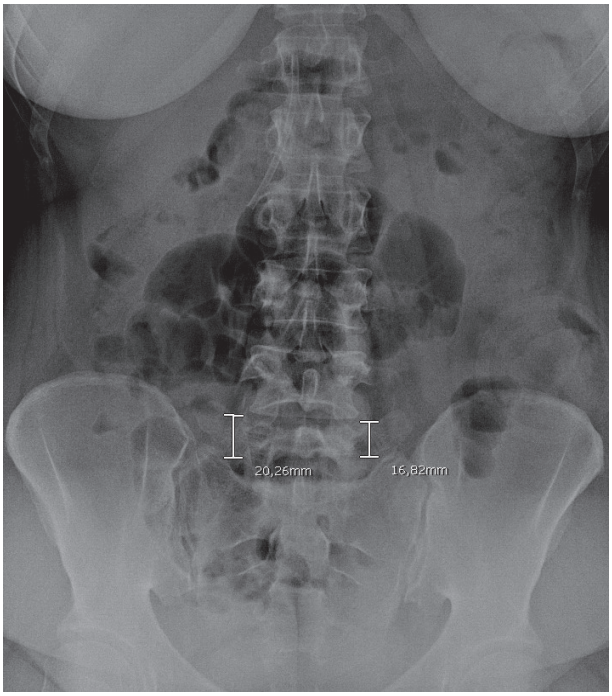

Figure 1. Castellvi radiographic classification Type Ia

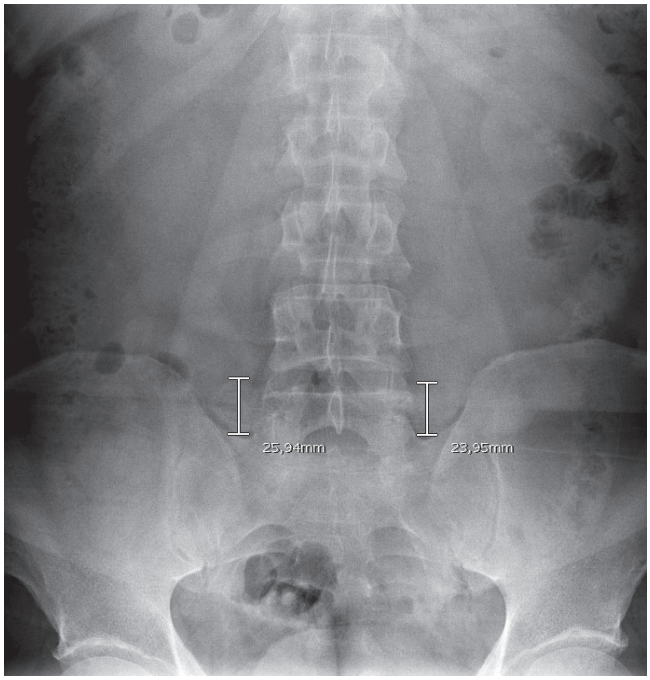

Figure 2. Castellvi radiographic classification Type Ib

In this study, we tried to reveal the frequency of LSTV and its relationship with nonspecific low back pain by retrospectively evaluating the radiographs of patients with nonspecific low back pain and abdominal pain.

MATERIALS AND METHODS

After the approval of the Ethics Committee of İstinye University (approval number: 2/2020.K-035), two-way lumbar radiographs

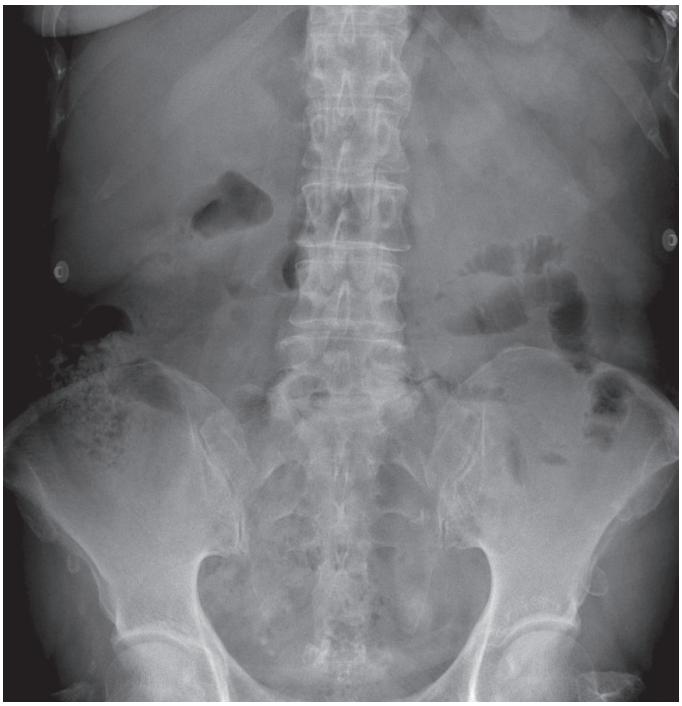

Figure 3. Castellvi radiographic classification Type IIa

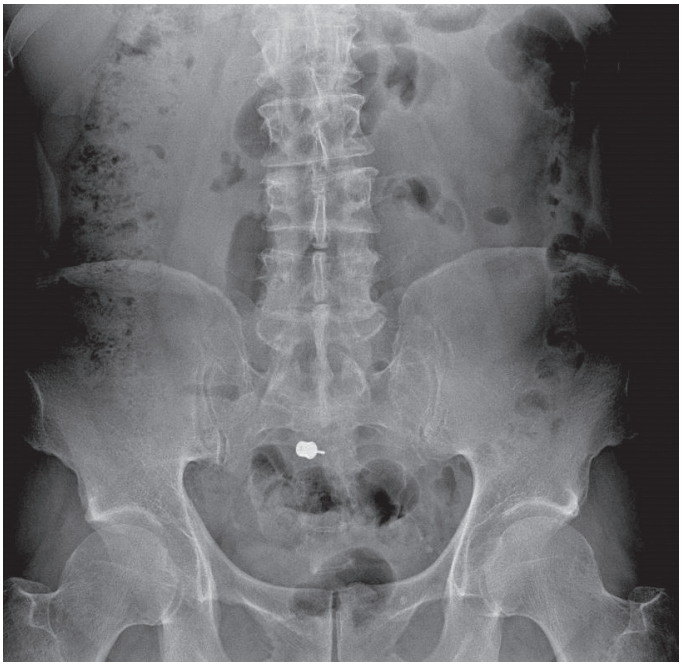

Figure 4. Castellvi radiographic classification Type IIb

of patients admitted to our hospital with nonspecific low back pain (group 1) and standing direct abdominal radiographs of patients who presented with abdominal pain (group 2) were examined retrospectively.

Images were obtained from the SYNAPSE (PACS) system (Fujifilm Global, Tokyo, Japan) available at our hospital. Radiographs that clearly showed the articulation of the 12th rib with the T12 vertebra, sacral wings and transverse processes of the lumbar vertebrae were evaluated. Patients with a history of trauma, history of lumbar surgery, neurological findings of the lower extremity, a positive Lasègue test, a known malignancy, spondylolisthesis, spinal fractures and spine infections, patients who lacked optimal images due to advanced osteoporosis and abdominal gases, scoliosis patients with lumbar Cobb's angle >10° and patients aged <18 years were excluded from the evaluation. A total of 411 patients in group 1 and 520 patients in group 2 were included in the study. Data were evaluated according to Castellvi's radiographic classification, and the prevalence of LSTV was reported.

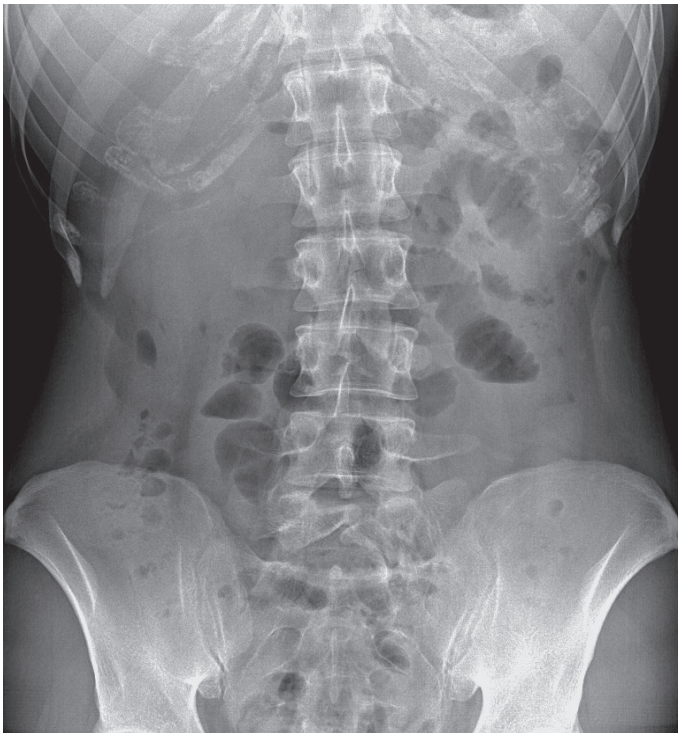

Figure 5. Castellvi radiographic classification Type IIIa

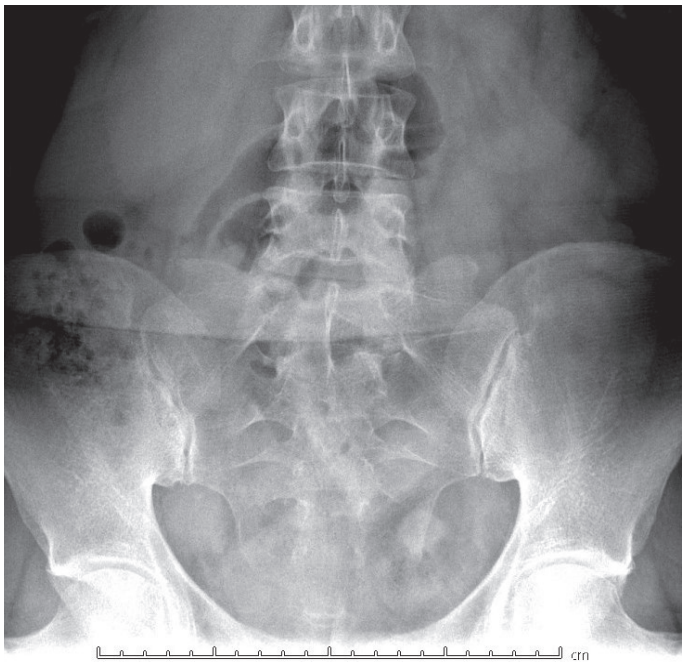

Figure 6. Castellvi radiographic classification Type IIIb

RESULTS

From a total of 931 patients, 411 with nonspecific low back pain (group 1; 175 men, 236 women) and 520 with abdominal pain (group 2; 246 men, 274 women) were evaluated. The prevalence of LSVT was 27.5% in group 1 and 36.7% in group 2. According to Castellvi's classification of LSTV, 38 patients (9.2%) had Type Ia, 35 (8.5%) had Type Ib, 10 (2.4%) had Type IIa, 11 (2.7%) had Type IIb, four (1.0%) had Type IIIa, 13 (3.2%) had Type IIIb and one (0.2%) had Type IV LSTV in group 1. In group 2, 74 patients (14.2%) had Type Ia, 54 (10.4%) had Type Ib, 13 (2.5%) had Type IIa, nine (1.7%) had Type IIb, four (0.8%) had Type IIIa, 30 (5.8%) had Type IIIb and seven (1.3%) had Type IV LSTV. The most frequently observed LSTV types were Type Ia, Ib and IIIb. The average patient age was 45.2 (range: 18–83) years in group 1 and 41.5 (range: 18–81) years in group 2, and the difference between the two groups was not statistically significant (p=0.06).

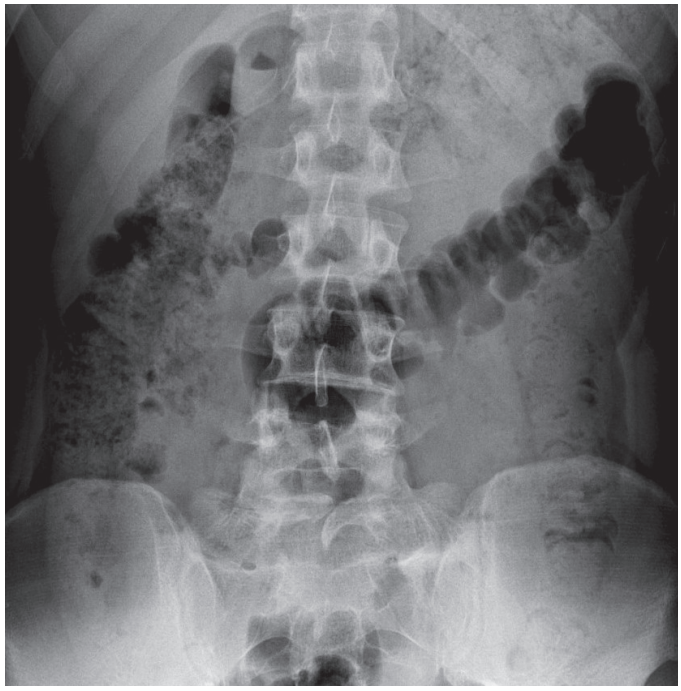

Figure 7. Castellvi radiographic classification Type IV

Statistical Analysis

Data analysis was performed using SPSS (IBM, Armonk, NY, USA). Datas on age were expressed in mean and standard deviation. Chi-square test was utilized to compare LSTV, subtypes of LSTV, gender between two groups. The Mann-Whitney U test was used to compare continuous variables. (such as age ofpatients). A p value of <0.05 was considered statistically significant.

DISCUSSION

To the best of our knowledge, no large-scale studies have determined the prevalence of LSTV in Turkey. In previous studies, the incidence of LSTV ranged from 4% to 35.9%[1-3]. This wide range in prevalence was associated with intercommunal differences, differences in classification and radiological evaluation errors[11]. Tini et al.[12] examined 4,000 radiographs and reported LSTV prevalence of 6.7%, Nardo et al.[13] reported a prevalence of 18.1% in 4,636 radiographs and Luoma et al.[14] reported a prevalence of 30% in a population of 163 men. In another study, Uçar et al.[15] determined the prevalence of LSTV as 18.9% over 3,607 radiographs. Among routine radiographs, LSTV can be best detected by lumbosacral radiographs and standing direct abdominal radiographs. Therefore, we included patients who presented to our hospital for nonspecific low back pain and abdominal pain.

The exact origin of LSTV is unknown[16]. Some studies have asserted that Castellvi Type I transitional vertebra has no clinical and surgical significance[17,18]. However, since otherwise would cause confusion in calculating the prevalence of LSTV, Castellvi Type I was also evaluated in our study. From a statistical perspective, even when Castellvi Type I cases were excluded from both groups, LSTV prevalence did not differ significantly between group 1 (35.5%) and group 2 (32.9%) (p=0.7). However, if these rates were examined by sex, the prevalence of Castellvi Type II and higher was significantly greater in women than in men (p<0.000).

The L5-S1 level is a frequent site of surgical procedures[19]. Studies have reported a correlation problem between the clinical evaluation of patients with LSTV and imaging[7,20]. Spinal surgeries performed at the wrong vertebral level pose a serious medicolegal problem. For this reason, identifying the vertebral level in spinal surgery, especially in individuals with LSTV, is significant[16]. Radiographs must be evaluated before surgery. Vertebral level-related errors are more often encountered when surgical planning is done using MRI alone without radiography[21]. This puts a financial burden on both the patient and hospital and increases the risk of postoperative complications and re-surgery. For this reason, physicians dealing with spinal surgery should make additional efforts to determine the level of LSTV and compare the lumbosacral radiographs with MRI and fluoroscopy images taken during surgery[3,7,20].

Study Limitations

There were limitations to our current study of note. Because this was small sample size and a retrospective study. MRI would have detected more spinal abnormalities such as annular tears, disc herniations, end-plate changes, and spinal or foraminal stenosis, which would have provided a better estimate of the distribution of other spinal problem.

CONCLUSION

In conclusion, no correlation was found between the presence of LSTV and nonspecific low back pain. LSTV is a common anomaly in our population and should be kept in mind during surgical planning and intraoperative level determination.

Ethics

Ethics Committee Approval: This study approved by İstinye University Ethics Committee (approval number: 2/2020.K-035).
Informed Consent: Retrospective study.
Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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CAN ENDOSCOPIC LUMBAR DISCECTOMY VIDEOS SHARED ON YOUTUBE BE USED AS PATIENT EDUCATION TOOLS? A QUALITY CONTROL STUDY

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ABSTRACT

Objective: Today, the internet is the initial resource of health information for people who are worried about their health condition. For this reason, it is crucial to clarify the reliability and content correctness of online medical videos. Therefore, this current study aimed to investigate the reliability and correctness of videos associated with endoscopic lumbar discectomy on YouTube®.

Materials and Methods: We conducted a search on YouTube® using the keywords "endoscopic lumbar discectomy". The headings of the first 50 videos on YouTube® associated with endoscopic lumbar discectomy were obtained and simultaneously evaluated by two spine surgeons. We excluded from our analysis videos with advertisements and video in a language other than English. We evaluated the videos using the DISCERN and JAMA scores and video power index.

Results: The average number of views per video was 95,954. Most of the video contents were surgical techniques and general information. The average video length was 7.67 minutes. The average DISCERN and JAMA scores were determined as 30.2 and 1.94, respectively. According to the average DISCERN scores, 38% of the videos were evaluated as very poor, 44% as poor, 16% as average and 2% of as good in terms of video reliability.

Conclusion: Generally, the reliability of the videos uploaded on YouTube® associated with endoscopic lumbar discectomy was "poor" or "very poor". Therefore, we recommend that YouTube® videos should not be used as patient education tools for endoscopic lumbar discectomy.

Keywords: Lumbar disc herniation, endoscopic lumbar discectomy, reliability, YouTube

INTRODUCTION

YouTube® is currently the leading video-sharing internet site and it is used by more than 30 million people daily[1]. For this reason, it is crucial to clarify the reliability and correctness of medical videos on YouTube®. Recently, many studies have been conducted that evaluate the contents of medical videos on YouTube®. In most of these studies, the reliability was reported to be low[1-4].

Spine surgery is a medical topic that is commonly searched on the internet[5]. Many patients who are recommended surgical treatment for lumbar disc herniation search internet sites, particularly on YouTube®, for additional information. The present study is the first in the literature that evaluates the contents of videos associated with endoscopic lumbar discectomy, which is a relatively new technique that has become more popular recently. The main aim of the present study was to investigate the reliability and correctness of videos associated with endoscopic lumbar discectomy on YouTube®.

MATERIALS AND METHODS

We searched "endoscopic lumbar discectomy" on YouTube® on 8th October 2019 and chose the option to see the number of views. The titles of the first 50 YouTube® videos associated with endoscopic lumbar discectomy were obtained and evaluated simultaneously by two spine surgeons. We screened the results and excluded the following from our analysis: videos with advertisements, duplicate or repetitive videos, videos shorter than 30 seconds and videos in a language other than English. We divided the videos into subgroups as "real" and "animation" according to the type of display; as "physician", "medical facility", "manufacturing company", "TV channel" and "medical illustrator" according to the uploader; and as "patient info", "surgical technique", "patient experience" and "lecture" according to the content. Additionally, numbers of views and comments, number of likes and dislikes, upload date, video length and whether or not the video had an audio were recorded in our data.

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We calculated the like ratio using the subsequent method for determining the reputation: [like count / (dislike count + like count) × 100)]. To conjointly evaluate the view and like ratios, we used the video power index (VPI) that was used by Erdem et al.[6] using the VPI method: (like ratio x view ratio)/100. We analysed the average view count per day using the following method: (total view count/the amount of time (in days) that the video has been online for viewing on YouTube®.

Evaluation of the Reliability

Each video was evaluated by two spine surgeons simultaneously using the DISCERN and JAMA scales. Total scores were noted individually by two viewers to stay impartial. We used the mean DISCERN and JAMA scores of both viewers to analyse the mean scores.

DISCERN Scale: The DISCERN scale evaluates the reliability of videos. DISCERN scores of 63-75 points are categorised as "excellent", 51-62 as "good", 39-50 as "average", 28-38 as "poor" and <28 as "very poor". Based on this method, higher DISCERN scores indicate a higher quality of information[7] (Table 1).

JAMA Scale: The JAMA scale is a tool that is used to evaluate information obtained from medical websites. Based on this method, higher scores indicate an increased quality of the assessed information[8] (Table 2).

Statistical Analysis

We used the IBM Statistical Package for Social Sciences Statistics 22 software for statistical analysis. The Kruskal-Wallis test was used in intergroup evaluations and Mann-Whitney U test in the detection of the group that led the variance. Spearman's

Table 1. DISCERN scale

Section	Questions	No	Partly			Yes
Reliability of the publication	1. Are the aims clear?	1	2	3	4	5
	2. Does it achieve its aims?	1	2	3	4	5
	3. Is it relevant?	1	2	3	4	5
	4. Is it clear what sources of information were used to compile the publication (other than the author or producer)?	1	2	3	4	5
	5. Is it clear when the information used or reported in the publication was produced?	1	2	3	4	5
	6. Is it balanced and unbiased?	1	2	3	4	5
	7. Does it provide details of additional sources of support and information?	1	2	3	4	5
	8. Does it refer to areas of uncertainty?	1	2	3	4	5
Quality of information on treatment choices	9. Does it describe how each treatment works?	1	2	3	4	5
	10. Does it describe the benefits of each treatment?	1	2	3	4	5
	11. Does it describe the risks of each treatment?	1	2	3	4	5
	12. Does it describe what would happen if no treatment is used?	1	2	3	4	5
	13. Does it describe how the treatment choices affect overall quality of life?	1	2	3	4	5
	14. Is it clear that there may be more than 1 possible treatment choice?	1	2	3	4	5
	15. Does it provide support for shared decision making?	1	2	3	4	5
Overall rating of the publication	16. Based on the answers to all of these questions, rate the overall quality of the publication as a source of information about treatment choices	1	2	3	4	5

Table 2. JAMA scale

JAMA scoring system		Rating	
Section		**No**	**Yes**
Authorship	Authors and contributors, their affiliations, and relevant credentials should be provided	0	1
Attribution	References and sources for all content should be listed clearly, and all relevant copyright information should be noted	0	1
Disclosure	Website "ownership" should be prominently and fully disclosed, as should any sponsorship, advertising, underwriting, commercial funding arrangements or support, or potential conflicts of interest	0	1
Currency	Dates when content was posted and updated should be indicated	0	1

analysis was used in evaluating the correlation between the data. We calculated Krippendorff's α value to evaluate the inter-rater consistency between the viewers. Kripppendorff's $\alpha<0.67$ was classified as weak, $0.67\leq\alpha<0.80$ as moderate and ≥ 0.80 as excellent. P value less than 0.05 was assumed to be significant.

RESULTS

We analysed the top 50 most watched videos. Forty-two videos contained real images while eight consisted of animated videos. The content of the videos included 70% (n=35) surgical techniques, 24% (n=12) general introduction (patient info), 4% (n=2) patient experiences and 2% (n=1) lectures. In addition, 64% of the videos were shared by physicians, 22% by medical facilities, 10% by manufacturing companies, 2% by TV channels and 2% by medical illustrators.

Thirty videos (60%) mentioned using the tranforaminal technique, nine videos (18%) used the interlaminar technique, nine (18%) videos used the microendoscopic technique and one (2%) video mentioned using the unilateral biportal endoscopic technique. One video (2%) did not mention any specific endoscopic technique. Twenty-seven videos (54%) had audios while 23 videos (46%) did not. The general features of the videos used in this study are shown in Table 3.

The mean view count per video was 95,954 (range: 2,413-2,827,927). The total number of views of all of the videos was 4,527,724. Lengths of the videos, number of views, duration since uploading, number of comments, number of likes, view ratio (daily view counts), like ratio, and VPI assessments are shown in Table 4. The dissemination of the videos according to the uploaders is shown in Table 5.

The average DISCERN score analysed by the two viewers was 30.22±8.4 and 30.18±9.2 respectively. The average JAMA score of the videos analysed by the two viewers was 1.85±0.35 and 1.92±0.3, respectively. Hence, the average DISCERN score was 30.2±8.5 and average JAMA score was 1.89±0.3. When the DISCERN scores of both viewers were analysed using the Spearman test, we found a strong correlation. There was a

Table 3. General features of the videos

Image type	Number	Percentage (%)
Real	42	84
Animation	8	16
Uploaders		
Physician	32	64
Medical facility	11	22
Manufacturing company	5	10
TV channels	1	2
Medical illustrator	1	2
Video content		
Surgical technique	35	70
Patient info	12	24
Patient experience	2	4
Lecture	1	2
Endoscopic technique		
E-TF	30	60
E-MED	9	18
E-IL	9	18
E-UBE	1	2
E-NS	1	2
Audio		
Yes	27	54
No	23	46

TF: Tranforaminal, MED: Microendoscopic, IL: Interlaminar, UBE: Unilateral biportal endoscopic, NS: Nasal endoscopy

Table 4. Variables of video power index of videos

Variables	Mean	Range (min-max)
Video length (minutes)	7.67	0.75-63.5
View count	95,954	2,413-2,827,927
Time since video upload (days)	1,965.7	43-3,941
Comment count	11.08	0-224
Like count	223.82	3-6,600
View ratio	64.6	0.92-1,971
Like ratio	89.6	64.71-98.67
VPI	48.96	0.69-1,275

VPI: Video power index, min: Minimum, max: Maximum

Table 5. Distribution of video features according to uploaders

	Number	Length (min)	Likes	Dislikes	Comments
Physician	32	8.07	108.1	40.81	8.5
Medical facility	11	5.41	669.09	39.1	24.45
Manufacturing company	5	11.8	70.6	6.2	2.6
TV channels	1	1.68	5	0	0
Medical illustrator	1	4.8	11	2	0

moderate agreement between the observers in the reliability analysis using the Krippendorff's alpha test (r=0,776, p<0.001, Krippendorff α=0.77). In addition, the JAMA scores of the two viewers using the Spearman test were determine to have a very strong correlation. There was also a moderate agreement between the two viewers in the Krippendorff alpha test (r=0.758, p <0.001, Krippendorff α=0.731)

After analysing the average DISCERN scores of the two viewers, we found that the quality of the videos was very poor in 38%, poor in 44%, average in 16% and good in 2% of the videos used in our study.

We compared the DISCERN, JAMA and VPI values of the videos between the physician, medical facility and other groups. In terms of DISCERN and JAMA scores, we found insignificant differences between these various groups (p=0.083 and p=0.466, respectively) Conversely, the VPI values of the videos uploaded by medical facilities were found to be significantly higher than the videos uploaded by physicians and others (p=0.031) (Figure 1).

Since "surgical technique" was the largest subgroup of videos in terms of the content, we compared DISCERN and JAMA scores and VPI assessments between the surgical technique videos and others. The average DISCERN scores of the surgical technique videos were significantly lower than those of the others (28.1 vs 35, p=0.019). However, the average JAMA scores and VPI values did not show any significant difference between the surgical technique videos and the others (p=0.528 and p=0.646, respectively). Although there was a considerable difference in terms of the mean VPI values between the surgical technique videos and the others (10.8 vs 137.9), we found no statistically significant difference. This difference in the mean VPI values

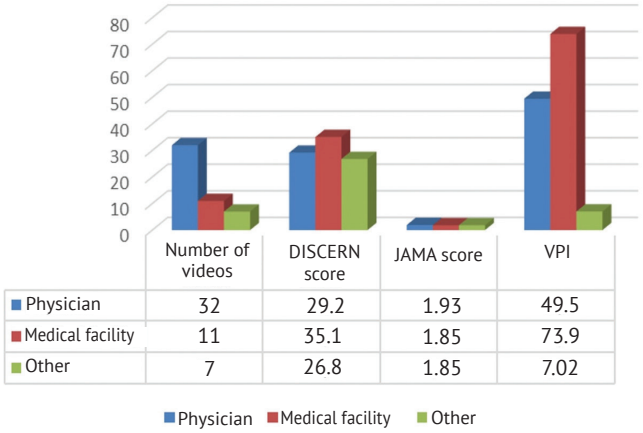

Figure 1. Number of videos according to the uploaders and main DISCERN, JAMA and VPI scores of videos uploaded by physicians, medical facilities and others

VPI: Video power index

was due to the substantial difference in view and like counts of the first and second most viewed videos versus the other videos, which were patient experience and general introduction videos (view count; 2,830,340 and 1,099,638, respectively), (like count; 2,200 and 6,600, respectively) (Figure 2).

One of the parameters used in comparing the videos in this study was videos with audio and without an audio. In the videos with audio group, the average DISCERN score was 34.6, while the average DISCERN score of videos without audio group was 25. The higher average DISCERN score of videos with audio were found to be statistically significant (p=0.0001). However, the two groups' assessment of VPI and JAMA scores were

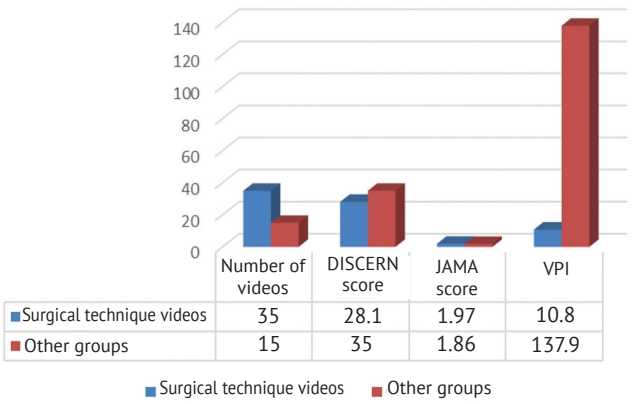

Figure 2. Number of videos according to the content and main DISCERN, JAMA and VPI scores of surgical technique videos and others
VPI: Video power index

found to be statistically insignificant (p=0.693 and p=0.387, respectively.) Similar to the results above, although there was a marked difference between the VPI values of the videos with and without audio (80.7 vs 11.6), no significant statistical difference was found. This was most probably because the first and second most viewed videos were both videos with audio.

Another parameter used in comparing the videos in this study was whether the videos were real or animated. When compared in these terms, the differences in JAMA and DISCERN scores were found to be statistically insignificant (p=0.403 and p=0.710, respectively). Conversely, the VPI values of the animated videos were found to be statistically higher than those of the real videos. (95.1 vs 40.1, p=0.030)

We also evaluated the correlation between the parameters of the DISCERN and JAMA scores, VPI and DISCERN scores, VPI and JAMA scores, view count and DISCERN scores and view count and JAMA scores. We only found a moderate negative correlation between VPI values and DISCERN scores (r=−0.29) and no correlation amongst the other parameters.

DISCUSSION

Reports have shown that the reliability of health-based information delivered by physicians is higher than information delivered by others[9-14]. However, the present study showed insignificant differences between the DISCERN and JAMA scores of the videos uploaded by physicians and those uploaded by medical facilities or others. In the study of Erdem et al.[6] they assessed kyphosis videos on YouTube® and found that the VPI values of the videos uploaded by physicians had the best scores. However, our data showed that the mean VPI value of videos uploaded by medical facilities was higher than the others and the difference was significant. We attribute this result to the advertisements that medical facilities generate to make their videos more known and accessible.

In Erdem et al.'s[6] study, academic videos that had been uploaded by authors who were associated with a university or research group had significantly lower VPI values than other groups' videos, although they had the highest quality scores. In their study, they found an insignificant correlation between VPI and quality scores. Comparatively, neither Erdem et al.'s[6] study nor ours found any correlation between the number of views and quality scores in our respective studies. In our study, we only found a moderately negative correlation between VPI values and DISCERN scores, which is also similar to the results of Erdem and Karaca's[6] study.

In the literature, many reports have shown that videos on the internet regarding many health care topics was unreliable. Berland et al.[15] showed that patients may face challenges in obtaining accurate and correct information from the internet, and the absence of reliable internet-based medical knowledge might deleteriously influence patients' decision making on treatment options. Previous reports regarding spinal surgery showed that the videos on lumbar discectomy[1,16], anterior cervical discectomy and fusion[11], scoliosis[17] and kyphosis[6] on YouTube® were in low quality. Our study showed that videos regarding endoscopic discectomy on YouTube® are not educational, and these results are consistent with the results of previous studies[1-4,6,9-18]. Most of the videos in the present study were found as very poor or poor. From this data, we can conclude that such videos present a risk of misinforming patients and negatively affecting the communication between the physician and patient[6].

In the present study, the DISCERN scores of surgical technique videos were significantly lower than those of other videos. Since surgical technique videos provide information about a particular surgical technique, this difference in DISCERN scores may be related to the lower points assigned to questions 9-15, which evaluated the information quality about other treatment choices.

A former systematic review showed that a large number of health-based videos on YouTube® include subjective knowledge and experiences of the patients[19]. However, we found that most of the videos about endoscopic lumbar discectomy were uploaded by physicians and the percentage of videos consisting of patient experience was considerably lower than what is reported in the literature. One of the 50 videos in our study consisted of patient experience. The DISCERN score of this video was lower than the average DISCERN score (22 vs 30.5), as might be expected. However, the view count of this video was significantly higher than any other video in our study, as well as the mean view count of all the videos in our study (2,830,103 vs 230,568). This video's view count was even higher than the total view count of the other 49 videos combined. (2,830,340 vs 1,967,384) The reason for this could be understandable, as there is evidence in the literature suggesting that the regular viewer has issues understanding videos uploaded by physicians[14]. Watching a patient who had a related experience might relieve the patients' concerns in a

more relatable way that medical professionals may not have considered[11]. For these reasons, viewers might have been more interested in inpatient experiences than in surgical technique and general information videos.

In the present study, we analysed not all, but only the most viewed videos on this subject on YouTube®. Therefore, our findings might not reflect the data of all videos on the subject. Even though this might seem to be the main limitation of this study, the total view count of the videos that were included in this study is 4,797,724, which included most of the total views of all the videos on YouTube® concerning endoscopic lumbar discectomy. In the present study, the 50th most viewed video's view count was only 2,413. This means that even if we had added 100 more videos to our study, it would only alter the total view count by less than 240,000 views. Additionally, our study only included videos that were in English, and endoscopic lumbar discectomy videos published in any other language were not assessed.

CONCLUSION

The reliability of videos concerning endoscopic lumbar discectomy uploaded on YouTube® was low. Our results show that patients cannot differentiate between correct and incorrect medical information on YouTube® and often rate personal patient experience videos higher than more factual, educational and technique-based videos. Using videos on YouTube® as patient education tools for endoscopic lumbar discectomy can often be misleading and inaccurate.

Ethics

Ethics Committee Approval: The study was not conducted on animals or human subjects.

Informed Consent: The study was not conducted on human subjects.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: H.Y.E., S.K., Design: H.Y.E., S.K., Data Collection or Processing: H.Y.E., S.K., Analysis or Interpretation: H.Y.E., S.K., Literature Search: H.Y.E., S.K., Writing: H.Y.E.

Conflict of Interest: The authors declared no conflict of interest regarding the present study.

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THE IMPORTANCE OF SUBCUTANEOUS TISSUE THICKNESS FOR THE OCCURRENCE OF SURGICAL SITE INFECTION AFTER LUMBAR DISC SURGERY

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ABSTRACT

Objective: Previous studies have shown that the length of the surgical path is important in surgical wound infection after a major lumbar surgery. We investigated for the first time the relationship between wound infection occurrence after lumbar disc surgery and subcutaneous tissue thickness.

Materials and Methods: We retrospectively identified 1,275 patients who underwent lumbar disc surgery between 2015 and 2020. Of these, 32 patients were hospitalised with a diagnosis of surgical superficial or deep wound infection. Demographic data, comorbidities, body mass index and body surface areas (BSAs) of the patients were recorded. Subcutaneous adipose tissue thickness and distance from the lamina to the skin were measured on magnetic resonance imaging examinations. Results were compared with that of the control group.

Results: Superficial and deep wound infections were detected in 62.5% and 37.5% of patients, respectively. Age (p=0.182), comorbidities (p=0.425), body mass index (p=0.182), BSA (p=0.569) and subcutaneous adipose tissue (p=0.110) did not contribute to the occurrence of wound infection after lumbar disc surgery. However, the distance between the lamina and skin (p=0.017) was found to be statistically different in women with a wound infection.

Conclusion: We found that that a long distance between the lamina and skin in women might be a risk factor for the occurrence of surgical wound infections.

Keywords: Discectomy, infection, wound, subcutaneous, surgical

INTRODUCTION

Surgical site infection (SSI) after discectomy is rare, but debilitating and potentially life-threatening ranging from 0.09% to 2.1%[1-5]. It also significantly reduces patient satisfaction due to re-hospitalisation[6] and increased length of hospital stay[7]. Despite intensive studies to identify its predisposing risk factors, it has not yet been fully elucidated[8,9]. Advanced age; smoking; comorbidities such as diabetes, hypertension, etc.; steroids use and surgical-related causes have been listed as risk factors[1,2,10-13].

The body mass index (BMI) has for long been used in spinal surgery as a parameter to predict the occurrence of SSI[5,11-13]. Growing evidence from studies indicates that a high BMI contributes to reoperation[14], and SSI occurrence[8]. However, it was suggested that the definition of obesity using the BMI did not accurately reflect the regional adipose tissue because it did not take into account the presence of muscle tissue[15]. To solve this problem, some claimed that the thickness of the subcutaneous tissues in the surgical pathway, rather than the fat distribution of the whole body, could be an important causal factor[16-19] Mehta et al.[16] evaluated the subcutaneous fat tissue (SFT) thickness and distance from the lamina to the skin (DLS) in patients with spinal who developed SSI. They suggested that SFT thickness and DLS provided stronger data to predict the likelihood of SSI occurrence, which was confirmed by others with similar data[17,19].

Therefore, we investigated the effects of BMI, body surface area (BSA), SFT and DLS on postoperative SSI occurrence in patients with lumbar disc surgery.

MATERIALS AND METHODS

Patients who underwent microdiscectomy with a diagnosis of lumbar disc herniation (LDH) between 2015 and 2020 and

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subsequently developed SSI were retrospectively analysed. We found that 32 patients developed SSI, which was classified as either superficial or deep. BMI, BSA, SFT and DLS were measured in all the patients. The measured values were used to determine associations with SSI occurrence. This study was approved by the local ethics committee (registration number: 05/15/2020-2020.05.1.05.037).

Patients who underwent surgery at one or two levels by the microdiscectomy procedure were included in the study. Patients with a spinal fracture, infection and tumour, spondylolisthesis, deformity and previous spinal surgery were not included in the study.

Incisional SSI is classified as superficial (from the skin to the lumbodorsal fascia) or deep (lumbodorsal fascia and below). We classified our patients as those with superficial or deep wound infection. The representative cases for superficial and deep infections are presented in Figures 1 and 2, respectively.

The results were compared with those of 80 women and 80 men, selected randomly from a pool of patients who were operated in the same date range and with the same surgical approach, but did not develop SSI. All the patients received a single dose of antibiotic prophylaxis intravenously 30 minutes before the surgery. In all surgeries, the same protocol was used for the preparation of the surgical area.

In the follow-up, patients with wound problems that required antimicrobial treatment were re-hospitalised. Each patient was questioned and investigated for localised pain, erythema, oedema, incision dehiscence, purulent drainage from the incision and fever >38 °C. The last magnetic resonance imaging (MRI) examination of the patients shortly before the lumbar disc surgery was obtained, and a new MRI was performed when hospitalised for the SSI. Tissue samples submitted for culture that were obtained by wound swap, needle aspiration or the open surgery method were recorded.

The BMI classification was used with its definitions follows: BMI: 18.5–24.9 kg/m^2 (normal), 25.0–29.9 kg/m^2 (pre-Obesity), 30.0–34.9 kg/m^2 (Obesity class I), 35.0–39.9 kg/m^2 (Obesity class II) and above 40 kg/m^2 (Obesity class III) in adults. BSA was calculated and expressed in m$^{2(20)}$.

The data from lumbar MRI scans belonging to the patients and saved in Digital Imaging and Communications in Medicine (DICOM) format were obtained with a software provided by DICOM company. SFT and DLS for each patient were measured on the axial and/or sagittal T1-weighted image (presented in Figure 3). The measurement was made by two independent observers, and the average of the results was considered.

Statistical Analysis

Nominal data are presented as percentages while numerical data are presented as average and standard deviation. Comparison between groups was done using the chi-square and Fisher's exact test depending on the number of group subjects for nominal data, Kruskal-Wallis and Mann-Whitney U tests for

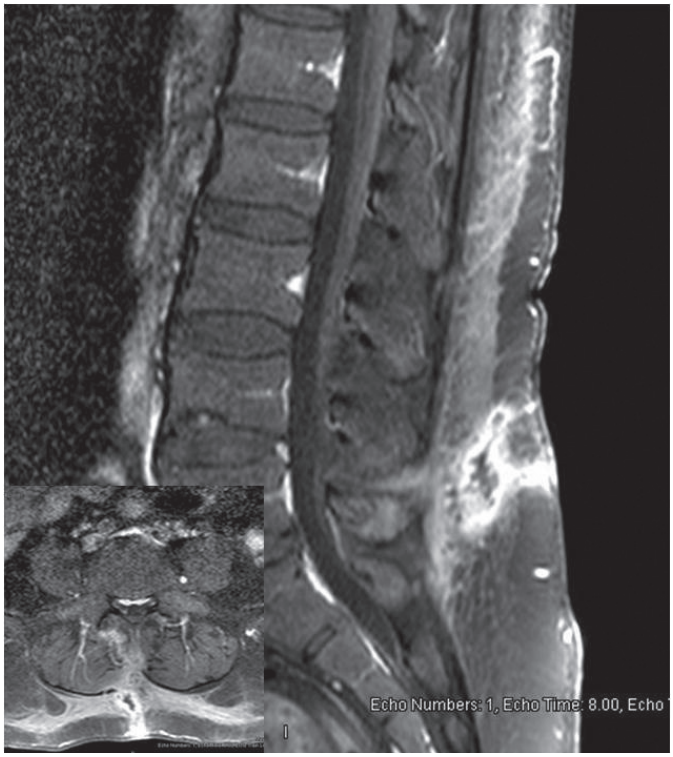

Figure 1. The figure shows a superficial SSI in the T1-weighted contrast MRI of a patient who underwent L5-S1 discectomy
SSI: Surgical site infection, MRI: Magnetic resonance imaging

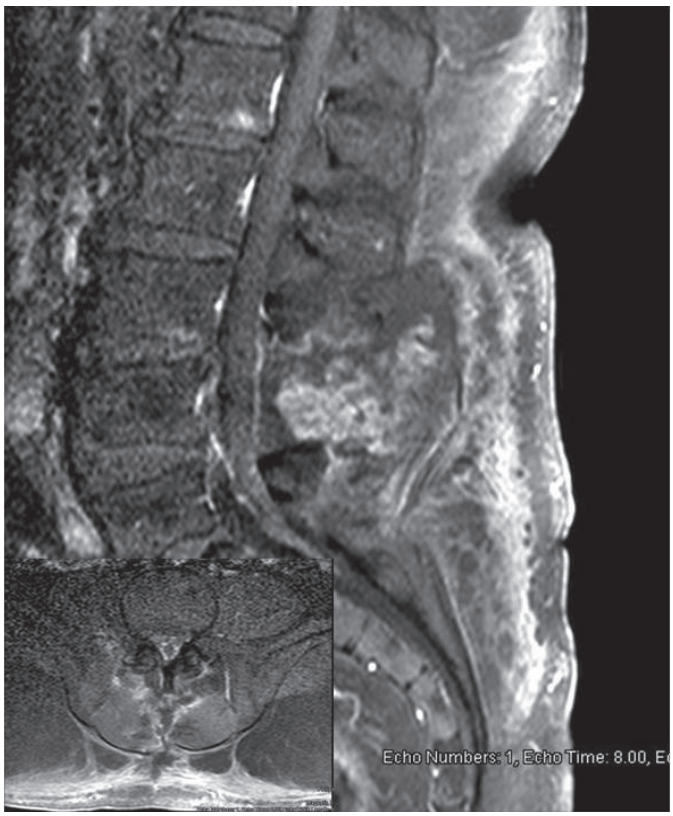

Figure 2. The figure shows a deep SSI in the T1-weighted contrast MRI of a patient who underwent L4–5 discectomy
SSI: Surgical site infection, MRI: Magnetic resonance imaging

sequential data and variance analysis and t-test for numerical data. Bonferroni correction was used when variance analysis was done. P<0.05 was considered significant. Professional help was obtained for the statistical calculations.

RESULTS

SSI was detected in 32 patients (2.5%) after the LDH surgery. Characteristics of the study population and comorbidities are presented in Table 1.

The most common complaint at re-admission was low back pain and temperature increase in the incision line and the most common finding was severe low back pain with percussion and wound dehiscence. In the 32 patients who developed SSI, 36 levels of lumbar disc surgery were performed (four surgeries were performed at two levels). The most frequent level was L4–5 (22 cases, 61.2%), followed by L4–5 (10 cases, 27.8%), L2–3 (2 cases, 5.5%) and L2–3 level (2 cases, 5.5%). The superficial SSI was encountered in 71.9% of patients (11 women vs 12 men) and deep in 28.1% (4 women vs 5 men).

We evaluated whether the BMI, BSA, SFT and DLS had any effect on SSI occurrence (presented in Table 2). In the SSI group, 33.3% of the women were pre-obese, 67.7% were obese, and this rate was 64.8% and 35.2% for men, respectively. Comparing the group of men with and without SSI, there was no statistically significant difference in terms of age, comorbidity, SFT, DLS, BMI and BSA (no data provided). When comparing the group of women with and without SSI, there was no statistically significant difference in terms of age, comorbidity, SFT, BMI and BSA (no data provided). When the SSI and non-SSI groups were compared, the DLS value was found to be statistically different in the SSI group (p=0.017) (presented in Table 2). The factor that made the statistical significance was women. Compared to the non-infected group of women with SSI, the DLS value was to be found statistically different in women (p=0.014). Therefore, it is thought that DLS may be a risk factor for SSI occurrence in women.

The bacteria isolation rate was 65.6% (n=21/32). Culture sampling was performed in five patients during debridement. No intervention was conducted because five patients were considered to have no material to be sampled. Gram-positive cocci were responsible for 61.9% of the SSIs, while Gram-negative cocci were responsible for 38.1%. No organism was isolated in five patients (15.6%), three of whom had deep and two had superficial infections. Twenty-one patients were treated with an antibiotic regimen determined by the antibiogram results. The remaining 11 patients were treated with antianaerobic and antiaerobic antibiotics.

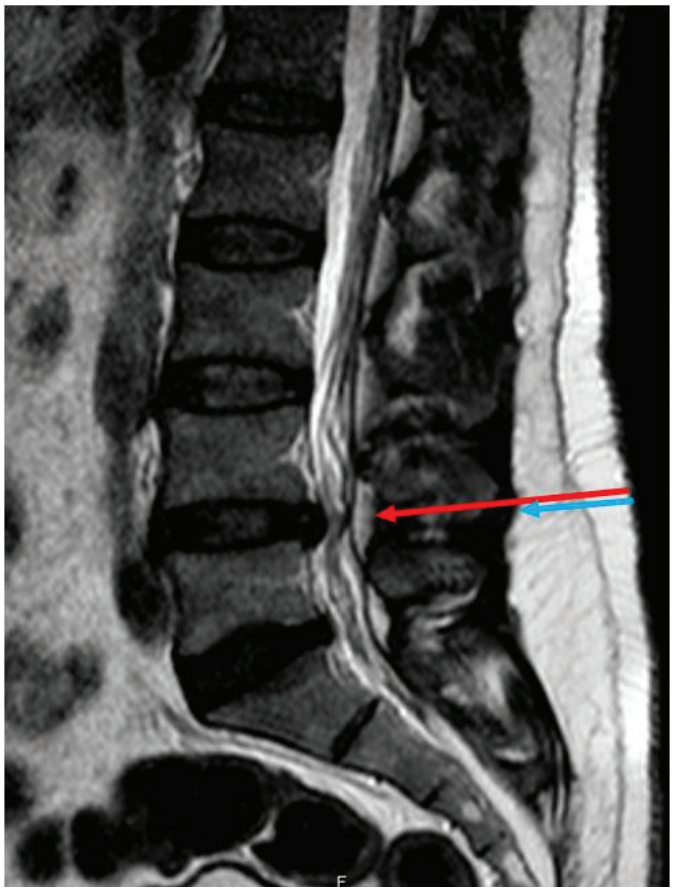

Figure 3. The figure shows the measurement of subcutaneous fat tissue (blue arrow) and distance of the lamina-to-skin (red arrow) on the T1-weighted MRI along the surgical route
MRI: Magnetic resonance imaging

Table 1. The table shows the age, sex and comorbidities of the patients included in the study

	Patients in the control group (n=160)	Patients in the SSI group (n=32)	p
Age, mean (± SD), year	50.5 (±12.4)	48.3 (±11.9)	0.747
Diabetes	30	9	0.229
Hypertension	45	9	0.577
IHD	9	4	0.237
COPD	11	1	0.694
RA	7	2	0.647
Comorbidities (total)	102	25	-

SSI: Surgical site infection, SD: Standard deviation, IHD: Ischemic heart disease, COPD: Chronic obstructive pulmonary disease, RA: Rheumatoid arthritis, n: Number

Table 2. The table shows the statistical comparisons of BMI, BSA, and radiological measurements of patients with and without SSI

	Patients in the control group (n=160)	Patients in the SSI group (n=32)	p
BMI, mean (± SD), kg/m²	28.8 (±4.83)	30.1 (±4.96)	0.182
BSA, mean (± SD), m²	1.92 (±0.18)	1.94 (±0.03)	0.569
SFT, mean (± SD), mm	27.4 (±11.9)	31.05 (±11.36)	0.110
DLS, mean (± SD), mm	61.73(±13.0)	67.92 (±14.35)	0.017*

SSI: Surgical site infection, SD: Standard deviation, BMI: Body mass index, BSA: Body surface area, SFT: Thickness of subcutaneous fat tissue, DLS: Distances from the lamina to the skin, *Statistically significant (p<0.05), n: Number

The antimicrobial treatment duration of the patients ranged from seven to 37 days. In addition, one of the patients received hyperbaric oxygen therapy as an additional treatment. The average hospital stay for the patients with SSI (range: 4 to 26 days) was 11.5±5.9 days (10.2±4.7 for women and 12.5±6.7 for men).

DISCUSSION

Depending on the technique of the intervention, wound complications occurred at a rate of 2.1% in microdiscectomy, 1.2% in microendoscopic discectomy and 0.5% in the percutaneous discectomy procedure[5]. Golinvaux et al.[4] compared patients who underwent a discectomy in the Spine Patient Outcomes Research Trial (SPORT) study (n=232), a randomised controlled trial, with patients registered in the National Surgical Quality Improvement Program (NSQIP) study (n=6,842). The analysis revealed that the incidence of superficial SSI in the SPORT study was 2% and deep SSI was 0%, whereas in the NSQIP study, it was 0.6% and 0.3%, respectively. Smith et al.[21] analysed 7,213 discectomy patients and found that SSI was present in 0.9%(superficial in 0.5%, deep in 0.4%) of the patients. In the study that used a minimally invasive surgical technique, the SSI occurred in 0.09% of the 4,350 patients (all deep)[3]. In a similar study conducted using the same method with 4,027 patients, the rate of SSI was 0.65% (superficial in 0.42%, deep in 0.23%), and it was concluded that MIST is an independent protective factor against infection[2]. In a systematic review, Zijlmans et al.[22] investigated whether postoperative deep haematoma ranging from 0.15% to 2% was the source of infection, and found no statistical difference in the SSI rate between those who were drained (0.47%) and those who were not (0.88%). The rate of patients with SSI in our single-centre study was 2.5%, which was considerably higher than that in the literature. On the other hand, superficial SSI was detected in 2/3 of the total population in accordance with previous studies.

Numerous studies focusing on the effect of BMI on SSI occurrence after discectomy have been published[4,7,12,13]. In the report comparing the results of the two major studies median BMI was found to be 27.8 kg/m² for SPORT and 29.6 kg/m² for NSQIP, median values of both studies were in the pre-obesity class, and the SSI occurrence rate was less than 2%[4]. In daily hospitalised patients, BMI and SSI were 29.4 kg/m² and 1.13%, respectively[12]. Rihn et al.[13] compared the SSI results in patients with BMI greater and less than 30 kg/m² and found an SSI rate of 2% in both groups. Fakouri et al.[7] evaluated two groups of patients, non-obese and obese, with a median BMI of 24 kg/m² and 38.7 kg/m², respectively. They found that the risk of re-hospitalisation in patients double when the BMI is greater than 40 kg/m². The above-mentioned articles concluded that obesity is not a risk factor for SSI. In our study, the BMI was higher in patients with SSI than in those without SSI, but no statistically significant difference (p=0.182) was found. We concluded that BMI is not a risk factor, which is consistent with the results of previous studies.

A study reported that the BMI result does not accurately reflect the regional adipose tissue[15]. It is also unable to distinguish between fat and lean mass, whereas the body composition consists of fat, muscles, bones, water and other tissues. Therefore, researchers attempted to obtain a new parameter to estimate SSI by measuring regional subcutaneous tissue[16-19]. Mehta et al.[16] examined the SFT and DLS by taking measurements at the L4 level in 28 cases who underwent fusion surgery. They found higher SFT (p=0.035) and DLS values (p=0.046) in infected patients than in healthy subjects and concluded that SFT is more valuable in predicting SSI than BMI. Li et al.[18] studied the SFT in 20 patients with transforaminal lumbar interbody fusion (measured at the same level) and concluded that ıt is an independent risk factor for SSI occurrence (p=0.001). Lee et al.[17] evaluated subcutaneous adipose tissue with multi-level measurements from T12 to L5. They found that each mm of SFT increase leads to a 6% increase in SSI rate, and if the thickness is above 5 cm, it leads to a 4-fold increase, which supports the finding that SFT has a statistically stronger effect compared to BMI. Peng et al.[19] found that there was a significant increase in the SSI rate when the fat tissue thickness exceeded 4 cm in patients who underwent spinal surgery (performed multi-level measurements). The route through which surgery was performed was assessed in the study. When comparing the SSI and non-SSI groups, a statistically significant difference

was found in the DLS measurement results in favour of the SSI group (p=0.017). After applying additional statistical test, we found that the difference was due to the high DLS values in women (p=0.008). In our study, it was concluded that the length of the surgical path rather than the SFT thickness is an important factor in the occurrence of SSI in women. Our results were similar to those of patients who had undergone a major spinal surgery.

BSA is often used to calculate the doses of treatment agents. Recently, studies have been conducted to link BSA to body weight and obesity[23,24]. In obesity, a disproportionate increase in BSA occurs in patients with different weights as the height remains constant. Even though BSA can be calculated using different methods[20,23,24], its results have generally been shown to deviate significantly from the bodyweight curve[20]. In our study, BSA has the weakest statistical result (p=0.569) among the four measurements examined. We believe that it is not appropriate to be used in such studies.

CONCLUSION

To our knowledge, the present study is the first in the literature that investigated the relationship between SSI, SFT and DLS in patients who underwent LDH surgery. Our study revealed that the DLS could be used to predict the risk of SSI occurrence in female patients.

Ethics

Ethics Committee Approval: This study was approved by the Ethics Committee of University of Health Sciences Turkey, Bağcılar Training and Research Hospital (registration number: 05/15/2020-2020.05.1.05.037).

Informed Consent: Retrospective study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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

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CASE REPORT
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DYNAMIC INSTRUMENTATION OF THE THORACIC SPINE

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ABSTRACT

The aim of this report was to present a new surgical alternative for pathologies affecting the thoracic spine, and to also share our experience of treating such cases using dynamic systems. Two patients exhibiting thoracic spine pathologies (traumatic disc herniation and thoracic stenosis) that did not necessarily require surgery using rigid systems were selected for stabilization using the dynamic system. The patients exhibited a decrease in postoperative visual analog scale scores, and the follow-up period remained uneventful. The results of this report suggest that dynamic systems can be used as an alternative to rigid systems for treatment of thoracic spine pathologies.

Keywords: Dynamic instrumentation, peek rod, thoracic

INTRODUCTION

Although there is considerable scientific evidence on the surgical treatment of thoracic spine pathologies available, the majority of studies carried out to date tend to focus on the use of rigid systems. The efficacy of these systems are well-established; however, the treatments does not require with the rigid systems for the patients are not clear[1,2]. Various industrial materials and systems for surgical treatment of the lumbar spine have been developed and, despite lack of a common consensus, there is a general tendency towards certain treatment options (dynamic, rigid, or hybrid systems) for specific pathologies[2,3]. All segments of the human spine contribute to spinal alignment and allow movement in motion. The occurrence of various pathologies affecting range of motion in the lumbar region of the spine led to the development of dynamic systems specifically designed for this region which, in turn, highlighted the need for similar developments in treatment options for the thoracic spine[4]. The thoracic vertebrae are not stationary and exhibit considerable stability, despite having inferior range of motion compared to other regions. Pathologies such as disc herniation, traumatic fractures, osteoporotic compression fractures, and thoracic stenosis affecting these regions typically result in a degradation of stability.

This case report presents two patients treated for pathologies affecting the thoracic spine using dynamic instrumentation.

CASE REPORT

Retrospective evaluation of two patients diagnosed with multiple thoracic disc herniation after trauma and myelomalacia due to thoracic stenosis and treated using thoracic dynamic systems [with straight PolyEtherEtherKetone (PEEK) rod] at our clinic between 2014 and 2015 was carried out. The median age of the patients was 42.5 (31-54) years, and the mean follow-up period was 27 (20-34) months.

Posterior decompression and stabilization of the spine using T1-6 titanium screws and straight PEEK rods was carried out to treat the patient diagnosed with multiple disc herniations after trauma. The second patient exhibiting T10-11 stenosis with myelomalacia was treated using T10-11 segmental stabilization after decompression (total laminectomy + bilateral partial medial facetectomy) (Figure 1a-d).

Radiological examination of the patients was carried out at the last follow-up appointment although, and the visual analog scale (VAS) scores of the patients in the preoperative (1st month) and postoperative (last examination) periods were recorded and checked for improvement. Both patients exhibited improvement in VAS scores and a decrease in pain scores in

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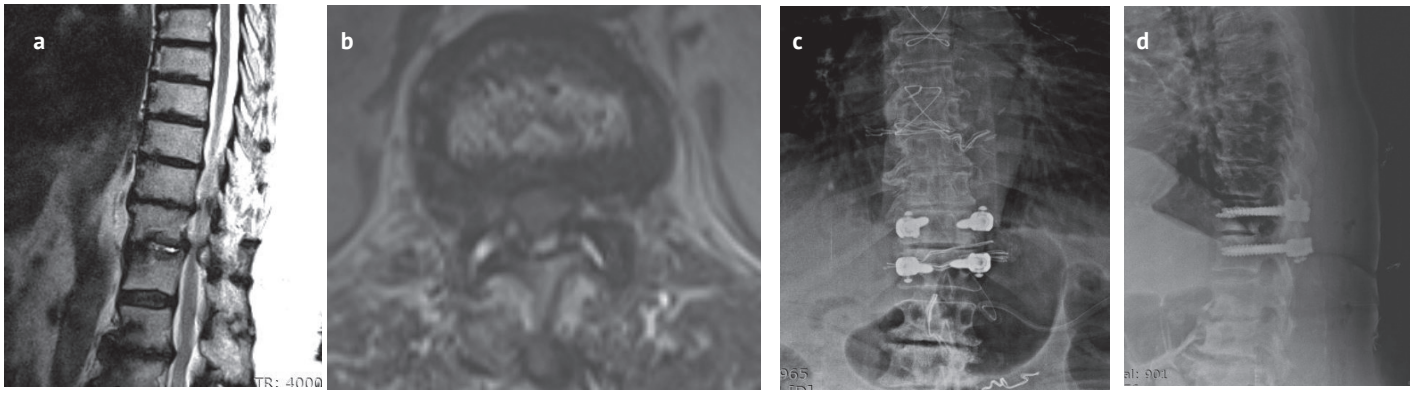

Figure 1. A 54-year old female patient exhibiting gait disturbance presented at our clinic. Radiological examination showed myelomalacia and thoracic spine stenosis at the T10-11 levels **(a, b)**. Decompression with laminectomy, partial medial fasetectomies, and dynamic stabilization using PEEK rods was carried out **(c, d)**.
PEEK: Poly Ether Ether Ketone

the 1st month postoperatively (Table 1), although statistical evaluation could not be carried out due to the small sample size. The last follow-up appointment showed no increase in pain scores, and radiological examination confirmed no problems with the stabilization systems.

DISCUSSION

Rapid developments in diagnostic methods such as computerized tomography and magnetic resonance imaging have led to increased detection of pathologies affecting the thoracic region[1]. A recent study in Japan found that the rate of surgical interventions for pathologies affecting the thoracic region, such as thoracic masses, discopathies, and infectious pathologies, were unexpectedly high at 6%[1-3]. However, despite an increase in the frequency of interventions in this region, instrumentation has always typically been based on rigid systems and there is limited evidence available on the use of dynamic systems in the thoracic region. This can be attributed to the fact that the thoracic region has always been perceived as being rigid, resulting in limited biomechanical development of dynamic systems for this region.

A large number of studies have examined the range of motion in the cervical and lumbar regions[4-7], and comparison of the range of motion produced by rigid and dynamic systems in the lumbar spine have been a focal point of interest. However, studies focusing on the thoracic spine are extremely rare[8].

Despite being surrounded by the rib cage, the thoracic spine exhibits considerable range of motion as shown in studies examining the peak points of flexion and extension of the spine. Bible et al.[9] noted that although the range of motion in the thoracic region was less compared to the cervical and lumbar regions, it played a crucial role in spinal alignment[9].

The total kyphosis angle (T1-L1) in the thoracic spine was 40.2±11.4 in flexion and 8.5±12.8 in extension[8], and this difference is particularly striking for moving thoracic vertebrae. Morita et al.[8] showed that the segmental kyphosis angle increased during flexion from T1 to T6-7 and from T10 downwards.

Upon examining previous cases treated at our clinic, we found that a majority of surgeries were performed to treat pathologies and protect movement at these levels. The increase in the segmental kyphosis angle observed in these regions during flexion suggests that, similar to the lumbar region, efforts should be made to protect the range of motion. Although it is logical that rigid systems should be used in patients with obvious instability, such as those observed at every level of the spine, dynamic systems can be considered in cases where minimal level of support is sufficient, even if it is in the thoracic region.

Previous cadaver and canine model studies have examined the stability of the thoracic region as well as impairment of this stability upon bone resection. Furthermore, it was also investigated whether the thoracic region has significant pathological status in the range of motion in the cases of flexion, extension and lateral bending[10-12].

Studies examining bone resections found that partial discectomy with resection of the rib head resulted in a significant increase in motion, and unilateral resection of the rib head along with removal of the facet joint did not lead to any significant instability. In case of thoracic disc herniations, posterolateral approaches were typically preferred, with rigid stabilization being the treatment of choice in patients requiring excessive bone resection from the lateral side[13]. However, dynamic stabilization was considered to be sufficient in the two cases reported here as massive bone resection was not necessary and there was no evidence of distorted costovertebral joints and ligamentous structures, and the follow-up period was seen to remain uneventful.

Currently, there is no defined treatment protocol for patients with significant disc herniation and thoracic discogenic pain after trauma. Discogenic pain in the lumbar spine is usually treated using dynamic stabilization, and this approach may also be reasonably applied to the thoracic region. Our team

has previously performed dynamic stabilization using PEEK rod and transforaminal microdiscectomy in the T2-3, T3-4, and T4-5 regions, and the patients typically exhibited rapid, significant improvement in their pain scores and uneventful follow-up periods.

This case report had several limitations. Firstly, the sample size was small, and longer follow-up of a larger number of cases would provide more reliable results. Secondly, the small sample size also made statistical evaluation of the results difficult. Thirdly, development of an optimal system was not possible. The PEEK rods used in this study were straight (6 mm in diameter) and were not specifically designed for use in the thoracic spine, and dynamic systems developed in accordance with the anatomy of the thoracic region (for physiological thoracic kyphosis) may produce better regional range of motion in the thoracic spine. Future studies using similar techniques and a multi-centric approach should be carried out for more generalizable results.

In conclusion, dynamic systems may be considered as a potential surgical treatment option in patients exhibiting thoracic spine pathologies, such as stenosis and disc herniation, without severe bony resection, such as costovertebral joint, pedicle, corpus. However, better evidence from larger studies as well as biomechanical development of industrial dynamic systems is necessary as this is still a very new concept.

Ethics

Informed Consent: Verbal informed consent was obtained from the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

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

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ATLANTOAXIAL SUBLUXATION IN A PATIENT WITH PSORIATIC ARTHRITIS: A CASE REPORT

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ABSTRACT

Psoriatic arthritis (PsA) is a chronic inflammatory arthritis associated with psoriasis. While psoriasis is seen in 1–2% of the general population, PsA is seen in 6–40% of psoriasis patients. In 70% of patients with PsA, the cervical spine is affected and myelopathy develops. The case presented is that of a patient with non-traumatic, upper cervical instability on the basis of PsA, who was diagnosed of myelopathy and was treated surgically.

Keywords: Psoriasis, psoriatic arthritis, spondyloarthropathy, cervical instability, atlantoaxial subluxation

INTRODUCTION

Spondyloarthropathy (SpA) is a disease group characterised by synovitis and enteritis, with spinal and oligoarticular involvement, for which there is a genetic predisposition. Psoriasis is a rheumatismal disease which manifests with arthritis, negative rheumatoid factor and the presence of HLA-B27 antigen especially in those with spinal involvement. Psoriatic arthritis (PsA) is a chronic inflammatory arthritis associated with psoriasis. It is a member of the SpA family with common immunopathological, clinical and radiological features. Psoriasis is seen in 1–2% of the general population while PsA in 6–40% of psoriasis patients[1]. Although it may be seen at any age, the frequency increases in the 30–50 years age group[2]. In 70% of patients with PsA, the cervical spine is affected and myelopathy develops in a very small proportion of these patients[3].

The case presented here is that of a patient with non-traumatic, upper cervical instability on the basis of PsA, who was diagnosed of myelopathy and was treated surgically.

CASE REPORT

A 48-year-old male diagnosed with psoriasis 24 years ago was presented with complaints of neck pain and paraesthesia in the right arm which had been ongoing for 4 months. The patient had no history of trauma and physical examination revealed increase in deep tendon reflexes and the bilateral Hoffmann sign was determined. No motor deficit was observed. According to the laboratory tests, result showed that rheumatoid factor was negative and HLA-B27 was positive. On magnetic resonance imaging, on the T2 sequence, a hyperintense lesion was seen within the spinal cord at the C1–2 level, which was interpreted as myelomalacia. On the dynamic cervical magnetic resonance (MR) images, an advanced degree of narrowness was determined in the spinal canal at C1–2 and C3–4 levels, especially in extension (Figure 1A and B). On dynamic computed tomography and plain radiographs, there were evident findings of instability at both levels and the diameter of the spinal canal was reduced (Figure 2A–C). Widespread ligament calcification was seen and fusion had developed especially between the lower cervical vertebrae.

The patient was positioned prone with the head in a Mayfield headpiece under general anaesthesia. With a midline approach, the muscles were stripped bilaterally from suboccipital as far as C5 level. First, by placing C1 lateral mass screws, C2 pedicular screw and C3, 4 and 5 lateral mass screws, they were joined with a rod. Then C1 laminectomy was applied, C2 sublaminar decompression, and decompression with C3–4 interspinous ligament and ligamentum flavum excision. No perioperative

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complications developed. Postoperatively, no motor or sensory deficit was observed in the patient. On MR and X-ray imaging, the spinal cord was seen to have been decompressed (Figures 3A and B). The patient was followed for about 2 years. Pain complaints of the patient decreased. No walking disorder detected.

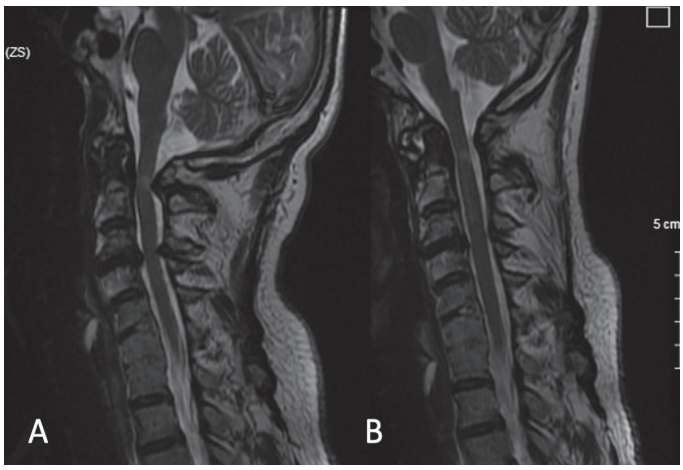

Figure 1. Atlantoaxial subluxation and myelopathy **(A)** extension, **(B)** flexion position of the dynamic cervical magnetic resonance images

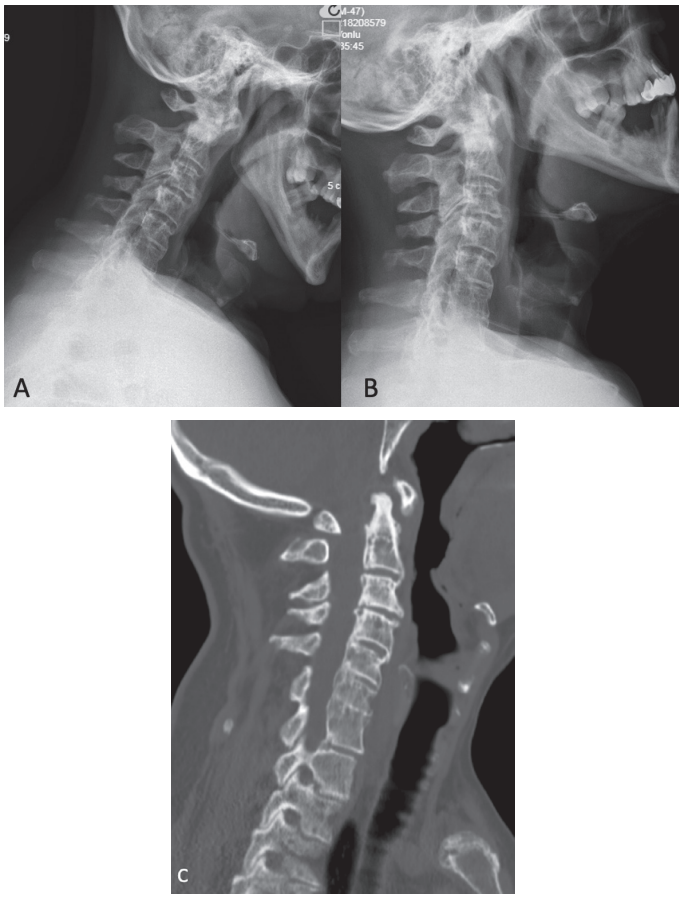

Figure 2. Atlantoaxial subluxation showing dynamic cervical X-ray images **(A)** flexion, **(B)** extension, and **(C)** cervical sagittal computed tomography image

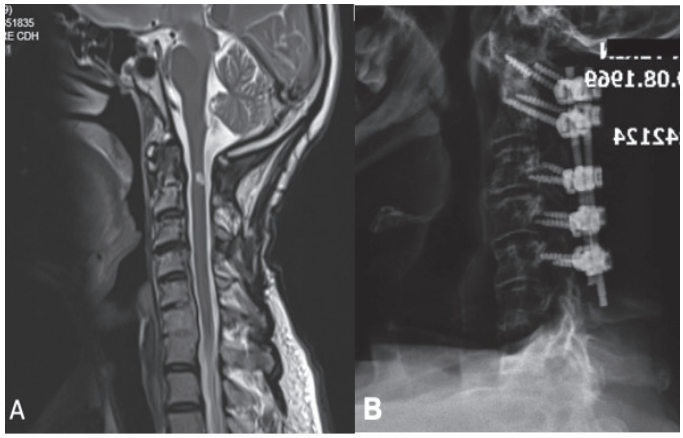

Figure 3. Postoperative cervical spine **(A)** magnetic resonance sagittal T2 weighted images, and **(B)** lateral X-ray image. Myelopathy can be seen easily after spinal canal decompression

DISCUSSION

Psoriatic arthritis (PsA) is classified as inflammatory arthritis associated with psoriasis, which progresses to joint destruction[4]. The exact prevalence of PsA is not known taking into consideration there is no globally accepted criteria. The prevalence in patients with psoriasis varies between 6% and 42%, and in 17% of cases, there are no skin findings[2]. Although the cause of the disease is not fully known, genetic, immunological and environmental factors are thought to play a role in the pathogenesis. There is no specific laboratory test for PsA. Non-steriods, disease-modifying drugs, corticosteroids and biological agents are used in treatment[1,5].

Axial spine involvement can generally be seen in 20–40% of PsA cases, and this rate can increase up to 51% in long-term follow-up[5,6]. As the duration of the disease and the number of peripheral joints involved increase, the percentage of cervical spine involvement increases also[5]. There may be sacroiliac involvement at a 30–50% rate, symmetrically or asymmetrically[7,8]. Radiological cervical spine findings are relatively common (35–75%) in PsA patients[3]. Cervical spine lesions have been reported as apophyseal joint erosion, vertebral plate erosion and atlantoaxial subluxation[3]. Cervical spine anomalies are seen in two patterns in PsA. The first pattern is a table of erosive and/or cervical subluxation as in rheumatoid arthritis, and the second pattern is ligament ossification and ankylosis resembling ankylosing spondylitis[9]. In these patients, odontoid erosion may develop at a low incidence. Neurological complication rates are low despite cervical involvement in PsA (2–14%)[3,9,10].

Symptoms in cervical spine pathologies which develop associated with degenerative or inflammatory etiologies are axial neck pain, myelopathy or radiculopathy. Neck pain is the most frequently seen finding associated with cervical region involvement in SpA. Myelopathy develops associated with brainstem or spinal cord pressure. Early findings associated with

myelopathy are difficulty in walking or maintaining balance and in the later stage, motor neuron findings are seen[11].

Surgical treatment is applied to patients with findings of instability and/or myelopathy and to cases which develop, radiculopathy. It is important that instability is treated before the emergence of myelopathy findings in particular. In 43–70% of patients diagnosed of cervical instability because of PsA, neurological deficits develop within 5 years[12].

Several different methods are used in the fusion of C1–C2 vertebrae in the surgical treatment of atlantoaxial instability. It is necessary to add the occipital bone to C1-C2 fusion if there is accompanying basilar invagination. Generally, when there is stenosis of the spinal cord or nerve roots, spinal cord decompression is applied. Autogenous bone grafts are preferred for fusion purposes. The current, most widely used surgical method is the application of decompression by placing mass screws to C1 and pedicle screws to C2 if necessary[13].

In the case presented, as there was no accompanying basilar invagination, occipital screws were not applied. Spinal stenosis was determined related to posterior ligament thickening in the C2–C3 space in addition to stenosis and C1–C2 instability, therefore, C1 mass, C2 pedicle and C3–4–5 lateral mass screws were applied. C1 laminectomy was applied for decompression, C2 sublaminar decompression, and C3–4 space decompression was achieved with ligamentum flavum excision. Autogenic bone was used for fusion (Figures 3A and B).

In conclusion, it must be taken into consideration that a narrow spinal canal and instability could develop in PsA, and in cases with the risk of cervical instability in particular, the application of surgical treatment before myelopathy findings emerge will significantly prevent morbidity.

Ethics

Informed Consent: Informed consent was obtained from the patient regarding that their surgery and the surgical approvement would be published as a case presentation article of ours entitled "Atlantoaxial Subluxation in a Patient with Psoriatic Arthritis: a case report".

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.R.Ö., E.Y., C.S., S.N., Concept: C.S., Design: M.R.Ö., E.Y., Data Collection or Processing: C.S., Analysis or Interpretation: M.R.Ö., S.N., Literature Search: C.S., Writing: M.R.Ö.

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COMPLEX REGIONAL PAIN SYNDROME FOLLOWING SPINAL DISEASES AND SURGERIES

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ABSTRACT

Complex regional pain syndrome (CRPS) impairs the patient's active life and his/her psychological state due to reductions in functional movements, severe pain, and muscle atrophy. Fractures and surgical operations are important risk factors for CRPS, and several studies reported incidences of CRPS following surgical procedures to the upper or lower limb. CRPS can also be seen after spinal diseases and surgeries, yet the literature includes only limited number of studies in this area and there are not enough works considering incidence of CRPS following spinal problems. While early diagnosis and appropriate treatment of CRPS in acute period are very important for prevention of chronic symptoms (including allodynia, swelling, muscular atrophy, osteoporosis and contracture), clinicians need to be aware that the spinal problems may cause CRPS. The aim of this review is to emphasize the possibility of CRPS development after spinal diseases or surgeries and strongly argue that the diagnosis of CRPS following spinal problems must be considered by clinicians.

Keywords: Complex regional pain syndrome, spinal disease, spinal surgery, spinal cord injury, spinal tumor

INTRODUCTION

Complex regional pain syndrome (CRPS) impairs the patient's active life and his/her psychological state due to reductions in functional movements, severe pain and muscle atrophy. CRPS is characterised by a severe, generally not well-tolerated, pain that usually involves the extremities. The most significant complaints are severe pain with edema and other vasomotor and motor symptoms, such as temperature and/or skin colour asymmetry, dystonia and tremor. Although current medical treatments often target acute symptoms, CRPS can also become chronic, lasting for months or years, accompanied with other symptoms due to irregularities in the sympathetic nervous system. Even though CPRS can be characterised as a chronic neurological disease, it is generally caused by a triggering trauma, such as fractures, surgeries or even minor injuries.

Acute and Chronic CRPS

CRPS may be categorised into two: CRPS type 1 may occur without nerve lesions and CRPS type 2 is associated with nerve lesions caused by a triggering trauma[1,2]. Even in the absence of nerve damage, a triggering trauma and subsequent flared posttraumatic inflammation may be observed. The progression of this syndrome is variable, but the clinical presentation is often similar in both groups: in the acute period, common features include the five main signs of inflammation, namely, pain, edema, erythema, changes in skin temperature/colour and dysfunction[2]. In fact, the transient features of CRPS may be observed more commonly than most clinicians realise and CRPS may even occur after minor limb injuries. As CRPS becomes chronic, symptoms can evolve, and allodynia, sweating, dystonia and muscle atrophy may occur during the disease course. During this period, symptoms may appear exaggerated and disproportionate in degree and duration with respect to the triggering event, and chronic symptoms of CPRS can no longer be explained by the initial trauma.

Vasomotor dysfunction is common in patients with CRPS. While the affected limb is generally warmer than the healthy limb at earlier stages, it becomes colder in the later phases of the syndrome[2]. While red and hot lesions are observed in the acute phase, if the patient is not treated appropriately, the drop in the skin temperature of the affected area can result in cold lesions in the chronic phase.

Importance of Early Treatment of CRPS

In patients with CRPS, symptoms tend to begin during the first month following trauma and/or immobilisation of the extremity[3]; physical problems may begin approximately 2 years after disease onset[4,5]. Since CRPS has no known evidence-based effective treatment, approximately 15% of the

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patients experience unbearable pain. If CRPS is not properly treated in the acute period (3–6 months from onset), tendons may shorten and fibrosis may develop[6]; thus, contractures may occur very quickly.

In chronic CRPS, symptoms can lead to complete disruption of normal daily activities due to severe pain and atrophy in the affected limb. This may lead to excessive use and abuse of drugs for CRPS treatment[3,7], and drug side effects may be observed. In particular, long-term and high-dose usage of opioids may cause severe problems due to tolerance, dependence, immune suppression and dysfunction in the endocrine system. Long-term usage of opioids may also cause hyperalgesia[8]. Respiratory suppression due to opioid overdose may result in death.

Delayed and insufficient treatment may increase the risks of complete deterioration in daily activities, major depression and suicide[7]. If treatment options are ineffective, amputation may be required; physical and psychological problems in CRPS may become so severe that clinical teams encountered patients who requested limb amputation[1]. However, even after such a drastic intervention, phantom pain (77% of the cases)[9] and CRPS recurrence in the remaining extremity (24% of the cases)[10] remain as potential risks.

As presented above, early treatment of CRPS is very important in preventing long-term symptoms (allodynia, muscular atrophy, etc.); thus, clinicians must start appropriate treatment protocols without any delay when early diagnosis of CRPS is possible[11]. Unfortunately, CRPS is not easy to diagnose.

Early Diagnosis of CRPS

Early diagnosis of CRPS may prevent long-term complications and sequelae, including muscle atrophy, osteoporosis, joint stiffness, tendon shortening and contracture, which weaken the patient's active life by reducing his/her functional movements. A major problem with the diagnosis of CPRS is that symptoms can mimic other diseases. Diagnosis relies on clinical findings; unfortunately, a gold standard and objective diagnostic test for CRPS is not yet established. CRPS is diagnosed clinically using the diagnostic criteria of the International Association for the Study of Pain (*Budapest Diagnostic Criteria* for CRPS)[7,12].

Table 1 lists some of the diagnostic signals that should be considered[3]. During differential diagnosis, especially for complex cases, imaging tests (including magnetic resonance imaging and computed tomography) may be performed to exclude other possible diseases. Plain film may also be used, except in extreme cases (Sudeck's atrophy).

Electromyography and nerve conduction studies may help assess the presence of nerve injury and muscle fibre loss. Three-phase bone scintigraphy may detect trophic changes of the bone. Local anaesthetic sympathetic blocks are commonly used for diagnostic purposes. If a patient has a good response to a diagnostic sympathetic block with local anaesthetic, sympathetic denervation through radiofrequency ablation can be offered for therapeutic purposes.

Since CRPS symptoms are similar to that of other diseases, patients often undergo evaluation by multiple specialists before the final diagnosis is confirmed, and this may lead to significant delays in treatment. These delays may also increase the risk of the disease becoming chronic and may lead to serious economic losses for the patient.

Risk Factors for CRPS and Incidence of CRPS after Fractures/Surgeries

Common risk factors for CPRS are listed in Table 2[13-17]. According to de Mos et al.[14], women are three times more affected by

Table 1. Differential diagnosis[3]

• Infection (bone, soft tissue, joint or skin)
• Orthopaedic mal-fixation
• Joint instability
• Arthritis or arthrosis
• Bone or soft tissue injury (including stress fracture, instability or ligament damage)
• Compartment syndrome
• Neural injury (peripheral nerve damage, including compression or entrapment, or central nervous system or spinal lesions), or neuropathy (such as from diabetes, alcohol misuse)
• Thoracic outlet syndrome (due to nerve or vascular compression)
• Arterial insufficiency [usually after preceding trauma, atherosclerosis in older people or thrombangitis obliterans (Burger's disease)]
• Raynauld's disease
• Lymphatic or venous obstruction
• Brachial neuritis or plexitis (Parsonage-Turner syndrome or neuralgic amyotrophy)
• Erythromelalgia (may include all limbs)
• Self-harm

Table 2. Risk factors for CRPS[13-17]

Risk factors	
Age	The most common age is 61-70 years
Gender	Female: Male 2:1
Localization	Upper-lower limb 3:2
Menopause	
Osteoporosis	
Asthma	
ACE inhibitory treatment	Affects the neuroimflammatory mechanism that causes CRPS through substance P and bradykinin metabolism
Migraine	
Smoking	Poor prognosis in smoking

CRPS: Complex regional pain syndrome, ACE: Angiotensin-converting enzyme

CPRS than men. Individuals aged 61–70 years are most commonly affected, and the risk is highest in postmenopausal women. According to the same study, the upper limb is affected more frequently than the lower limb, and the most common trigger events are fractures, accounting for 44% of the cases. As shown in Table 3[18-23] and Table 4[23-34], several studies reported a high incidence of CRPS, especially after distal radius fracture (32.2%), Colles' fracture (36.7%), tibial fracture (30%) and shoulder (11.1%) and tibial (31%) surgeries[1]. Unfortunately, CPRS-related complications following orthopaedic surgeries may negatively affect the postoperative healing process, and the syndrome may lead to serious long-term problems, including unbearable pain and immobilisation.

While there is a strong evidence of CRPS incidence following fractures and surgical operations, there is little prior work on the incidence of CRPS following spinal surgeries. Most studies indicating potential presence of CRPS following spinal diseases and surgeries are based on case studies.

METHODS

This study aimed to present a review of the literature on CRPS occurrence following spinal problems and surgeries to improve physicians' awareness of this. For this review, we combed the published literature for studies of patients who developed CPRS after three main spinal problems, including degenerated/herniated disc surgeries, spinal cord injury (SCI) and spinal cord tumor. Published studies were grouped under these three categories and further investigated according to the type of CRPS (1 or 2), disease origin and grade, type of surgeries prior to CRPS onset, disease course, therapies following diagnosis of CRPS and age (ranged from 22 to 69 years) and sex of the

Table 3. Reported incidence of CRPS following fractures of the upper and lower limb[1]

Region	Antecedent event	Study	Incidence
Upper limb	Distal radius fracture	Jellad et al. 2014[18]	32.1% (26:61)
		Dijkstra et al. 2003[19]	1.1% (1:87)
	Colles' fracture	Bickerstaff and Kanis 1994[20]	28.1% (77:197)
		Atkins et al. 1990[21]	36.7% (22:38)
	Wrist fracture	Beerthuizen et al. 2020[22]	7.9% (18:209)
	Scaphoid fracture	Beerthuizen et al. 2020[22]	0% (0:27)
Lower limb	Tibial fracture	Sarangi et al. 1993[23]	30% (9:21)
	Ankle fracture	Beerthuizen et al. 2020[22]	15.2% (21:117)
	Fifth metatarsal fracture	Beerthuizen et al. 2020[22]	2.9% (3:100)

CRPS: Complex regional pain syndrome

Table 4. Reported incidence of CRPS following surgical procedure of the upper and lower limb[1]

Region	Operation	Study	Incidence
Upper limb	Shoulder	Chalmers et al. 2014[24]	11.1% (1:8)
		Arndt et al. 2012[25]	3.0% (3:97)
		Gonzalez et al. 2011[26]	0.9% (35:3975)
		Bishop et al. 2005[27]	1.3% (1:79)
		Borgeat et al. 2001[28]	1.0% (5:516)
	Carpal tunnel relaese	Shinya et al. 1995[29]	1.9% (2:105)
		Lichtman et al. 1979[30]	5.0% (5:95)
		MacDonald et al. 1978[31]	2.2% (4:182)
	Dupuytren's contracture	Lilly and Stem 2010[32]	2.0% (1:49)
		Bulstrode et al. 2005[33]	2.4% (6:247)
Lower limb	Tibial	Sarangi et al. 1993[23]	31% (9:20)
	Ankle and foot	Rewhorn et al. 2014[34]	4.4% (17:373)

CRPS: Complex regional pain syndrome

Table 5. CRPS cases following spinal diseases and spinal surgeries

Case study	Patient Age/Gender CRPS type	Spinal disease or spinal surgery	Treatment	Progress
Plancarte 1997[35]	39/F CRPS2	Postoperative automated laser discectomy	Chemical lumbar sympathectomy	Chemical sympathectomy resulted in resolution of the pain syndrome
Fish 2005[36]	65/M CRPS2	Post-lumbar surgery (sacroiliac fusion)	Subsequently three sympathetic blocks and conservative treatment	The patient had dramatic improvement after treatment and no recurrence of the CRPS developed
Chae et al. 2009[38]	40/M CRPS2	Postoperative micro-discectomy for lumbar spine herniation (L4-5)	Spinal cord stimulator	VAS score and tingling sensation improved, but tremor, weakness and hyperesthesia still existed
Weisz et al. 2010[41]	39/M	Cervical disc protrusion and posterior foraminotomy (C5-6, C6-7)	Conservative treatments (opioids, tricyclics and hypnotics)	Postoperative 34. month less intense, several features of CRPS were still evident
Knoeller et al. 2011[37]	31/F	Implantation of an artificial disc (L4/5 segment)	CT-guided sympathetic block	Second week of treatment pain, allodynia, swelling regressed, only slight sensory disturbance left
Kim et al. 2016[42]	22/M	Lumbar herniated intervertebral disc disease (L4-5)	Decompression of herniated disc	Symptoms relieved after operation. VAS score improved
Jung et al. 2018[39]	31/F	Lumbar discectomy for herniated lumbar disc (L5/S1)	Sacral epiduroscopic laser decompression (SELD)	After second SELD, the patient'S pain markedly decreased. On the second visit in the outpatient clinic, the patient was absent of pain without any other medications

CRPS: Complex regional pain syndrome, VAS: Visual analog scale, CT: Computed tomography, F: Female, M: Male

patients. We also focused on the reported progress of the disease after therapy.

DISCUSSION

CRPS following Degenerated and Herniated Disc Surgeries

Table 5 lists several studies that report CRPS cases following spinal diseases/procedures. *These studies highlight the possibility of CRPS associated with spinal procedures and the importance of early treatment for effective results.*

Plancarte and Calvillo[35] reported a patient with CRPS type 2, following automated laser discectomy, who presented sympathetically maintained pain and serious disability. The author suggested that CRPS can be associated with spinal procedures, including automated laser percutaneous discectomy. In another case study, Fish presented a patient with CRPS type

2 in a distal extremity associated with an anterior sacroiliac fusion with local bone graft[36]. Fish argued that CRPS can be associated with spinal procedures and sacroiliac arthrodesis. Both Plancarte and Fish concluded that early intervention is important in long-term resolution of CRPS symptoms.

Knoeller at al.[37] reported a case of CRPS 1 of the left leg following lumbar spine surgery (implantation of an artificial disc type in the L4-5 segment) using a midline left-sided retroperitoneal approach via a ventral access (this surgery requires mobilisation of the sympathetic trunk). The report emphasised that diagnosis of CRPS following lumbar spine surgery via a ventral access must be considered a differential diagnosis, and Knoeller at al.[37] highlighted the importance of early diagnosis, as early initiation of therapy in CRPS type 1 may improve the progress of a disabling severe disease.

Chae et al.[38] reported about CRPS type 2 following a postoperative lumbar spine surgery and pointed out the importance of distinguishing CRPS symptoms from postoperative symptoms. Despite the difficulty in differentiating postoperative syndrome in the lumbar spine from CRPS, they recommended that physicians should consider CRPS as the primary cause of postoperative syndrome in the lumbar spine after orthopaedic surgery, as this may prevent significant losses in time before the start of an effective treatment.

Similarly, Jung et al.[39] noted that CRPS-like symptoms can appear after lumbar spinal surgery due to adhesion and inflammation in the epidural space. They reported the case of a 31-year-old patient diagnosed with CRPS type 2 following L5-S1 discectomy. Unfortunately, the patient did not respond to conventional therapies or to spinal cord stimulation for the treatment of CRPS. Consequently, for diagnostic and therapeutic purposes, sacral epiduroscopic laser decompression (SELD) was performed twice 1 month apart. During these procedures, severe adhesion and inflammation at the L4-S1 epidural space were detected. The catheter was placed to perform mechanical adhesiolysis and laser decompression at the herniated intervertebral disc. Three days after the second intervention, the visual analogue scale (VAS) score had improved, and 8 months later, the patient reported complete absence of pain. The authors suggested that if CRPS-like symptoms originating from the lumbar spine cannot be treated by conventional therapy, SELD may be considered an appropriate diagnostic and therapeutic option.

More recently, Wolter et al.[40] carried out a study to determine the frequency of CRPS following spinal surgery and to investigate the disease course and prognostic factors. 35 patients (18 women and 17 men) who were treated for CRPS (1 or 2) were included in the study. The authors considered the CRPS type, disease origin and grade and type of surgeries prior to CRPS onset. Table 6 reports data regarding six patients (one patient had cervical and five patients had lumbar spine surgery) who had undergone spinal operations just before the onset of CRPS symptoms (median, 5 days; range: 1–14) and had no other trauma preceding the development of CRPS symptoms. As shown, CRPS symptoms following spinal surgery can start very quickly. Consequently, the authors concluded that even if CRPS may occur relatively rarely following spinal surgeries, physicians must be aware of the possibility of CRPS, as early diagnosis and treatment are important to prevent complications.

Most studies about CRPS following spinal problems focus on lumbar disc protrusion and lumbar spinal surgery. In Wolter et al.[40], only one patient had cervical surgery before CRPS. Weisz et al.[41] reported the case of a 39-year-old patient who had shown CRPS symptoms following cervical spine surgery (posterior foraminotomy at C5–6 and C6–7). Following the surgery, the patient experienced pain, paraesthesia, swelling of the left hand and forearm and increasing inability to use the left hand; as a result, the patient was diagnosed with CRPS. The treatment included opioids, tricyclics and hypnotics on a daily basis, which improved physical features and associated psychological and social problems. 34 months after surgery, symptoms remained less intense; however, several features of CRPS (swelling, paleness and cold and wet skin) were still evident.

Kim et al.[42] reported a case of CRPS that was caused by L4–5 herniated intervertebral disc without a history of trauma

Table 6. Data on six patients who had urdergone spinal operations shortly before CRPS symptoms (Wolter et al.[40])

Study	Patient Age/Gender	Spinal disease/surgery	Time between operation and onset of CRPS
Wolter et al. 2012[40]	57/M	Cervical spine surgery	1 day
	45/F	Lumbar disc operation (L4-5)	7 days
	48/M	Dorsovental spondylodesis (L5-S1)	14 days
	44/F	Lumbar disc operation (L5-S1)	14 days
	32/F	Lumbar disc prothesis (L4-5)	2 days
	69/M	Hernilaminectomy (L5) and nucleotomy (L4-5 and L5-S1)	3 days

CRPS: Complex regional pain syndrome, M: Male, F: Female

or surgery. Percutaneous nucleoplasty was considered as a treatment option for CRPS, after which the symptoms were relieved and the VAS score had improved. While CRPS from a mild herniated intervertebral disc without surgical intervention is even rarer than CRPS after surgery for disc diseases, this possibility should be kept in mind during differential diagnosis.

CRPS in Spinal Cord Injury

Pain is a frequent complication of SCI, and identifying the possible causes of the pain is very important for effective treatment. While neurological problems like stroke and peripheral nerve injuries are known etiological causes of CRPS, several studies reported CRPS also in patients with SCI[43-47]. Table 7 summarises the key findings of some of these case studies.

Gellman et al.[44] studied 60 patients with cervical SCI and identified an overall incidence rate of 10% of CRPS. Lefkoe and Cardenas[45] presented the case of a 25-year-old tetraplegic male patient with complete traumatic injury of the cervical cord (C6) who presented CRPS. In addition, Lefkoe and Cardenas[45] pointed out that in patients with SCI, diagnosis of CRPS might be challenging due to the presence of severe pain and other common CRPS complications, such as heterotopic ossification or deep venous thrombosis in SCI patients without CRPS.

Gallien et al.[46] reported eight CRPS cases in a study of patients with SCI. The study included one female and seven male patients, with a median age of 35. The causes of SCI included gunshot wounds (n=5), car accidents (n=2) and fall (n=1). Five patients had complete SCI, and three patients had incomplete SCI. Four patients were tetraplegic, while four patients were paraplegic. The authors discussed the diagnosis, risk factors and treatment and concluded that, even if this syndrome may be more common in other forms of neurological diseases, such as stroke, CRPS might also be observed as the main source of pain in patients with SCI.

Sutbeyaz et al.[47] reported the case of a 49-year-old man with C7 incomplete tetraplegia who presented CRPS type 1 in both upper and lower extremities. The authors emphasised that CRPS type I might be more common in SCI than usually suspected and that tetraplegic patients should be carefully evaluated for the presence of CRPS type I.

CRPS in Spinal Cord Tumor

We have found only one published case of a patient with cervical spinal cord tumor (schwannoma) and CRPS type 2[48]. This 63-year-old patient underwent urgent neurosurgery, and the spinal lesion was excised. At 6 weeks after the procedure, the symptoms had completely disappeared. After 1 year, the patient was still completely asymptomatic.

CONCLUSION

Early diagnosis and proper treatment of acute CRPS are very important in preventing the development of chronic symptoms (including allodynia, swelling, muscular atrophy, osteoporosis and contracture). Clinicians must be aware of the potential scenarios in which patients may develop CRPS. Fractures and surgical operations are critical risk factors for CRPS. *In this review, we emphasised the possibility of CRPS development after spinal diseases and/or surgeries.* While the literature on CRPS following spinal problems consists primarily of small case studies and there are limited data on the incidence of CRPS following spinal problems, there is growing evidence that CRPS may also occur after spinal diseases or surgeries and that the diagnosis of CRPS following spinal problems must be considered by clinicians.

Table 7. CRPS cases following spinal cord injury

Case study	Patient Age/ Gender	Spinal diseases	CRPS treatment	Progress
Lefkoe and Cardenas 1996[45]	25/M	C6 complete tetraplegia	Conservative treatments	Conservative treatments resulted in the resolution of the pain syndrome
Sutbeyaz et al. 2005[47]	49/M	C7 incomplete tetraplegia	Conservative treatments	After 6 weeks of treatment, the patient's VAS score for pain had decreased by more than 50%
Akkoc et al. 2008[43]	55/F	Spinal cord injury	Pulse radiofrequency lumbar sympatholysis	VAS score improved. For 4 months folow-up, the patient did not require opioid

CRPS: Complex regional pain syndrome, M: Male, F: Female, VAS: Visual analog scale

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Ethics

Peer-review: Externally peer-reviewed.

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RETRACTION LETTER

Effectiveness of Gensingen Brace Treatment for Adolescent Idiopathic Scoliosis: A Prospective Cohort Study. J Turk Spinal Surg. 2020;31:130-134.

The corresponding and the first author, (Şahin Karalar), and the Journal wish to retract the July 2020 original article entitled "Effectiveness of Gensingen Brace Treatment for Adolescent Idiopathic Scoliosis: A Prospective Cohort Study." The authors of the paper used "Gensingen Brace" without the permission of the doctor, Hans-Rudolp Weiss, who is the proprietor of this brace.

The corresponding author requests retraction of the paper in its entirety and apologizes to the reviewers, editors, and readers of Journal of the Turkish Spinal Surgery for any adverse consequences that may have resulted from the paper's publication.

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