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Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spinal Surgery Society. The 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 developing of spinal knowledge. The journal publishes original scientific research articles, invited reviews and case reports accepted by the Editorial Board, in English.

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The article is reviewed by secretaries of the journal after it is uploaded to the web site. Article type, presence of 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 participating in the study to a significant extent. All authors should confirm that they have read the study and agreed to the submission to the 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.

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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.

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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".

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ARTICLE WRITING

Clinically relevant scientific advances during recent years include the 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 rigour of the 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 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 a written permission letter, and it should be submitted along with the manuscript.

Review articles: The format for reviews substantially differ 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

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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 that 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 with 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.

-Keywords : 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.

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The first paragraph should introduce the general topic or problem and emphasize 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 the 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 historical 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 be 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 describe 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

INSTRUCTIONS to AUTHORS

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 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 belong. 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 something else (different in what way? the reader may 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 the 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 a 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 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

INSTRUCTIONS to AUTHORS

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 the 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:

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;8:5-9.

Book chapter:

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:

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:

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:

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

Book in press :

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:

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:

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

INSTRUCTIONS to AUTHORS

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 abbreviations.

-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 the 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 a historical precedent. Instead, indicate the point in the manuscript by providing citation by superscribing.

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 the 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 significance 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

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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

1. Morphometric analysis

Anesthesiology

Animal study

Basic Science

1. Biology
2. Biochemistry
3. Biomaterials
4. Bone mechanics
5. Bone regeneration
6. Bone graft
7. Bone graft substitutes
8. Drugs

Disc

1. Disc Degeneration
2. Herniated Disc
3. Disc Pathology
4. Disc Replacement
5. IDET

Disease/Disorder

1. Congenital
2. Genetics
3. Degenerative disease
4. Destructive (Spinal Tumors)
5. Metabolic bone disease
6. Rheumatologic

Biomechanics Cervical Spine

1. Cervical myelopathy
2. Cervical reconstruction
3. Cervical disc disease
4. Cervical Trauma
5. Degenerative disease

Complications

1. Early
2. Late
3. Postoperative

Deformity

1. Adolescent idiopathic scoliosis
2. Kyphosis
3. Congenital spine
4. Degenerative spine conditions

Diagnostics

1. Radiology
2. MRI
3. CT scan
4. Others

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Epidemiology

Etiology

Examination

Experimental study

Fusion

1. Anterior
2. Posterior
3. Combined
4. With instrumentation

Infection of the spine

1. Postoperative
2. Rare infections
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4. Spondylodiscitis
5. Tuberculosis

Instrumentation

Meta-Analysis

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2. Fractures
3. Kyphoplasty
4. Medical Treatment
5. Surgical Treatment

Outcomes

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2. Patient Care
3. Primary care
4. Quality of life research
5. Surgical

Pain

1. Chronic pain
2. Discogenic pain
3. Injections
4. Low back pain
5. Management of pain
6. Postoperative pain
7. Pain measurement

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2. Manipulation
3. Non-Operative Treatment

Surgery

1. Minimal invasive
2. Others
3. Reconstructive surgery

Thoracic Spine

Thoracolumbar Spine

Lumbar Spine

Lumbosacral Spine

Psychology

Trauma

1. Fractures
2. Dislocations

Spinal cord

1. Spinal Cord Injury

Spinal stenosis

1. Cervical
2. Lumbar
3. Lumbosacral

Tumors

1. Metastatic tumors
2. Primary benign tumors
3. Primary malign tumors

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ORIGINAL ARTICLES

JOURNAL OF TURKISH SPINAL SURGERY

EDITORIAL

Dear Colleagues,

I feel very privileged to be the person responsible for publishing this, the 2nd issue, of our professional journal this year. I want to extend a heartfelt thanks to all the authors, reviewers, assistant editors, secretaries and the Galenos publishing team for the effort they expended in order to get this issue done. The Journal of Turkish Spinal Surgery (www.jtss.org), is the official publication of the Turkish Spine Society. In addition, we are very happy to announce that we will be accepting new reviewers for our journal. Please apply to us, as soon as possible, if you are interested. I hope that each of you will take the time to review this issue very carefully, and add the information and insights contained herein, to your already very well informed knowledge bases.

In this issue, there are six clinical research studies and one basic science study. The first study is a Retrospective Clinical Study about "The Effect of Long- and Short-Level Fusions on Sagittal Balance Parameters of Patients Treated with Transforaminal Lumbar Interbody Fusion for Degenerative Spine Older Than 65 Years". The second study is a basic science study about "Amifostine decreases lipid peroxidation activity after spinal cord injury in rats". The third, is a clinical study, "Evaluation of Satisfaction with a Questionnaire According to Fracture Level and Fracture Type of Patients who Underwent Baloon Kyphoplasty". The fourth article is about "Lumbopelvic Stability, Lumbopelvic Mobility and Spinopelvic Parameters in Patients with Lumbar Disc Herniation". The authors of the fifth study examined "Is it Possible to Determine the Prevalence of Adult Thoracic Scoliosis by Looking at Chest X-ray?". The sixth study is about "The relationship between clinical and imaging findings in mechanical thoracic spine pain: a retrospective cohort study" while, in the seventh, the authors Evaluated "Traditional training versus virtual reality and haptic enabled simulation training for posterior cervical screw placement".

I hope our readers appreciate the work, and that each of you take the time to read and absorb the vital information contained here. As always, it's our goal to provide you with the most current research available, and information on current practices and methodology. Our mission is to guarantee that we remain on the forefront of all the latest developments, and this issue is intended to further that goal.

With kindest regards,

Editor in Chief
Metin Özalay, M.D.

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DOI: 10.4274/jtss.galenos.2022.57441

THE EFFECT OF LONG- AND SHORT-LEVEL FUSIONS ON SAGITTAL BALANCE PARAMETERS OF PATIENTS TREATED WITH TRANSFORAMINAL LUMBAR INTERBODY FUSION FOR DEGENERATIVE SPINE OVER OLDER THAN 65 YEARS

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ABSTRACT

Objective: This study assessed the outcomes of transforaminal lumbar interbody fusion (TLIF) in patients with degenerative spine conditions above the age of 65 years and investigate the effects of fusion levels on the sagittal balance parameters.

Materials and Methods: This retrospective study reviewed patients with degenerative spine diseases who underwent lumbar fusion with the TLIF procedure older than 65 years. Patients with three or less segments involved in the fusion were assigned to the short-level fusion group, and the patients with more than three segments involved in the fusion were assigned to the long-level fusion group. The anteroposterior and lateral spine radiographs of the patients were used to measure pelvic incidence (PI), pelvic tilt (PT), sacral slop (SS), lumbar lordosis (LL), distal lumbar lordosis, thoracolumbar kyphosis, thoracic kyphosis (TK), T1 spinopelvic inclination (T1SPI), T9 spinopelvic inclination (T9SPI) and T1 pelvic angle (TPA).

Results: The study included 45 patients, 28 females and 17 males, who met the inclusion criteria. The long- and short-level fusion groups comprised 25 and 20 patients, with the mean ages of 68.87 and 67.72 years and mean follow-up periods of 26.96±15.53 and 27.61±11.83 months, respectively. TK and T9SPI values showed no difference between the groups before and after surgery, but a statistically significant increase in the values was observed postoperatively in the patients who underwent long-level fusion. The preoperative SVA values were significantly higher in the long-level fusion group than in the short-level fusion group. No difference in the postoperative SVA values was found between the groups. The PT, PI, SS, TPA, T1SPI was not statistically differ between the groups before and after surgery.

Conclusion: TLIF contributes to the improvement of the sagittal balance parameters in both short- and long-level fusions in patients above the age of 65 years with degenerative spine conditions.

Keywords: Long level fusion, sagittal parameters, TLIF, degenerative spine

INTRODUCTION

Degenerative spine conditions are characterized by the progressive degeneration of bony structures and intervertebral discs, with overloading being a key pathogenic factor[1]. The age-related pathological changes in the spine may occur due to different factors; commonly including trauma, metabolic conditions, exposure to toxic substances, genetic factors, and vascular disorders[2,3]. Chronic trauma is considered the leading cause, as it has been established that degenerative spine diseases are primarily caused by chronic overload[1].

Although lumbar interbody fusion was introduced approximately 70 years ago, longer life expectancy, novel implant designs, and the desire for a better quality of life have led to an increased frequency of fusion surgeries even today[4]. Transforaminal lumbar interbody fusion (TLIF) has been considered as the gold standard among the techniques applied to the interbody space because of its minimal association with the neurovascular structures and ease of application to the target segments[5].

The maintenance and restoration of the sagittal balance (SB) has become a topic of great interest in lumbar surgery as it directly affects the surgical outcomes and quality of life. Physiological lumbar lordosis (LL) is important in maintaining

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SB, whose impairment is closely associated with chronic lower back pain and disability[6].

Previous studies have reported an increased morbidity and mortality in spinal surgeries with increasing age, as the complication rates rise and the optimal surgical outcomes are compromised[7,8]. Several studies have investigated the efficacy and safety of TLIF therapy in the younger population; however, their impact in elderly patients remains unclear[5].

The objective of surgical treatments in patients with degenerative spine conditions is to obtain a stable spine with decompressed neural elements and coronal and sagittal alignment[9]. The procedure for the restoration of spine alignment may require a surgical approach that combines fusion, decompression, and osteotomy[10]. However, specific information on the number of fusion levels is not available[10].

This study aimed to assess the outcomes of TLIF in patients with degenerative spine conditions above the age of 65 years and investigate the effects of fusion levels on the SB parameters.

MATERIALS AND METHODS

This retrospective study reviewed 135 patients with degenerative spine diseases who underwent lumbar fusion with the TLIF procedure in our Orthopedics and Traumatology Department of between 2016 and 2021. The records of the patients were obtained from the archive system of the clinic. Written informed consent was obtained from all patients before the study. This study was performed after obtaining the institutional review board approval (2022/02) from İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedics and Traumatology committee. Of the 135 patients, 63 were above the age of 65 years. The study included 45 of the 63 patients who had regular outpatient follow-ups for at least 12 months and whose radiological data were accessible. The age, gender, surgical procedure, and postoperative follow-up period of these patients were collected from their medical records. The SB parameters were measured and recorded preoperatively and at the final follow-up visit. The patients with neuromuscular and inflammatory comorbidities, incomplete follow-ups, and no spinal radiography were excluded from the study.

As per the literature, patients with three or less segments involved in the fusion were assigned to the short-level fusion group, and the patients with more than three segments involved in the fusion were assigned to the long-level fusion group[10,11]. Short-level fusion was only conducted on the patients with nerve compression and degeneration in the upper and lower segments, whereas long-level fusion was conducted on the patients with multisegmental nerve compressions, degeneration, and instability[11] (Figure 1-4).

Surgical Procedure and Follow-up

A senior surgeon and his team performed posterior fixation with multiaxial pedicle screws using an interbody cage and allograft on all the patients. Using the standard TLIF method, the cage was inserted in the correct position through unilateral facetectomy and partial laminectomy. Postoperative corsets were not used on the patients and early mobilization was conducted. The patients were evaluated in the outpatient clinic at 1, 6, and 12 weeks. Patients without postoperative complications were called for the control visits at intervals of 6 months.

Radiological evaluation

The radiographs of the patients were used to measure pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), LL, distal LL (DLL), thoracolumbar kyphosis (TLK), thoracic kyphosis (TK), T1 spinopelvic inclination (T1SPI), T9 spinopelvic inclination (T9SPI), T1 pelvic angle (TPA).

PI is the angle between the perpendicular line drawn at the sacral-end upper-plate midpoint and the line connecting the axis of the femoral head to this midpoint. PT is the line connecting the vertical line drawn from the femoral head axis and the sacral-end upper-plate midpoint from the femoral head axis. SS is the angle between the line drawn from the last upper sacral plate and the horizontal line drawn from the last upper sacral plate midpoint. LL is the Cobb angle between L1 vertebra upper endplate and S1 vertebra upper endplate. DLL

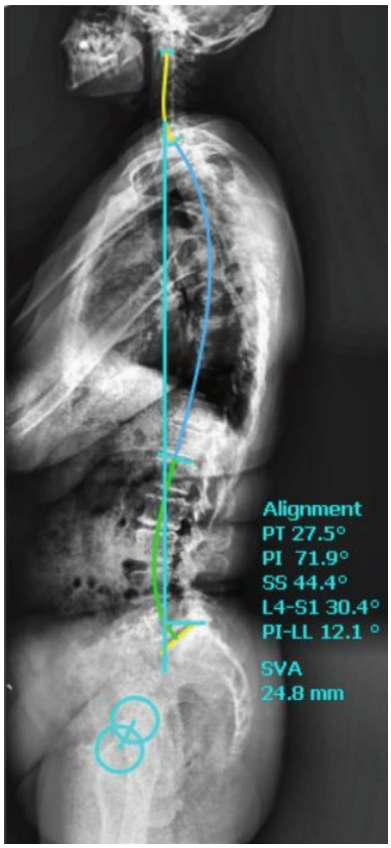

Figure 1. Preoperative lateral spine radiograph of patients treated with short level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

is the Cobb angle between L4 vertebra upper endplate and S1 vertebra upper endplate TLK is the Cobb angle between T10 vertebra upper endplate and L2 vertebra lower endplate. TK is the Cobb angle between T4 vertebra upper endplate and T12 vertebra lower endplate. T1SPI is the angle between the line drawn from the center of T1 vertebra to the femoral head axis and the vertical plumb line. T9SPI is the angle between the line drawn from the center of the T9 vertebra to the femoral head axis and the vertical plumb line. TPA is the angle between the line drawn from the femoral head axis to the center of T1 vertebra and the line drawn from the femoral head axis to the sacral-end upper plate. SB is the distance from the vertical descending line at the center of C7 vertebra to the posterior upper-plate posterosuperior corner of the S1 vertebral body. The distance of this line from the S1 vertebral body to the final upper-plate posterosuperior corner, 2.5 cm anteriorly and posteriorly, is considered a neutral SB. Distance of >2.5 cm anteriorly was considered positive SB and that posteriorly was considered negative SB.

Statistical Analysis

The statistical data of the study was analyzed using the SPSS (Statistical Package for Social Sciences) for Windows 25.0. Descriptive statistics, including minimum, maximum, and median values, were used in the analysis of the data. Since the sample sizes of the study groups were smaller than 30, non-parametric tests were used for statistical analysis. Wilcoxon test was used to determine whether the two dependent variables differed, and Mann-Whitney U test was used to test whether the two independent groups differed with regard to a quantitative variable. This study considered $p<0.05$ as statistically significant.

RESULTS

The study included 45 patients, 28 female and 17 male, who met the inclusion criteria. The long- and short-level fusion groups comprised 25 and 20 patients, with the mean ages of 68.87±4.94 and 67.72±6.61 years and mean follow-up periods of 26.96±15.53 and 27.61±11.83 months, respectively (Table 1). Both preoperative and postoperative LL values were significantly higher in the short-level fusion group than in the long-level fusion group. Postoperative LL values showed significant increase in both the groups compared with the preoperative LL values.

The TK and T9 spino-pelvic inclination (T9SPI) values showed no difference between the groups before and after surgery, but a statistically significant increase in the values was observed

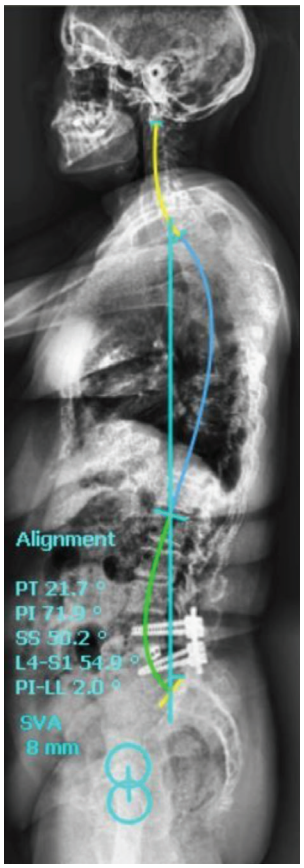

Figure 2. Postoperative lateral spine radiograph of patients treated with short level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

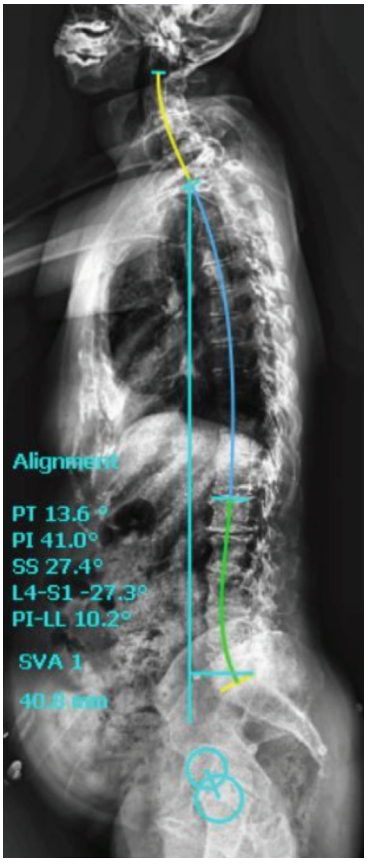

Figure 3. Preoperative lateral spine radiograph of patients treated with long level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

postoperatively in the patients who underwent long-level fusion.

The preoperative sagittal vertical axis (SVA) values were significantly higher in the long-level fusion group than in the short-level fusion group. No difference in the postoperative SVA values was found between the groups. The SVA values of both the groups exhibited a significant decrease post-surgery.

The PT, PI, SS, TPA, T1 spino-pelvic inclination (T1SPI), and decompressive lumbar laminectomy values did not statistically differ between the groups before and after surgery (Table 2).

Revision surgery was performed in 4 (16%) patients with long-level fusion and 3 (15%) patients with short-level fusion due to the development of proximal junctional kyphosis (PJK) at the end of the second year of follow-up.

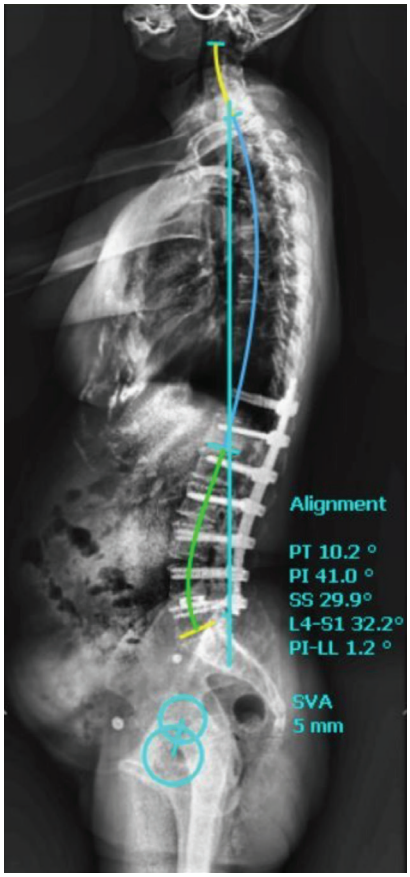

Figure 4. Postoperative lateral spine radiograph of patients treated with long level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

DISCUSSION

TLIF in patients above the age of 65 years improved LL and SVA in both the long- and short-level fusion groups and TK and T9SPI improvement was observed in the long-level fusion group.

The prevalence of spinal surgeries increases with the aging population[12]. Although conservative treatments are preferred to minimize morbidity, surgical treatments are inevitable in some cases. Decompression alleviates neurological symptoms; however, it cannot optimally be performed alone due to its potential of increasing spinal instability[13,14]. Thus, most surgeons recommend the accompaniment of decompression with fusion and instrumentation[14,15]. Long-level fusion is preferred for multisegmental degeneration with high sagittal imbalance.

Previous studies have shown that the appropriate application of the TLIF technique accompanied with posterior instrumentation is effective in the restoration of global SB[16]. This study demonstrated a significant postoperative improvement in SVA in both the groups. Since long-level fusion was performed in the patients with multisegmental degeneration and instability, the preoperative SVA measurements were higher in them, which was an expected outcome. Long-level fusion significantly improved T9SPI, one of the global SB indicators, and corrected TK.

The restoration of LL is closely associated with patient satisfaction in degenerative spine conditions[17]. In addition, biomechanical and clinical studies have reported a reduction in the degeneration of the adjacent segments on LL restoration[18]. Previous studies provide indications about the expected increase in LL following TLIF surgery. Hsieh et al.[19] have shown that TLIF reduces LL. In contrary, other studies have reported an increase in LL between 1.5° and 17°[20,21]. The performance of bilateral facetectomy and the number of grafts used as per the surgeon's choice can account for the differences between the studies. In our study, an increase of 13° and 11.15° in the long- and short-level fusion groups were achieved in post-surgical LL. The postoperative increase in the LL values of both the groups was statistically significant compared with their preoperative LL values.

Glattes et al.[22] were the first to identify PJK. PJK is determined by measuring the proximal sagittal Cobb angle (proximal junctional angle) between the lower endplate of the uppermost instrumented vertebra and the upper endplate of the above two vertebrae of the uppermost instrumented vertebra[23]. This

Table 1. Distribution of age and follow-up duration of group

	Long-level fusion group		Short-level fusion group	
	Min.-max.	($\bar{X}$ ± SD)	Min.-max.	($\bar{X}$ ± SD)
Age	65-86	68.87±4.94	65-77	67.72±6.61
Follow-up duration	12-60 (Month)	26.96±15.53	12-48 (Month)	27.61±11.83

SD: Standard deviation, Min.: Minimum, Max.: Maximum

Table 2. Comparison of preoperative and postoperative data

		Preoperative	Postoperative		
		Median (min.-max.)	Median (min.-max.)	Za	p-value
PT	Long-level fusion (n=25)	22.00 (0.30-33.40)	23.90 (2.70-241.00)	-1.338	0.181
	Short-level fusion (n=20)	23.30 (3.10-274.00)	22.95 (1.00-44.10)	-0.218	0.828
Z[b]		-0.368	-0.512		
p		0.713	0.608		
PI	Long-level fusion (n=25)	54.40 (28.20-97.40)	53.80 (28.60-90.40)	-0.503	0.615
	Short-level fusion (n=20)	58.95 (34.30-473.00)	58.05 (30.00-81.00)	-0.327	0.744
Z[b]		-1.090	-0.552		
p		0.276	0.581		
SS	Long-level fusion (n=25)	32.00 (14.00-68.30)	29.10 (17.70-48.00)	-1.384	0.166
	Short-level fusion (n=20)	36.50 (19.90-74.00)	35.60 (22.00-53.80)	-0.588	0.557
Z[b]		-1.064	-2.299		
p		0.287	**0.022***		
LL	Long-level fusion (n=25)	30.00 (1.00-75.90)	43.00 (18.80-59.90)	-0.548	**0.019***
	Short-level fusion (n=20)	41.40 (16.00-73.60)	52.55 (7.00-82.80)	-0.370	**0.036***
Z[b]		-2.378	-2.654		
p		**0.017***	**0.008***		
DLL	Long-level fusion (n=25)	27.30 (8.70-64.10)	29.00 (17.20-52.70)	-1.266	0.205
	Short-level fusion (n=20)	30.55 (11.00-62.00)	32.55 (18.00-58.50)	-0.044	0.965
Z[b]		-1.656	-0.342		
p		0.098	0.733		
TLK	Long-level fusion (n=25)	14.20 (1.50-52.90)	14.00 (1.20-29.50)	-0.365	0.715
	Short-level fusion (n=20)	5.75 (0.60-28.50)	7.85 (1.00-29.00)	-0.181	0.856
Z[b]		-1.840	-1.774		
p		0.066	0.076		
TK	Long-level fusion (n=25)	26.50 (1.80-44.20)	35.00 (0.60-51.40)	-2.829	**0.005***
	Short-level fusion (n=20)	33.80 (8.00-48.30)	31.55 (7.00-63.30)	-0.497	0.619
Z[b]		-2.141	-0.736		
p		0.432	0.462		
T1SPI	Long-level fusion (n=25)	3.10 (0.30-9.60)	4.00 (0.10-11.20)	-1.050	0.294
	Short-level fusion (n=20)	4.90 (1.00-11.20)	3.70 (0.00-15.00)	-1.111	0.266
Z[b]		-0.868	-0.657		
p		0.385	0.511		
T9SPI	Long-level fusion (n=25)	6.80 (0.20-20.10)	9.90 (0.90-21.10)	-2.370	**0.018***
	Short-level fusion (n=20)	9.50 (2.00-16.40)	10.25 (3.70-16.30)	-0.022	0.983
Z[b]		-1.695	-0.026		
p		0.090	0.979		
TPA	Long-level fusion (n=25)	21.00 (0.00-41.10)	22.50 (5.80-64.50)	-0.763	0.445
	Short-level fusion (n=20)	18.00 (0.50-32.60)	19.65 (2.40-36.90)	-0.719	0.472
Z[b]		-0.460	-0.473		
p		0.646	0.636		
SVA (mm)	Long-level fusion (n=25)	44.90 (5.00-152.70)	18.30 (0.70-110.30)	-1.612	**0.028***
	Short-level fusion (n=20)	26.40 (1.70-112.60)	16.15 (2.90-82.50)	-0.936	**0.048***
Z[b]		-1.997	-0.762		
p		**0.046***	0.446		

[a]Wilcoxon test; a: 0.05;* statistically significant difference
[b]Mann-Whitney U test; a: 0.05;* statistically significant difference
PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, DLL: Decompressive lumbar laminectomy, TK: Thoracic kyphosis, T1SPI: T1 spino-pelvic inclination, T9SPI: T9 spino-pelvic inclination, TPA: T1 pelvic angle, SVA: Sagittal vertical axis, TLK: Thoracolumbar kyphosis

condition is defined by an increase in the proximal junctional angle ≥10° and at least 10° more than the preoperative values[23]. The incidence of PJK varies between 17% and 61.7% in the literature[24,22]. In our study, revision surgery was performed in 4 (16%) patients with long-level fusion and 3 (15%) patients with short-level fusion due to the development of PJK at the end of the second year of follow-up.

In a study investigating the effects of long- and short-level fusion techniques on the radiological parameters in the treatment of degenerative scoliosis, patients who underwent long-level fusion had greater improvement in the spine-pelvis parameters, but no significant difference regarding PJK was observed between the two groups[25]. Another study showed no difference between long- and short-level fusions regarding LL restoration. In this study, the postoperative LL increased significantly in both the groups and TK and T9SPI were improved in the patients with long-level fusion.

Study Limitations

This study had a few limitations. The preoperative SB parameters were not similar between the two groups. An increase in PJK incidence was observed with the elongation of the follow-up duration, which may have impaired the radiological and clinical outcomes. Previous literature has reported on the impact of intervertebral cavity cage positioning on LL, which was not factored in for this study[10]. Future studies examining patient groups with higher homogeneity and with longer follow-up periods may further contribute to the literature.

CONCLUSION

Spine diseases in the elderly are complicated and require greater attention to decide the appropriate surgical treatments and fusion levels. TLIF contributes to the improvement of the SB parameters in both short- and long-level fusions in patients above the age of 65 years with degenerative spine conditions.

Ethics

Ethics Committee Approval: This study was performed after obtaining the institutional review board approval (2022/02) from İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedics and Traumatology committee.

Informed Consent: Written informed consent was obtained from all patients before the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

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

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AMIFOSTINE DECREASES LIPID PEROXIDATION ACTIVITY AFTER SPINAL CORD INJURY IN RATS

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ABSTRACT

Objective: Amifostine is a known radioprotective agent. It has been known for many years that it protects normal tissue from the undesirable effects of radiation and some chemotherapeutics due to its antioxidant effect and contains thiol. We investigated the effects of amifostine on the activity of lipid peroxidation in the spinal cord after experimental spinal cord injury in rats.

Materials and Methods: Thirty-five male Wistar albino rats were randomly divided into five groups, each containing seven rats. Group I (the control group) received laminectomies and spinal cord samples were obtained 24 h after laminectomy without trauma. Those in groups II to V all received laminectomies followed by traumatic spinal cord injury and tissue samples were taken 24 h later. Group II received no treatment; group III received 30 mg/kg methylprednisolone; group IV received 200 mg/kg amifostine; and group V received 2 mL 0.9% sodium chloride (sulfur tetrafluoride) solution. Medications were given intraperitoneally as single doses immediately after trauma. Spinal cord samples were taken 24 h post-trauma and studied for lipid peroxidation activity.

Results: Lipid peroxidation activity in the tissue samples was increased by injury. Both amifostine and methylprednisolone treatment decreased this activity, indicating a reduction in neutrophil infiltration of the damaged tissue. The effect of amifostine on lipid peroxidation activity was similar to that of methylprednisolone.

Conclusion: Amifostine may be effective in protecting the spinal cord from secondary injury.

Keywords: Amifostine, methylprednisolone, lipid peroxidase, spinal cord injury

INTRODUCTION

Recent research has revealed that most posttraumatic tissue damage and neurological disturbances are due to secondary reactive events[1,2]. This notion of a secondary mechanism was first posited by Allen[3] in 1911, who concluded that the necrotic matter left by a traumatic hemorrhage contains harmful elements that cause secondary injury and that its removal may facilitate neurological recovery. After initial studies, which indicated that neurological deficits developed because of progressive and irreversible damage in long pathways after spinal cord trauma, in 1950, it was found that damage occurred owing to decreased blood flow in the spinal cord, whereas today, tissue destruction after trauma is believed to be due to ischemia[4]. The pathophysiology of spinal cord injury is best described as a "biphasic injury," which occurs by two mechanisms: primary (direct) and secondary (indirect). Neurological damage after acute spinal cord injury occurs as a result of primary mechanical injury, necrosis following secondary injury, and later apoptosis[5-7]. While primary damage occurs through mechanical action, secondary damage occurs when primary damage is compounded by a series of biochemical and cellular reactions. Pathophysiological events that develop after primary injury constitute secondary injury in the long term. Secondary pathological events, such as ischemia, cause significant injury, including excitotoxicity, increased intracellular neuronal Ca^{2+}, free-radical formation, and increased lipid peroxidation. Ischemia after spinal cord injury is directly involved in secondary pathophysiological processes. This process of secondary injury includes increased cell permeability, apoptotic signaling, ischemia, vascular damage, edema, excitotoxicity, ionic deregulation, inflammation, lipid peroxidation, free-radical formation, demyelination, Wallerian degeneration, fibroglial scar, and cyst formation[8-10]. Although we have been unable to produce clinical improvement after severe spinal cord injury, it is encouraging that studies have begun to obtain positive results from animal experiments. Based on recent developments in the physiology and pharmacotherapy of spinal cord injury, a large number of neuroprotective substances are being tested[11-13]. So far, only methylprednisolone has increased functional recovery in humans in controlled, multicenter clinical trials[14,15]. In addition to the recent wave of experimental

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studies, several new drugs still in the preclinical study phase show promise for the treatment of spinal cord injury. A crucial factor in the success of chemotherapy treatment for cancer is the degree of cytotoxicity that it produces in normal tissues. To counter these cytotoxic effects on non-cancerous tissue, several cytoprotective drugs have been developed. One of the most frequently used drugs is amifostine (WR-2721). Compounds containing thiols, such as sodium thiosulfate and diethyldithiocarbamate, have antioxidant properties and can protect normal tissue from the unwanted effects of radiation and some chemotherapeutics[16]. However, the use of thiol compounds as a cytoprotectant in the treatment of cancer has not been possible. Thiol compounds not only protect healthy tissues but also eliminate cytotoxic anticancer effects. Amifostine is an organic thiophosphate compound that was developed as a radioprotective agent at the Walter Reed Army Institute research laboratories during the Cold War to protect military personnel from potential nuclear radiation[17]. Its chemical name is S-2-[3-(aminopropyl amine)] ethyl phosphorothioic acid. Its molecular weight is 214.23 and its molecular formula is $C_5H_{15}N_2O_3PS$. Amifostine differs from other sulfide-containing compounds in that its thiol group is covered by phosphate, so it is protected. Amifostine itself is a prodrug with little to no cytoprotective effect[17,18]. When administered, dephosphorylation of amifostine is catalyzed by the alkaline phosphatase enzyme within the cells of the organism. This enzyme removes a phosphate group, allowing free thiol conversion of the drug into its active metabolite, WR-1065. The resulting metabolite is utilized by cells for cytoprotective purposes. The free thiol group is responsible for this property. Because thiol is a known antioxidant, it can remove the free-oxygen radicals generated by platinum, alkylating drugs, and radioisotopes that damage the DNA in normal cells, thereby reducing cellular toxicity. The cytoprotective efficacy of amifostine has been demonstrated by several clinical and preclinical studies[17,18]. *In vivo* research has demonstrated the drug's ability to reduce bone marrow toxicity caused by cisplatin, carboplatin, cyclophosphamide, nitrogen mustards, bleomycin, cytarabine, etoposide, daunorubicin, paclitaxel, mitoxantrone, vinblastine, melphalan, mitomycin C, carmustine, and fluorouracil[19-21]. However, unlike other thiol compounds, amifostine does not protect cancer cells from cytotoxicity[16]. Amifostine is a radioprotective agent that prevents cellular damage due to radiation and chemotherapy through free-radical scavenging, hydrogen donation, and inhibition of DNA damage. Amifostine is metabolized and accumulates to a much greater extent in normal cells than in tumor cells. As a result, it exerts a protective effect on normal tissues due to chemotherapy- or radiotherapy-induced toxicity without reducing the antitumor effects of cancer treatment. Detailed preclinical studies have shown that amifostine protects against radiation damage and the myelotoxic, nephrotoxic, and neurotoxic effects of chemotherapeutic agents, such as alkylating agents and platinum compounds[17,18]. The clinical use of amifostine enables safer and more effective administration of radiotherapy and other anticancer therapies.

This study aimed to compare the effects of amifostine with those of methylprednisolone on tissue lipid peroxidation and cell ultrastructure after experimental spinal cord injury. While the effects of methylprednisolone are well established, those of amifostine have not yet been investigated[22-24].

MATERIALS AND METHODS

Because this is an experimental study, informed consent was not required to be obtained. The study protocol was approved by the ethics committee of Ankara Training and Research Hospital, and the test procedures were performed in compliance with the study guidelines of the animal laboratory of the same hospital (approval no: 272, date: 26.03.2005).

Groups

A total of 35 male Wistar albino rats, each weighing 210-250 g, were randomly divided into 5 groups of 7 rats as follows:

Group I (N=7) (control): Tissue samples were collected 24 h after laminectomy without trauma.

Group II (N=7) (trauma): 50 g/cm contusion injury following laminectomy was applied. After 24 h, tissue samples were collected 1 cm from the injury center.

Group III (N=7) (MPSS): 50 g/cm contusion injury following laminectomy was applied. Methylprednisolone sodium succinate (Prednol L® Mustafa Nevzat; Istanbul, Turkey; 30 mg/kg) was then administered intraperitoneally (IP). After 24 h, tissue samples were collected 1 cm from the injury center.

Group IV (N=7) (amifostine): 50 g/cm contusion injury following laminectomy was applied. Amifostine (Er-Kim Ilaç.; İstanbul, Turkey; 200 mg/kg) was then administered IP. After 24 h, tissue samples were collected 1 cm from the injury center.

Group V (N=7) (vehicle): 50 g/cm contusion injury following laminectomy was applied. NaCl solution (2 mL, 0.9%) was then administered IP. After 24 h, tissue samples were collected 1 cm from the injury center.

The tissue samples were immediately frozen and stored in liquid nitrogen at 196 °C.

Surgical Procedure

All surgical procedures were performed under general anesthesia. For this purpose, 10 mg/kg xylazine (Bayer; Istanbul, Turkey) and 60 mg/kg ketamine hydrochloride (Parke-Davis; Istanbul) were administered intramuscularly. The anesthetized rats were placed in a prone position. A 3-cm longitudinal skin incision was made along the center of the back following shaving and skin cleansing with Batticon (Adeka; Turkey). After paravertebral resection, total laminectomy was performed on thoracic vertebrae 7, 8, and 9. Dura intake was released. All subjects except those in the control group underwent 50 g/cm spinal cord trauma in accordance with the Allen method[25] as follows: a 10 cm long and 5 mm wide cylindrical glass tube was

placed perpendicular to the laminectomy area. A 5 g weight (3 mm diameter, cylindrical steel column) was reduced from within this tube to a height of 10 cm. Spinal cord trauma was thus induced at 50 g/cm (trauma intensity = weight × height). The rats were sacrificed under deep anesthesia after the tissue samples were collected.

Homogenization of Tissues

Tissue samples were weighed and homogenized in ice using glass homogenizer in 10 mm Tris buffer containing 1 mm ethylenediaminetetraacetic acid (EDTA, Tekno-Kim, İstanbul, Turkey) 10 times their wet weight, and 1 mL of tissue homogenate was transferred to tapered Eppendorf tubes and centrifuged for 5 min at 5000 rpm. The supernatant of the samples was used to determine lipid peroxidation activity.

Lipid Peroxidation Measurement

For the measurement of tissue lipid peroxidation levels, the following procedure was performed: 0.2 mL of 8.1% SDS, 0.8% NaOH, and 0.5 mL of 20% acetic acid solution were added to less than 0.2 mL of 10% homogenized tissue samples and 1.5 mL of 0.8% thiobarbituric acid aqueous solution. The mixture condenser was heated in an oil bath at 95 °C for 60 min, and 4 mL of distilled water was then added. After cooling with water, a mixture of 1.0 mL of distilled water and 5.0 mL of butanol and pyridine was added and stirred vigorously. After centrifuging for 10 min at 4000 rpm, the organic layer was collected and the absorbance of the mixture was measured at 532 nm. Tetramethylpyrazine was used as the external standard. Lipid peroxidation was expressed as nmol. Fluorometric assessment (excitation: 515 nm; emission: 553 nm) is performed when a small amount of tissue such as a small organ or biopsy specimen is examined.

Electron Microscopy Review

Spinal cord segments obtained from the thoracic level of the trauma area were placed in 2.5% glutaraldehyde and fixed for 6 h. After the first fixation with 1% osmium tetroxide, a series of immersions in solutions containing increasing ethanol concentrations was used to dehydrate the aqueous component of this fixative from within the cells. The samples were then washed with propylene oxide and placed in epochs. Ultra-thin tissue sections of 60 nm thickness were cut with a glass knife using the LKB Nova ultramicrotome (Bromma; Sweden) and placed on copper grids. These sections were stained with uranyl acetate and lead citrate and examined with a transmission electron microscope (Geol JEM 1200; Tokyo, Japan).

Statistical Analysis

A One-Way ANOVA was performed using SPSS v.11.0 software to determine differences in lipid peroxidase activity between the groups. A posthoc test was used to show which groups were different. A p-value of <0.05 was considered statistically significant.

RESULTS

Drugs

MPSS: Although a few normal mitochondria were observed, about half of the remaining mitochondria were crystalline and the other half were swollen. In the small myelinated axons, some of the myelin layers were stripped. Of those remaining, about half were normal and the remaining half showed splitting of the myelin layers. In the medium-sized myelinated axons, there was a greater number of interruptions in the myelin layers, and the myelin layer was separated from the axon in most of the remaining axons. Much fewer of the axons were normal. Among the large myelinated axons, no normal axons were found (Figure 1). Trauma was not observed in the small vacuoles of the neurons.

Amifostine: The nuclei of all cells in the tissue samples were normal. Around a sixth of the mitochondria observed were normal. A small number of swollen mitochondria were detected. All the remaining mitochondria were identifiable. The small myelinated axons were completely normal and only a small number of axons could be seen through their myelin layers. The medium-sized myelinated axons exhibited some normal axons and a small number of axons with damaged myelin. Separation of the myelin layers was seen in the majority. In the large myelinated axons, some regular axons were seen, although lesser than the other groups, and a small number of axons were stripped of myelin. The remaining large percentage of axons was still in their myelin layers (Figure 2). Trauma was not observed in the small vacuoles of the neurons (Figure 3).

There was a significant difference between the groups in tissue lipid peroxidase activity ($p<0.05$) (Figure 4). Tissue lipid peroxidase activity was significantly higher in the trauma group than in the control group ($p<0.05$). There was also a significant

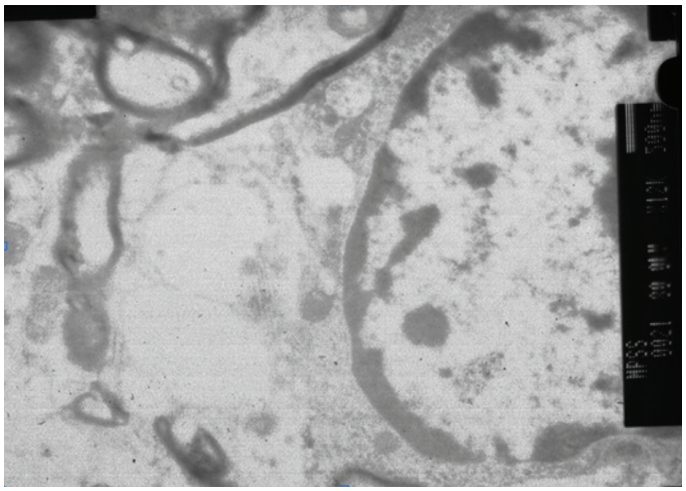

Figure 1. Electron microscopic image of spinal cord cells after damage and subsequent methylprednisolone treatment. The nuclei are normal. Swelling and crystallization of the mitochondria are apparent

difference between the control, MPSS, and amifostine groups in tissue lipid peroxidase levels ($p<0.05$) (Figure 4), but there was no difference between the trauma and vehicle groups in tissue lipid peroxidase levels ($p>0.05$). MPSS and amifostine prevented the increase in tissue lipid peroxidase activity. There was no significant difference between the tissue lipid peroxidase activity of these two groups ($p>0.05$) (Figure 4). The effect of the vehicle solution (NaCl) on tissue lipid peroxidase activity was not determined. Electron microscopy was performed on the samples from all groups to compare the intracellular structures. Approximately 300 samples were collected from each group. There was no significant difference between the control and amifostine groups in the results of small myelinated axons (Figures 2 and 3). In medium- and large-sized myelinated axons, amifostine provided significant protection (Figure 2). Cell nuclei were normal in all groups (Figures 5 and 6).

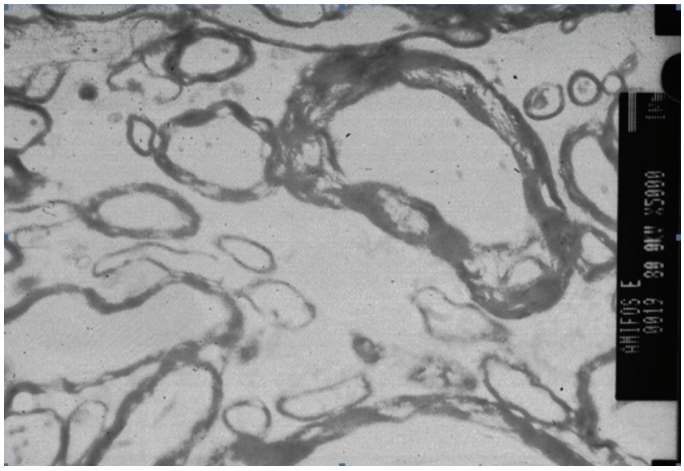

Figure 2. Electron microscopic image of spinal cord cells after damage and subsequent amifostine treatment. The cell nuclei are normal. The mitochondria are slightly swollen. There are no small vacuoles in the nuclei

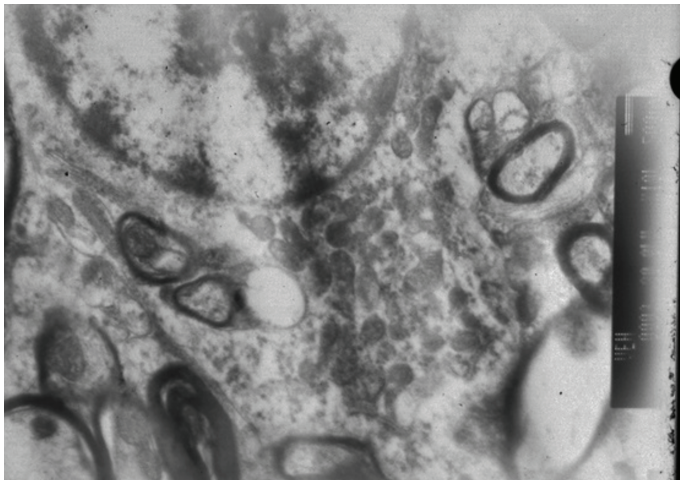

Figure 3. Electron microscopic image of spinal cord cells after damage and subsequent administration of NaCl (SF) solution. Considerable swelling of the mitochondria is apparent, with advanced crystallization. Small vacuoles can be seen in the nuclei

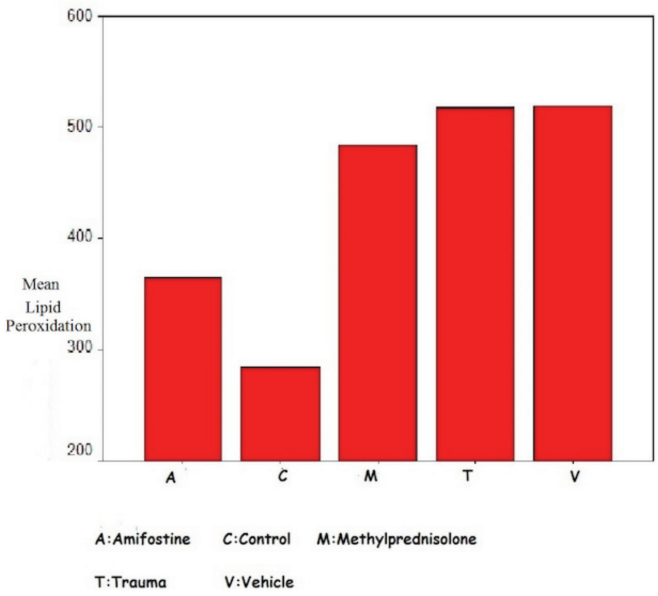

Figure 4. Mean lipid peroxidation levels of the five groups in this study

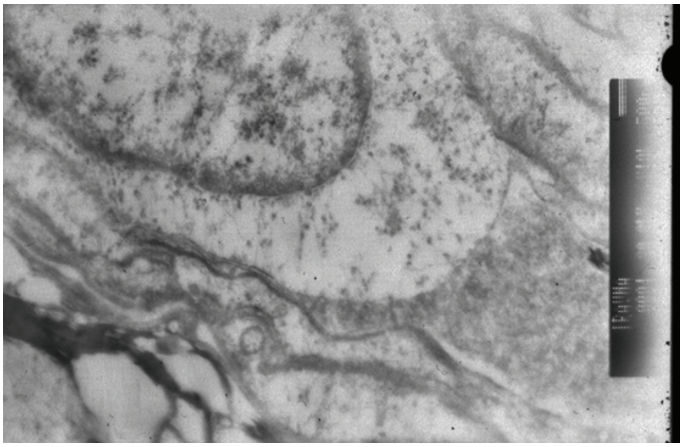

Figure 5. Electron microscopic image of spinal cord cells after damage. Considerable swelling of the mitochondria is apparent but no crystallization. Vesicular degeneration is present throughout

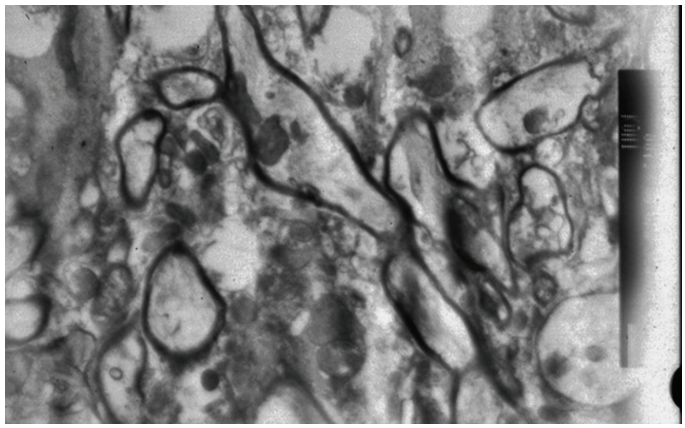

Figure 6. Electron microscopic image of normal spinal cord cells from our control group

DISCUSSION

Spinal cord injuries are a serious health problem comprising two stages[22-24]. In the first stage, primary injury occurs. In the second stage, secondary injury develops due to a series of pathophysiological processes occurring within hours or days of the primary injury. The main goal in the treatment of spinal cord injuries is to prevent secondary injury[26-27]. Pathophysiological events such as hemorrhagic necrosis, ischemia, edema, inflammation, extracellular Ca^{2+} loss, and intracellular K+ loss are responsible for the secondary injury. To prevent secondary damage, treatments including magnesium, calcium channel blockers, N-methyl-D-aspartate receptor blockers, and free-radical scavengers have been tested, but only MPSS has demonstrated any efficacy[28-31]. However, the effect of MPSS on secondary damage mediators is insufficient[32,33].

Amifostine is a cytoprotective drug used to prevent damage to the central nervous system (CNS) that may occur after radiotherapy for the treatment of cancer. It is a radioprotective agent that prevents radiation- and chemotherapy-induced cellular injury through free-radical scavenging, hydrogen donation, and inhibition of DNA damage. Radiation is known to cause microvascular damage to the CNS. Nieder et al.[34] have reported that vascular damage from post-radiation CNS toxicity induces peripheral edema in the surrounding area.

In addition, Nieder et al.[34] and Giannopoulou et al.[35] have shown that the production of blood vessels is decreased, and existing ones are damaged after irradiation of fertilized eggs. However, Kruse et al.[36] found a decrease in perivascular and interstitial fibrosis after administration of systemic amifostine in the ratio indicated by the cardiac radiation model.

These findings gave rise to the hope that systemic amifostine could be used against vascular damage, one of the most important components of CNS toxicity. In *in vitro* studies, Nieder et al.[34] also demonstrated that systemic amifostine increases post-radiation endothelial proliferation. Neuroprotection is extremely important for the spine because neurons in the spinal cord cannot regenerate. Neuroprotection may protect the axonal pathways required to heal damaged cells and provide metabolic support to damaged neurons. It may also prevent the emergence of mediators such as cytokines and free radicals that have additional toxic effects on neighboring cells and cause more neurodegeneration, cellular swelling, inflammation, and oxidative stress. The high availability of these mediators after experimental acute spinal cord injuries suggests that they have the potential to activate the neurodegeneration cycle. This includes molecules that are classically associated with CNS necrosis, including glutamate and intracellular Ca^{2+}. Glutamate is rapidly released following traumatic injury. The relationship between induced glutamate release, intrathecal Ca^{2+} increase, and cell death is unclear. Amifostine cannot pass the blood-brain barrier or may pass in very small amounts. However, it has been determined that there is a continuous transition in the blood-brain barrier after radiation. Nieder et al.[34] found that increased permeability of the blood-brain barrier after radiotherapy allows adequate penetration of amifostine. Lamproglou et al.[37] reported that 75 mg/kg and 100 mg/kg amifostine reduced neurotoxicity in the brain caused by radiation therapy by reducing systemic glutamate release. In their study on rats, Spence et al.[38] injected amifostine into the right lateral ventricle of rats. After 45 min, a single dose of radiation was given to the cervical spinal cord of the animals. Each rat was examined weekly for leg paralysis. In addition to neuroprotective effects, a histological examination found cell structures to be preserved. This was achieved through the protection of white matter and vascular elements. However, the same effect was not observed in the Schwann cells of the peripheral nerves of the cervical spinal cord. Ang et al.[39] evaluated white matter necrosis and demyelination of white matter 4-7 months after radiotherapy on rat spinal cords in 20-40 Gy intervals and confirmed the findings of Spence et al.[38].

In our study, electron microscopic examination found that, only in the rats given amifostine, were the nuclei and mitochondria preserved. In addition, we observed that intracellular structures, particularly small myelinated fibers, were preserved. The nervous system is rich in polyunsaturated lipids. Peroxidation of membrane lipids leading to the release of free radicals is an important mechanism in neuronal damage. Because free radicals are found early after traumatic injury, any effective neuroprotective agent must be given as soon as possible after trauma. In our study, the incidence of lipid peroxidation was significantly lower in the amifostine group (i.e., following administration of 200 mg/kg amifostine immediately after spinal cord injury) than in the trauma, vehicle, and MPSS groups. Nieder et al.[34] and Lamproglou et al.[37] suggested that amifostine acts as a free-radical scavenger by emitting superoxide anions that iodinate the radiation. In addition, amifostine is thought to increase endogenous glutathione concentrations. This is the major antioxidant in the mammalian CNS; it protects damaged tissue and increases the resistance of normal tissue. We found no increase in lipid peroxidase activity in our control group, which received only laminectomy with no trauma. We found no significant difference in lipid peroxidase activity between the vehicle and the trauma groups. This shows that the concentration of NaCl administered had no neuroprotective effect. This result was corroborated by the results of electron microscopic examination. MPSS is the only pharmacotherapeutic agent used clinically and is effective as a neuroprotectant following traumatic spinal cord injury. However, recent complications have led to restrictions on its use. Although MPSS has a neuroprotective effect, we found it to be less effective than amifostine.

In the literature, there are few studies on the neuroprotective effects of amifostine against radiation damage to the CNS and none on its neuroprotective effects in ischemic or trauma models of the brain or spinal cord. This study was the first to

examine the neuroprotective effect of amifostine on acute spinal cord contusion injury. We found 200 mg/kg amifostine administered IP after acute spinal cord contusion injury to be a more effective neuroprotective agent than MPSS and to reduce lipid peroxidase activity. Examination of the intracellular organelles of neurons, membranes, myelin sheaths, and axons found all to be better preserved by amifostine than by MPSS.

CONCLUSION

In this study, 200 mg/kg amifostine administered IP after acute spinal cord contusion injury was shown to have superior neuroprotective effects to MPSS that significantly reduce lipid peroxidation activity and protect the spinal cord. With further research into the effects of amifostine on spinal trauma, we hope to be able to contribute to the clinical improvement of spinal cord trauma outcomes.

Ethics

Ethics Committee Approval: The study protocol was approved by the ethics committee of Ankara Training and Research Hospital, and the test procedures were performed in compliance with the study guidelines of the animal laboratory of the same hospital (approval no: 272, date: 26.03.2005).
Informed Consent: Because this is an experimental study, informed consent was not required to be obtained.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: A.G., M.Ö.O., Design: A.G., M.Ö.O., Data Collection or Processing: A.G., M.Ö.O., Data analysis or Interpretation: A.G., M.Ö.O., Literature Search: A.G., M.Ö.O., Writing: A.G., M.Ö.O.
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Conflict of Interest: The authors have no conflicts of interest to declare.

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EVALUATION OF SATISFACTION WITH A QUESTIONNAIRE ACCORDING TO FRACTURE LEVEL AND FRACTURE TYPE OF PATIENTS WHO UNDERWENT BALLOON KYPHOPLASTY

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ABSTRACT

Objective: The aim of this study is to better understand which type of fracture and localization have more painful or worse outcomes for the kyphoplasty procedure.

Materials and Methods: Kyphoplasty cases operated between 2013 and 2018 were included in the study. The patients were contacted through the numbers registered in the hospital system. A questionnaire were asked to the patients. Patients were grouped according to gender, fracture level (T12-L1 and others) and fracture type (Osteoporotic, trauma, malignancy, unknown).

Results: Fourty-one patients were included in the study. Three-quarters of the patients were women and average age was 62. Ninety-two percent of the patients stated that the pain of the procedure was tolerable. Seventy percent reported that their pain decreased after the procedure and 75% of the patients stated that they could have this procedure done again. Pain reduction and the desire to have same surgery again were significantly higher in female patients than in the male group ($p<0.05$). In the T12-L1 group and osteoporotic fracture group, the procedure was more easily tolerated, the pain was relieved more and the desire to have the same surgery was higher ($p<0.05$).

Conclusion: Kyphoplasty is accepted as an operation that is well tolerated by patients and has good pain relief. Additionally more detailed information was obtained about the patient's complaints after the kyphoplasty procedure, according to the fracture level and type.

Keywords: Kyphoplasty, questionnaire, vertebroplasty, vertebra, fracture

INTRODUCTION

Osteoporosis is a disease of decreased bone density associated with an increased risk of fractures. The most common fractures among osteoporotic fractures are osteoporotic vertebral compression fractures (OVCF). It is also well known that trauma and malignancies can cause compression fractures. The prevalence of OVCF worldwide is between 1.4% and 2.6%[1]. Severe acute or chronic pain may occur after vertebral compression fractures and may affect the quality of life of the person[2]. If more than one segment is affected, short stature and kyphosis can be seen. The goals of OVCF treatment are to reduce the individual's pain, restore vertebral height and angular deformity causing kyphosis. Generally, the approach in the treatment of OVCF is conservative treatments, surgical open procedures and percutaneous minimally invasive procedures. In conservative treatment, after short-term bed rest, the patient is mobilized with an external orthosis; however, the duration of bed rest is prolonged in elderly patients. Pressure ulcers, urinary system infections, vertebral fractures associated with progressive decrease in bone mineral density, malnutrition due to decreased abdominal volume, venous thromboembolism and pulmonary complications can be seen due to the increase in immobilization time. Therefore, surgical or percutaneous minimally invasive treatment procedures should be considered in patient groups suitable for surgery[3,4].

Although it has similar aspects with vertebroplasty, kyphoplasty, which is a very different procedure, was first applied in 1998[5]. Unlike vertebroplasty, cement is injected after the cavity is created with an expandable balloon. High-density cement and trabecular bone around the impacted cavity are thought to prevent cement leakage. While vertebroplasty is mostly applied unipedicularly, kyphoplasty is applied bipedicularly[6].

The aim of this study is to better understand which type of fracture and localization have more painful or worse outcomes for the kyphoplasty procedure.

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MATERIALS AND METHODS

Kyphoplasty cases operated between 2013 and 2018 were included in the study. Procedures were performed under general anesthesia. Inclusion criteria; age over 50 years old, having a recently vertebra compression fracture, no spinal cord injury or pedicle fracture and pain without radiculopathy. Vertebral compression fracture was detected by X-ray computed tomography magnetic resonance and confirmed by clinical examination. Informed consent was obtained from the patients. Ethics committee approval was obtained from the İstanbul Yeni Yüzyıl University, Science, Social and Non-Interventional Health Sciences Research Ethics Committee (no: 2022/02-811).

Patients who died, patients with spinal canal compression or stenosis greater than 30% of canal diameter, patients with spinal cord injury or cauda equina syndrome and patients with local/systemic infections were excluded from the study.

The patients were contacted through the numbers registered in the hospital system. A 3-question questionnaire was asked to the patients[7]. Patients who did not respond in 3 calls were excluded from the study.

We evaluated our patients in 2 groups as T12/L1 (the most common fracture levels in the spine[8,9] and other levels). We also evaluated according to fracture type (osteoporotic, trauma, malignancy, cause unknown) and gender.

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. While evaluating the study data, chi-square analysis was used to determine the relationship between qualitative data as well as descriptive statistical methods (Mean, Standard Deviation, Median, Frequency, Ratio, Minimum, Maximum). Significance was evaluated at $p<0.01$ and $p<0.05$ levels.

RESULTS

Fifty-six patients who met the inclusion criteria were identified. Five patients refused to participate in the study. Ten patients could not be reached. Questionnaires were asked to the remaining 41 patients. While 75.6% (n=31) of the participants were female, 24.4% (n=10) were male. The age ranges were 55-76 and the mean age was 62. Type of fracture of the participants were 63.4% (n=26) osteoporotic, 14.6% (n=6) trauma, 9.8% (n=4) malignant and 12.2% (n=5) type of unknown (Table 1). Cement injection into the fracture is a tolerable procedure for 92.7% (n=38) of the participants, while 7.3% (n=3) is not. While the pain disappeared in 70.7% (n=29) of the participants after the injection, 9.8% (n=4) pain did not decreased and slightly decreased 19.5% (n=8). While 75.6% (n=31) of the participants wanted to have the same surgery again, 14.6% (n=6) were not sure and 9.8% (n=4) did not want it (Table 2). Fracture levels are shown in Table 3.

There was no correlation between gender and the tolerability of cement injection into the fracture ($p>0.05$).

A relationship was found between gender and pain relief after injection. The number of female who said yes was higher than that of male. ($p=0.001$; $p<0.01$). The number of female who said somewhat was lower than that of male. ($p=0.001$; $p<0.01$).

A relationship was found between gender and wanting to have the same surgery again. Female patients were more willing to have the same surgery again ($p=0.023$; $p<0.05$). The group that says I'm not sure; Female patients were less than male ($p=0.001$; $p<0.01$) (Table 4).

A statistically significant correlation was found between the fracture level and the tolerability of cement injection into the fracture ($p=0.021$; $p<0.05$). Those who say "yes the procedure is tolerable"; It was found to be high in the T12-L1 group ($p=0.001$; $p<0.01$).

Table 1. Demographic data of the study

		N	%
Gender	**Female**	31	75.6
	Male	10	24.4
Type of Fracture	**Osteoporotic**	26	63.4
	Trauma	6	14.6
	Malignancy	4	9.8
	Unknown	5	12.2
Level of Fracture	**T12-L1**	29	70.7
	Other levels	12	29.3

Table 2. Baloon kyphoplasty questionnaire

		N	%
Is cement injection to the fracture a tolerable process?	**Yes**	38	92.7
	No	3	7.3
Did your pain ease after injecting cement into your fracture?	**Yes**	29	70.7
	No	4	9.8
	Somewhat	8	19.5
Would you want to be if we offered the same surgery again?	**Yes**	31	75.6
	No	4	9.8
	I'm not sure	6	14.6

Table 3. Fracture levels

T8	2
T9	1
T10	2
T11	1
T12	17
L1	12
L2	4
L3	1
L4	1

A correlation was found between fracture level and pain relief after injection (p=0.001; p<0.01). Those who say yes; It was found to be high in the T12-L1 group (p=0.001; p<0.01). In patients who say no and somewhat; T12-L1 group was found to be lower than the other levels group (p=0.001; p<0.01).

A relationship was found between the fracture level and the desire to have the same surgery again (p=0.001; p<0.01). The group that said yes; T12-L1 group were higher than the other group (p=0.001; p<0.01). The group that said no and I'm not sure; T12-L1 group were lower than the other (p=0.001; p<0.01) (Table 5).

A correlation was found between the type of fracture and the tolerability of cement injection into the fracture (p=0.003; p<0.01). The group that said "yes the procedure is tolerable"; Osteoporotic group was higher than the malignancy group (p=0.001; p<0.01).

A relationship was found between type of fracture and pain relief after injection (p=0.001; p<0.01). The group that said yes; Osteoporotic group was higher than the trauma and malignancy groups (p=0.001; p<0.01). The group that says somewhat; Osteoporotic group was lower than the trauma and malignancy groups (p=0.001; p<0.01) and trauma group was higher than the groups of unknown (p=0.001; p<0.01). A correlation was found between the type of fracture and the desire to have the same surgery again (p=0.001; p<0.01). The group that said yes; Osteoporotic group was higher than the trauma and malignancy groups (p=0.001; p<0.01). The group that says I'm not sure; The trauma group was found to be higher than the osteoporotic group (p=0.001; p<0.01) (Table 6).

DISCUSSION

It has been stated in some previous studies that the most common vertebral fractures are in T12 and L1[8-10]. For this reason, we aimed to compare the most common fractures with less frequently seen fractures in order to evaluate the outcomes of kyphoplasty procedure in terms of patient satisfaction. As far as we know, there is no study comparing T12 and L1 with other vertebras. Likewise, we did not find any comparison between

Table 4. Relationship between gender and questions

		Gender		p
		Female	Male	
Is cement injection to the fracture a tolerable process?	**Yes**	28 (73.7%)	10 (26.3%)	0.422
	No	3 (100%)	0 (0%)	
		Female	Male	
Did your pain ease after injecting cement into your fracture?	**Yes**	25a (86.2%)	4b (13.8%)	
	No	4a (100%)	0a (0%)	**0.001****
	Somewhat	2a (25%)	6b (75%)	
		Female	Male	
Would you want to be if we offered the same surgery again?	**Yes**	25a (80.6%)	6a (19.4%)	
	No	4a (100%)	0a (0%)	**0.023***
	I'm not sure	2a (33.3%)	4b (66.7%)	

Chi-square test, **p<0.01

Table 5. Relationship between fracture level and questions

		Level of Fracture		p
		T12-L1	Other levels	
Is cement injection to the fracture a tolerable process?	**Yes**	29a (76.3%)	9b (23.7%)	**0.021***
	No	0a (0%)	3b (100%)	
		T12-L1	Other levels	
Did your pain ease after injecting cement into your fracture?	**Yes**	27a (93.1%)	2b (6.9%)	
	No	1a (25%)	3b (75%)	**0.001****
	Somewhat	1a (12.5%)	7b (87.5%)	
		T12-L1	Other levels	
Would you want to be if we offered the same surgery again?	**Yes**	28a (90.3%)	3b (9.7%)	
	No	1a (25%)	3b (75%)	**0.001****
	I'm not sure	0a (0%)	6b (100%)	

Chi-square test, **p<0.01

Table 6. Relationship between fracture type and questions

		Type of fracture				p
		Osteoporotic	Trauma	Malignancy	Unknown	
Is cement injection to the fracture a tolerable process?	**Yes**	26a (68.4%)	5a, b (13.2%)	2b (5.3%)	5a, b (13.2%)	**0.003***
	No	0a (0%)	1a, b (33.3%)	2b (66.7%)	0a, b (0%)	
		Osteoporotic	Trauma	Malignancy	Unknown	
Did your pain ease after injecting cement into your fracture?	**Yes**	23a (79.3%)	1b (3.4%)	0b (0%)	5a (17.2%)	**0.001****
	No	2a (50%)	0a (0%)	2a (50%)	0a (0%)	
	Somewhat	1a (12.5%)	5b (62.5%)	2b, c (25%)	0a, c (0%)	
		Osteoporotic	Trauma	Malignancy	Unknown	
Would you want to be if we offered the same surgery again?	**Yes**	24a (77.4%)	2b, c (6.5%)	0c (0%)	5a, b (16.1%)	**0.001****
	No	2a (50%)	0a (0%)	2a (50%)	0a (0%)	
	I'm not sure	0a (0%)	4b (66.7%)	2b (33.3%)	0a, b (0%)	

Chi-square test, **p<0.01

fracture types (Osteoporotic, trauma, malignancy, unknown) in patients who underwent kyphoplasty.

In the T12-L1 group and osteoporotic fracture group, the procedure was more easily tolerated, the pain was relieved more and the desire to have the same surgery was higher in our study. Some previous studies have compared lumbar and thoracic fractures[11,12]. Better functional scores and less pain were found in thoracic fractures. This was probably because of thoracic fractures are less problematic due to the stability of the rib cage.

Some studies about back pain have found that female consistently report more functional limitations and physical disability and slower recovery from disability than male patients[10,13,14]. Factors contributing to higher reporting of functional disability in osteoporotic vertebra fracture were attributed to the higher incidence of spinal stenosis, degenerative spine diseases, osteoarthritis and chronic joint pain in female[10]. However, since these studies were conducted with patients with low back pain who did not undergo surgery, they do not provide us with data on patients who underwent kyphoplasty. In our study pain reduction and the desire to have same surgery again were significantly higher in female patients than in the male group.

In a multicenter, randomized, double-blind, placebo-controlled study comparing OVCF younger than 6 weeks, it was proven that vertebroplasty has a higher pain relief effect than placebo[15]. Although vertebroplasty is a minimally invasive method, it can cause morbidity and even death in patients due to many complications that may develop during application. Many studies have reported that complications such as radicular pain, paralysis, and cement leaks resulting in death have developed in vertebroplasty surgery[16-18]. Balloon kyphoplasty has been introduced to minimize these disastrous consequences of vertebroplasty. Although the pain relief effect of kyphoplasty and vertebroplasty appeared to be similar, it was observed that kyphoplasty provided better kyphosis angle correction and better restored vertebral height[19]. When patients who underwent kyphoplasty and followed conservatively were compared, it was seen that kyphoplasty was better in improving quality of life, reducing pain, and helping the patient mobilization[20].

In our study, it was determined that the kyphoplasty procedure was successful in relieving the pain of the patients. Most of the participants answered "yes" to the question "Would you accept if we recommend same surgery again?" At the same time, most of the patients stated that the pain felt during the kyphoplasty procedure was tolerable.

Study Limitations

One of the limitation of our study was that pain assessment was not done with scoring systems such as the visual analog scale or oswestry disability index. Other limitation was that we did not compare the assessment of patient satisfaction with the radiological results. However, the main purpose of this study was to evaluate patient-centered outcome data.

CONCLUSION

Kyphoplasty is accepted as an operation that is well tolerated by patients and has good pain relief. Additionally more detailed information was obtained about the patient's complaints after the kyphoplasty procedure, according to the fracture level and type of fracture.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from the İstanbul Yeni Yüzyıl University, Science, Social and Non-Interventional Health Sciences Research Ethics Committee (no: 2022/02-811).

Informed Consent: Informed consent was obtained from the patients.

Peer-review: Internally and externally peer-reviewed.

Authorship Contributions

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

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LUMBOPELVIC STABILITY, LUMBOPELVIC MOBILITY AND SPINOPELVIC PARAMETERS IN PATIENTS WITH LUMBAR DISC HERNIATION

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ABSTRACT

Objective: This study aimed to evaluate lumbopelvic stability, lumbopelvic mobility, and spinopelvic parameters in patients with lumbar disc hernia (LDH).

Materials and Methods: The study included 20 patients with LDH who met the study inclusion criteria and 20 age and gender-matched healthy volunteers. All the subjects were evaluated using a visual analog scale for pain intensity assessment, trunk flexor, and right/left lateral trunk flexor muscle endurance tests and Sorensen tests for lumbopelvic stability, Schober and sit-and-reach tests for lumbopelvic mobility, lateral radiography for spinopelvic parameters and the Oswestry Disability Index for physical functionality.

Results: There was a significant difference between the groups with respect to lumbopelvic stability, lumbopelvic mobility, lumbosacral angle, pain, and physical functionality ($p<0.05$). A highly significant moderate to good negative correlation was obtained between endurance tests and pain and functionality scores. A highly statistically significant moderate to good negative correlation was found between pain scores, Oswestry functionality questionnaire results and Schober test values.

Conclusion: The results of this study showed that lumbopelvic stability, lumbopelvic mobility and lumbosacral angle values were decreased in patients with LDH compared with healthy individuals. Therefore, lumbopelvic stability and mobility exercises, and postural control exercises to correct the protective mechanisms that will improve spinopelvic parameters as well as optimal posture, should be included in rehabilitation programs for patients with LDH.

Keywords: Low back pain, lumbar disc herniation, lumbopelvic stability, lumbopelvic mobility, spinopelvic parameters

INTRODUCTION

Lumbar disc herniation (LDH) is a condition characterized by low back and leg pain caused by compression of the lumbar spinal root by the degenerated disc[1]. The highest prevalence is detected between the age of 30-50 years with a male/female ratio of 2:1. In patients aged 25-55 years, approximately 95% of LDH occurs in the lower lumbar spine (L_4-L_5 and L_5-S_1 level), and disc herniation above this level is more common in those aged >55 years[2,3]. The development of disc herniation may be promoted by a negative relationship between load and flexibility in the lumbar region. High intervertebral disc pressures mainly occur in stressful flexion of the lumbar spine with rotational movements and might cause earlier and more frequent ruptures of the annulus fibrosus in the physiological aging process[4].

To achieve and maintain optimal body segment alignment with the spine, pelvis, and lower extremities, lumbopelvic stability must be provided both in a static position and during dynamic activity[5]. Any problem in the spinal column, spinal muscles and one of the neural control units or atrophy in the lumbar region muscles with intervertebral disc damage, which is of great importance in lumbar stabilization, may affect lumbopelvic stabilization[6]. Although some studies in literature have reported that lumbopelvic stabilization is significantly decreased in individuals with LDH compared to healthy individuals[7-10], others have suggested that there is no change[11].

Lumbopelvic mobility is characterized by the coordination of the lumbar spine and hip to the pelvis during flexion and extension in the sagittal plane[12-15]. The changes in the range of motion and timing of lumbopelvic mobility may change the bending stresses of the lumbar segments[16]. However, the changing movement patterns of the lumbopelvic region may be a result of low back pain because of LDH[17]. Although there are studies speculating that lumbopelvic mobility is reduced in individuals with LDH compared to healthy individuals[13,18], there are also studies that argue the opposite[19,20].

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The symptoms that develop in patients with LDH may cause certain changes in the sagittal and coronal shape of the vertebral column[21]. Again there are studies speculating that spinopelvic parameters differ in individuals with LDH compared to healthy individuals[22-24], and there are also studies showing no difference[25,26].

The target of rehabilitation of patients with LDH is to stabilize the spine in a balanced and neutral stance and to provide appropriate muscle activation of the lumbar spine and pelvis. To the best of our knowledge, there is no study in the literature that has evaluated lumbopelvic stability, lumbopelvic mobility and spinopelvic parameters in patients with LDH. Therefore, the aim of this study was to evaluate the lumbopelvic stability, lumbopelvic mobility, and spinopelvic parameters in patients with LDH and in healthy individuals. It is hoped that this will contribute to the planning of future rehabilitation programs.

MATERIALS AND METHODS

This study was planned as a Master's Thesis. Forty-two patients with LDH applied to the department, and 40 of them participated in this study. Two patients could not perform the assessment tests and were excluded. The evaluations made in the scope of the study were applied to all the individuals.

The study included patients who presented at Private Otağtepe Medical Center between May 2021 and November 2021 with complaints of low back pain and were diagnosed with LDH by a specialist physician, and a control group of age and gender-matched healthy individuals. The patients included were aged 18-65 years, had pain complaints ongoing for at least 3 months and at most 12 months, met the study inclusion criteria, and voluntarily agreed to participate in the study. Exclusion criteria were defined as the presence of any orthopedic, neurological, cardiopulmonary, or rheumatological disease, a history of surgery on the column vertebralis, the presence of congenital problems (such as limb length discrepancy), scoliosis, tumor, spondylolysis-spondylolisthesis, structural problems of the vertebral column such as vertebral fracture, a history of musculoskeletal injury in the last 6 months, a history of trauma, or pregnancy.

The study was approved by Üsküdar University Clinical Research Ethics Committee (date: 30/04/2021, approval no: 2021-103), and was conducted in line with the Declaration of Helsinki. The purpose and content of the study were explained to all subjects in writing and orally at the beginning of the study. The information and voluntary consent form prepared in line with the standards of the Ethics Committee was signed by all subjects. The demographic data of the participants were recorded on the "Socio-demographic Data Form" prepared by the researchers. To evaluate lumbopelvic stability, the body flexor muscle endurance test developed by McGill, the Sorensen test, and right and left lateral trunk flexor muscle endurance tests were used. The test positions were explained and demonstrated to the study subjects. They were then asked to maintain the trunk flexion, extension, right and left lateral flexion positions for as long as possible during the test, and the measurements were recorded in seconds with a stopwatch. The tests were ended when the test position was disturbed or when the subject said they could not continue the test. Each measurement was repeated twice and the best measurement result was recorded[27].

For the body flexor muscle endurance test, the subjects were positioned standing on a flat surface with knees flexed, hands crossed on their shoulders, and the body in 60° flexion[28,29]. The participants were positioned in the prone position in such a way that their anterior superior spina iliaca came to the edge of the bed and their upper body was extended forward in a flat position from the edge of the bed in the Sorensen test. It was fixed on the thigh with the help of a physiotherapist[27]. In the body right/left lateral flexor muscle endurance test, participants were placed in a side-lying position to carry their body weight on their forearms and toes. This test was applied separately for the right and left sides[30].

Lumbopelvic mobility was evaluated with Schober's test and the sit-and-reach test. In the Schober test, the L5 spinous process and 10 cm above it was marked when the participants were standing upright. The patient was asked to perform maximum flexion without bending the knees, and the distance between the two points was measured with a 7 mm-wide tape measure, and the amount of increase was recorded. A minimum increase of 5 cm was expected in the distance between two points; if this difference is <5 cm, it is evaluated as decreased lumbar mobility[31]. In the sit-and-reach test, the subjects sit on the floor with the legs and knees extended. Plantar flexion of the foot was prevented by placing a 30 cm high wooden block on the sole of the foot, and the subject is instructed to reach forward without bending the knees. After three stretches, the position is held for 2 seconds and the distance between the distal phalanx of the third finger of the hand and the toes is measured. Reaching as far as the toes was recorded as "0", reaching beyond the toes as "positive (+)" and not reaching the toes as "negative (-)"[32].

Lumbar lordosis, sacral angle and lumbosacral angle measurements of the spinopelvic parameters were evaluated on standing lateral radiographs method during which the subjects were positioned standing upright with hands on the neck, knees in full extension and feet shoulder-width apart. All the measurements were made directly on the radiographs using the Cobb Method and a goniometer. Lumbar lordosis was measured as the angle between the upper surface of the sacrum and the upper surface of the first lumbar vertebra (L_1-S_1)[33]. The sacral angle was measured as the angle between the S_1 vertebra superior endplate and the horizontal line. The lumbosacral angle was measured as the angle between the lines along the upper edge of the S_1 and the lower edge of the L_5 vertebra[34,35]. Each measurement was repeated three times and the average was recorded[36,37].

A visual analog scale (VAS) was used for pain assessment. The patient was asked to mark the intensity of his pain at rest, at

night, and during activity on a 10 cm line marked from 0 to10, where 0 indicates no pain, and 10 indicates unbearable pain[38]. The Turkish version of the oswestry disability index (ODI) was used to evaluate the level of functionality and it was applied in face-to-face interviews with the study subjects. The validity study of the questionnaire was conducted by Yakut et al.[39]. The ODI measures the severity of pain as well as functional disability during activities of daily living such as personal care, walking, lifting, standing, sleeping, sitting, sexual life, social life, and travel. The ODI has 10 questions, each of which has 6 sections scored from 0-5 points. As the total score increases, the level of functionality decreases[40].

Statistical Analysis

The analysis of the study results was made using the Statistical Package for Social Sciences, version 16.0 software (SPSS Inc.; Chicago, IL, USA). The statistical significance value of $p \leq 0.05$ (two-sided) was taken in all analyses. The conformity of the data to normal distribution was tested with the Shapiro-Wilks test. Gender distributions in the groups were analyzed with the chi-square test. In the comparisons between the groups of the VAS scores, the ODI, McGill muscle endurance tests, Schober test from lumbopelvic mobility tests and the sit-reach test, the Mann-Whitney U test was used. In the spinopelvic parameter evaluations between groups, lumbar lordosis, sacral angle and lumbosacral angle measurement results were analyzed with the Independent Samples t-test. The correlations were analyzed with Spearman analysis.

RESULTS

The study was completed with 20 LDH patients and 20 healthy control subjects. Gender, age, height and body mass index were similar in both groups (Table 1). The distribution of herniation levels in patients with LDH is shown in Table 2.

The functionality levels of the LDH patients were statistically significantly lower than those of the healthy control group ($p<0.05$). The mean values of all endurance tests of the control group were higher than those of the LDH patients ($p<0.001$). The lumbopelvic mobility of the control group was higher than that of the LDH patient group. No statistically significant differences were detected between the two groups in respect of lumbar lordosis and sacral angle values ($p=0.733$, $p=0.374$). The lumbosacral angle values of LDH patients were statistically significantly decreased compared to the healthy control group ($p=0.012$, Table 3).

High-level significant negative correlations were found between endurance tests, pain scores, and functionality scores. There were also high-level significant positive correlations between pain and functionality scores. High-level statistically significant negative correlations were found between pain scores, ODI results, and Schober test values. There was a weak-moderate positive correlation between the endurance tests and the Schober test values (Table 4).

DISCUSSION

The results of the present study demonstrated that lumbopelvic stability, lumbopelvic mobility, and lumbosacral angle values were significantly decreased in patients with lumbar disc hernia compared to healthy individuals.

Atrophy, which may occur in the muscles because of LDH, may cause low back pain and affect the lumbopelvic stabilization as an important factor in low back pain[41]. Waldhelm and Li[29]. investigated the reliability of clinical measurements evaluating components related to core stabilization with a test-retest design on healthy young individuals, and reported that the reliability of trunk flexor muscle endurance test, Sorensen test, right/left lateral flexor muscle endurance tests were at the highest levels. In the present study, the lumbopelvic stability values of the cases were evaluated with these tests.

According to the results of a study by Abdelraouf and Abdel-aziem[8] athletes with low back pain yielded significantly lower results in the tested muscle endurance tests compared to a healthy group. In another study, trunk muscle endurance was compared between dancers with low back pain and healthy dancers, and it was found that dancers with low back pain had decreased right and left lateral trunk muscle endurance compared to the healthy dancers[10]. In contrast, Hosseinifar et al.[11] conducted a cross-sectional analytical study, and compared patients with chronic low back pain (n=30) and healthy individuals (n=30) in terms of lumbopelvic stability,

Table 1. The comparison of the demographic characteristics of the groups

	LDH group (n=20) Frequency (%)	Healthy group (n=20) Frequency (%)	p-value
Gender	14 Female (70%) 6 Male (30%)	13 Female (65%) 7 Male (35%)	0.736
	LDH group (n=20) Mean ± SD	**Healthy group (n=20) Mean ± SD**	**p-value**
Age (years)	45.25±7.59	42.10±11.39	0.151
Height (m)	1.63±0.09	1.67±0.08	0.262
Body mass index (kg/m²)	25.96±3.53	25.70±3.93	0.667

*<0,005, chi-square test, **Independent Samples t-test
n: Number of people, SD: Standard deviation, %: Percentage ratio, m: Meter, kg: Kilogram, LDH: Lumbar disc herniation

which is one of the factors suggested to prevent low back pain, and found that the groups were similar.

In the present study, similar to the results of the previous studies in the literature, it was found that all the endurance test values of the LDH patient group were decreased compared to the healthy control group. It can be considered that the *m. multfidius* and *m. transversus abdominis* muscles, which are among the main stabilizers, may develop atrophy because of LDH, and affect lumbopelvic stabilization. However, the structure of these muscles was not evaluated in this study. It can be recommended that future studies evaluate the muscle structures separately with methods such as measuring the cross-sectional area of the muscles on muscle ultrasound or lumbar MRI.

It has been speculated that repetitive lumbopelvic movement is a factor in the development and course of low back pain[42]. Kim et al.[13] evaluated the lumbopelvic rhythms during trunk flexion and extension in patients with low back pain and age-matched healthy individuals, and found statistically significant differences in lumbopelvic rhythms between the two groups. In a study that included 44 male adolescent football players with low back pain and 65 healthy male adolescent football players, it was found that the lumbopelvic movement was smaller in the group with low back pain compared to the healthy group[18].

Table 2. The distribution of herniation levels in patients with LDH

LDH Group (n=20)					
	L_1-L_2	L_2-L_3	L_3-L_4	L_4-L_5	L_5-S_1
Bulging	2	5	10	13	6
Protrusion		2	1	3	4
Extrusion				2	1
Sequestration					

n: Number of people, L: Lumbar vertebra, LDH: Lumbar disc herniation

In another study that included 39 healthy women and 27 women with low back pain, all aged 19-63 years, the effects of flexibility on low back pain were examined. The mean sit-reach test values was measured as 6.56 cm in the healthy women and as 4.11 cm in the female patients with low back pain[20]. In the present study, the Schober's test measurement was mean 14 cm in LDH patients and 15.85 cm in the healthy control group. The mean value of the sit-and-reach test measurements was 0.25 cm in the LDH patients and 2.05 cm in the control group.

The symptoms that develop in patients with LDH may cause certain changes in the sagittal and coronal shape of the vertebral column[21]. Several studies have focused on radiological parameters to assess the status of spinal sagittal imbalance[43]. In the present study, the lumbar lordosis angle, sacral angle, and lumbosacral angle values were measured on standing lateral radiographs to evaluate spinopelvic parameters. According to literature data, the lumbar lordosis angle is between 30°-80°, the sacral angle is between 30°-41°, and the lumbosacral angle is between 10° and 15° in a person standing at rest[33,35,44,45]. In a study investigating spinopelvic parameters between patients with LDH and healthy control subjects in the elderly population, the lumbar lordosis angle and sacral angle were found to be significantly lower in the lumbar disc herniated group compared to the control group[22]. In another retrospective and cross-sectional study, Endo et al.[23] evaluated spinopelvic parameters in LDH patients (n=61) and healthy individuals (n=60), and reported that the lumbar lordosis angle was smaller in the LDH patients (36.7°) than in the healthy individuals (49°). In addition to those studies, it has been suggested in another study that the lumbar lordosis angle is normal in patients with low back pain compared to healthy control subjects[25]. The sacral angle and lumbosacral angle values of 120 LDH patients and 120 healthy individuals were examined in a study by Ghasemi et al.[26] No statistically significant differences were detected between the sacral angle values of the LDH group (40.52°) compared with the control

Table 3. The comparisons of the clinical evaluation results of the groups

	LDH group (n=20) Mean ± SD	Healthy group (n=20) Mean ± SD	p-value
Body flexor muscle endurance test (sec)	12.76±1.20	34.41±1.56	**p<0.001***
Sorensen test (sec)	17.92±1.62	48.66±3.34	
Body right lateral flexor muscle endurance test (sec)	17.24±1.22	36.31±1.75	
Body left lateral flexor muscle endurance test (sec)	16.47±1.32	36.21±1.91	
Schober test (cm)	14±1.47	15.85±0.9	**0.000***
Sit-and-reach test (cm)	0.25±2.38	2.05±2.42	**0.021***
Lumber lordosis angle (degree)	54.39±7.24	56.76±9.26	0.733
Sacral angle (degree)	38.15±5.56	38.86±7.37	0.374
Lumbosacral angle (degree)	7.08±3.95	10.28±3.69	**0.012****
VAS	7.50±1.84	-	-
Oswestry disability index	23.50±8.28	1.15±2.73	**0.000***

*<0.005, Mann-Whitney U test, **Independent Sample t-test
VAS: Visual analog scale, n: Number of subjects, cm: Centimeter, sec: Second, SD: Standard deviation, LDH: Lumbar disc herniation

Table 4. Correlations between the endurance, mobility, pain, and functionality assessments

		Sorensen test	Body FMET	Right LFMET	Left LFMET	Schober test	Sit-and-reach test	Oswestry disability index
Sorensen test (sec)	p	-	**0.001**	**0.000**	**0.000**	**0.030**	0.185	**0.000**
	r	-	0.505	0.595	0.678	0.344	0.214	-0.717
Body FMET (sec)	p	**0.001**	-	**0.000**	**0.000**	**0.001**	0.144	**0.000**
	r	0.505	-	0.660	0.663	0.506	0.235	-0.625
Right LFMET (sec)	p	**0.000**	**0.000**	-	**0.000**	**0.003**	0.056	**0.000**
	r	0.595	0.660	-	0.909	0.455	0.304	-0.629
Left LFMET (sec)	p	**0.000**	**0.000**	0.000	-	**0.018**	0.053	**0.000**
	r	0.678	0.663	0.909	-	0.374	0.309	-0.608
Schober test (cm)	p	**0.030**	**0.001**	**0.003**	**0.018**	**-**	**0.001**	**0.000**
	r	0.344	0.506	0.455	0.374	**-**	0.514	-0.672
Sit-reach test (cm)	p	0.185	0.144	0.056	0.053	**0.001**	**-**	0.071
	r	0.214	0.235	0.304	0.309	0.514	**-**	-0.288
VAS	p	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.060**	**0.000**
	r	-0.585	-0.695	-0.596	-0.598	-0.602	-0.300	0.800
Oswestry disability index	p	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.071	-
	r	-0.717	-0.625	-0.629	-0.608	-0.672	-0.288	-

VAS: Visual analog scale, FMET: Flexor muscle endurance test, LFMET: Lateral flexor muscle endurance test, cm: Centimeter, sec: Second

group (39.30°). Sagittal spino-pelvic alignment was evaluated in a study of 198 patients with chronic low back pain and 709 healthy subjects. The sacral angle and lumbosacral angles were found to be significantly smaller in the patient group with chronic low back pain compared to the healthy control group. The lumbar lordosis angle (41°) in the patient group with chronic low back pain and the lumbar lordosis angle (42°) in the healthy group were small, but it was concluded that the difference was not statistically significant[35].

The lumbar lordosis angle, sacral angle, and lumbosacral angle values that were measured in the present study were similar to those reported in the literature. The lumbar lordosis angle was measured as 54.39° in LDH patients and 56.76° in healthy individuals. The sacral angle was 38.15° in LDH patients and 38.86° in healthy individuals. The lumbosacral angle was measured as 7.08° in LDH patients and 10.28° in healthy individuals. According to the results of the present study, the mean lumbar lordosis and sacral angle values of the patients with LDH and the healthy control group subjects were similar within the range of physiological values. It was also observed that the lumbosacral angle was decreased in the LDH group compared to the healthy control group and according to the physiological limits reported in the literature.

CONCLUSION

The results of this study demonstrated that lumbopelvic stability, lumbopelvic mobility, and lumbosacral angle values of the patients with LDH were statistically significantly lower than those of the healthy control group. When a rehabilitation program is created for LDH patients, lumbopelvic stability and mobility must be considered to be able to increase functionality after pain control is achieved. In addition to specific and isolated exercise training, exercises which aim to provide optimal postural control would be beneficial in rehabilitation programs.

Ethics

Ethics Committee Approval: The study was approved by the Üsküdar University Clinical Research Ethics Committee (date: 30/04/2021, approval no: 2021-103).

Informed Consent: The information and voluntary consent form prepared in line with the standards of the Ethics Committee was signed by all subjects.

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

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ORIGINAL ARTICLE
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IS IT POSSIBLE TO DETERMINE THE PREVALENCE OF ADULT THORACIC SCOLIOSIS WITH A CHEST X-RAY?

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ABSTRACT

Objective: In this study, we planned to examine the prevalence of adult thoracic scoliosis in Turkey.

Materials and Methods: A retrospective, cross-sectional evaluation of randomized digital standing posterior-anterior plain chest radiographs of 1200 patients aged 25 and older, consisting of 600 women and 600 men, was performed. IIf there is no curvature in the thoracic spine it was measured between T1- T12 but if there is curvature, it was performed with the Cobb angle measurement tool of the PACS system using the Cobb method. The measured curvatures were divided into four groups. The first group consisted of patients with coronal curvature of less than 10º the second group consisted of patients with coronal curvature between 10º and 19º, the third group consisted of patients with a curvature of 20º 29º, and the fourth consisted of patients with curvature of 30º or higher.

Results: Scoliosis was detected in 51 (8.5%) of 600 female patients, 39 (6.5%) of 600 male patients, and 90 (7.5%) of all patients. When the male and female groups were examined, no statistically significant difference was found between the two (p=0.118). However, a statistically significant positive correlation was found between age and Cobb angle (p=0.018).

Conclusion: Postero-anterior plain chest radiographs can easily be used to determine the prevalence of adult scoliosis. However, more studies should be conducted with larger sample groups to get a better picture of the prevalence of adult thoracic scoliosis in the community.

Keywords: Adult thoracic scoliosis, chest X-ray, prevalence

INTRODUCTION

Scoliosis is defined as a coronal spine curvature with a Cobb angle of 10° or more[1]. Adult scoliosis is a term that refers to all forms of scoliosis that occur skeletally in adults, regardless of whether the deformity develops before or after skeletal maturation[1]. Adult scoliosis is examined in three groups: Primary degenerative scoliosis, progression of idiopathic adolescent scoliosis in adult life, and secondary adult curves[2]. Adult degenerative scoliosis is included in adult scoliosis. As longer life spans are achieved thanks to the medical advances, the prevalence of age-related spinal degeneration and adult degenerative scoliosis have increased accordingly[3]. It is important to figure out the prevalence of adult scoliosis to fully determine its overall burden on the society. Review of the literature shows that studies on the prevalence of scoliosis are mostly related to thoracolumbar scoliosis[4,5]. Thus, the information on thoracic scoliosis is quite limited. Besides the existing studies only examined either the patients aged 25-64 years or those aged 50 years or older[6,7]. The literature therefore lacks a comprehensive study covering all adult groups.

The aim of this study is to determine the prevalence of thoracic scoliosis in all adult aged 25 years and older who have completed spinal maturation and to examine its effects on age, gender and Cobb angle using routine standing posterior-anterior chest radiographs.

MATERIALS AND METHODS

A cross-sectional evaluation was made by retrospectively scanning digital standing posterior-anterior plain chest radiographs of 1200 (600 female, 600 male) patients aged 25 and older in a tertiary public hospital. Patients were excluded from the study if they were previously applied spinal instrumentation, in case of presence of a detected spinal pathology (presence of concomitant spinal radiographs and/or computed tomography and/or magnetic resonance imaging), and if radiographs are of poor image quality. The date of January 1, 2021 was determined as the beginning of the study and the posterior-anterior plain chest radiographs of 600

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female and 600 male patients aged 25 years and older that were performed since that date at the emergency department or outpatient clinics due to various indications were obtained through the ExtremePACS (Hacettepe Teknokent A.Ş., Ankara, Turkey) PACS system and evaluated. Coronal thoracic spine curvature was measured by 3 different experienced clinicians (OO. FD. OB.) and averaged for each patient. If there is no curvature in the thoracic spine it was measured between T1-T12 but if there is curvature, measurement was performed with the Cobb angle measurement tool of the PACS system using the Cobb method. The measured curvatures were divided into four groups according to the study of Reamy and Slakey[8]. The first group consisted of patients with coronal curvature of less than 10º the second group consisted of patients with a coronal curvature of between 10º and 19º, the third group consisted of patients with a curvature of 20º to 29º, and the fourth consisted of patients with a curvature of 30º or more. The study was conducted in accordance with the principles of the Declaration of Helsinki and local ethics committee approval was obtained.

Statistical Analysis

The data were evaluated using SPSS 25.0 (IBM Corp., Armonk, NY, USA). Histogram and normality graphs and Kolmogorov-Smirnov test of normality were used for distribution analysis, and the data were not normally distributed. Descriptive statistical methods were used for demographic data. The data are expressed as mean ± standard deviation. The presence of scoliosis in two independent groups (male and female) was compared using the Pearson chi-square test. Spearman correlation analysis was used to compare two quantitative data. A value of $p<0.05$ was considered significant.

RESULTS

A total of 1200 patients, 600 women and 600 men, aged 25 years and older, who visited our emergency department and outpatient clinics, were examined. The mean age of women was 46.51±24.00, and that of men was 44.83±16.38 while overall mean age was 45.68±20.55. Scoliosis was detected in 51 (8.5%) of 600 female patients, 39 (6.5%) of 600 male patients, and 90 (7.5%) of all patients. No statistically significant difference was found between the female and male patient groups (p=0.118). Of 90 patients with scoliosis, 72 (80%) had curvature between 10º and 19º, 9 (10%) had curvature between 20º and 29º, and another 9 (10%) had curvature of 30º or higher (Table 1). A statistically significant positive correlation was found between age and the increase in Cobb angle (p=0.018) (Table 2).

DISCUSSION

This study estimated the prevalence of thoracic adult scoliosis to be 7.5% in adults aged 25 years and older. It has been observed that, albeit not statistically significant, it was more common in women than it is in men, and a statistically significant relationship was found between age and Cobb angle.

Prevalence estimation can be obtained from pilot studies or previous studies[9]. However, estimating prevalence for sample size calculations is not an easy task, given the overall scarcity of conclusive prevalence studies in this area and the extensive prevalence figures available[9]. Our study is a pilot study as well. While calculating the sample size, we decided to determine a sample size larger than the previous studies had. Review of the literature shows that the number of sample groups rarely exceeded 1000[6,7,10] and generally they were below 1000. The sample size in our study is 1200.

There are approximately 25 times more studies about adult lumbar scoliosis than adult thoracic scoliosis. There is a shortage of prevalence studies on adult thoracic scoliosis. Therefore, more studies on this subject and more conclusive results with meta-analyses are needed. We have not found any study on adult thoracic prevalence carried out in Turkey. Most of the studies in this area are related to idiopathic scoliosis, especially adolescent idiopathic scoliosis[11-16]. In these studies, the prevalence of adolescent idiopathic scoliosis was found to be 2.5% which is compatible with the prevalence of the cases in other countries[17-20]. Since adult scoliosis includes both the persistence or progression of adolescent scoliosis in adult life and adult degenerative scoliosis, 7.5% prevalence rate is not an unexpected value. While adolescent idiopathic scoliosis is more common in females according to the prevalence studies carried out in Turkey and in the world[11-20] and although more females suffer from adult thoracic scoliosis than males, this difference is not statistically significant. Whereas scoliosis is statistically more common in females during adolescence, the fact that this disparity disappears in adulthood suggests that degenerative scoliosis is more common in males. The fact that men are more involved in working life and are more open to trauma and spinal degeneration make us think that the disparity between men and women in idiopathic scoliosis may disappear in adult scoliosis.

In this study, we found a statistically significant relationship between age and Cobb angle showing that this angle increased

Table 1. Relationship between gender and scoliosis groups

n (%)	Female	Male	Total
Group 1 (Cobb Angle: 0º-9º)	549 (91.5%)	561 (93.5%)	1110 (92.5%)
Group 2 (Cobb Angle: 10º-19º)	40 (6.7%)	32 (5.3%)	72 (6%)
Group 3 (Cobb Angle: 20º-29º)	4 (0.7%)	5 (0.8%)	9 (0.8%)
Group 4 (Cobb Angle>30º)	7 (1.2%)	2 (0.3%)	9 (0.8%)
Total	600	600	1200

Table 2. Relationship between age and Cobb angle

	Cobb Angle P(r)[1]
Age	**0.018 (0.68)***

[1]*Statistically significant (p<0.05)

with aging. With the advances in the medical field, the expected lifespan has increased. Along with it, the exposure of the spine to degenerative processes has also rose. Since degenerative spine diseases inflate with age[21-24], the rise in the prevalence of degenerative scoliosis due to degenerative spine diseases is an expected result. For this reason, the relationship between age and Cobb angle that this study put forward is a predictable result.

CONCLUSION

There are very few studies in the literature on adult thoracic scoliosis which, to our knowledge, has not been studied in Turkey at all. In addition to this study, many more studies should be carried out and a reliable literature should be built for more conclusive results.

Ethics

Ethics Committee Approval: The study approval was obtained from University of Health Sciences Turkey, Gaziosmanpaşa Training and Research Hospital, Clinical Research Ethics Committee (approval no: 08, date: 02.02.2022).
Informed Consent: A retrospective, cross-sectional study.
Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: Ö.Ö., F.D., S.K., Design: Ö.Ö., O.B., A.M.T., Data Collection or Processing: Ö.Ö., O.B., E.C., Analysis or Interpretation: Ö.Ö., F.D., Literature Search: Ö.Ö., A.M.T., S.K., Writing: Ö.Ö., E.C.
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THE RELATIONSHIP BETWEEN CLINICAL AND IMAGING FINDINGS IN MECHANICAL THORACIC SPINE PAIN: A RETROSPECTIVE COHORT STUDY

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ABSTRACT

Objective: Back pain is a very common musculoskeletal condition that affects the quality of life. There are few studies on thoracic spine pain, and the relationship between the degree of degeneration to imaging and pain severity remains unclear. We described the characteristics, etiology and imaging findings of patients with dorsalgia.

Materials and Methods: Between 2019-2020, 200 patients who applied to our clinic with complaints of back pain were retrospectively scanned. Demographic - pain characteristics and diagnoses of the patients were recorded. Kyphosis angle, Cobb angle and vertebral heights were evaluated as thoracic direct radiography findings. Modified Pfirmann grading systems, Modic changes and disc herniations were used to detect degenerative inter-vertebral disc changes via MRI. The relationship between radiological findings and clinical features was evaluated.

Results: It was determined that 80 of 200 patients with dorsalgia required imaging examination. Postural dysfunction and myofascial pain syndrome were diagnosed in 82.5% of the patients. A statistically significant difference was found between the distributions of Pfirrmann grade according to age, the presence of pain at night, the duration of pain, gender and neuropathic pain ($p<0.001$). A statistically significant difference was found between the Modic types with the age and duration of the pain of the patients ($p=0.020$). There was no statistically significant difference between thoracic levels with Phirmann grades and Modic degeneration ($p>0.050$).

Conclusion: Postural disorder and myofascial pain syndrome is the most common cause of thoracic spine pain. The imaging method can be used for further examination of the diagnosis. The pfirrmann grade and the modic changes increase with age. However, there is no clarity on the relationship between such changes and the severity of back pain. Methods for the recognition, prevention and reporting of pain should be developed.

Keywords: Dorsalgia, upper back pain, magnetic resonance imaging, degeneration, thoracic spine pain

INTRODUCTION

Thoracic spine pain (TSP) involves the area between the cervicothoracic (C7-T1) and thoracolumbar (T12-L1) junctions. For dorsalgia, different from the cervical and lumbar spine, the first thing to consider is to distinguish between visceral and musculoskeletal pain. Many diseases that are reflected in these areas may cause pain in patients with back pain. Therefore, the patient should be handled in detail. The imaging method can be used as further examination for the diagnosis. However, the most common cause of dorsalgia is musculoskeletal diseases.

Pain is defined as an unpleasant experience that is felt as a result of actual or possible tissue damage and is affected by many psychological and physiological variables[1]. Acute pain is the biological symptom of a nociceptive stimulation that lasts 3 months or less, caused by tissue damage as a result of disease or trauma[1,2]. Chronic pain is usually defined as 3 months or more. It has been determined in general population studies that the most common area of chronic pain is the back and waist region[1,2].

Dorsalgia prevalence was found to be 7-38% in small-scale studies. The incidence of thoracic disc lesions affecting the spinal cord is one case per million people per year and generally affects adults[3,4]. It has been reported that back pain is observed in 75% of the working population, especially in industrialized countries[1]. The most common causes of dorsalgia are posture disorder and painful muscle syndromes such as myofascial pain syndrome (MPS) and fibromyalgia syndrome (FMS). Osteoporotic vertebral fracture, degenerative diseases, spondyloarthropathies, discopathies are diseases that should be considered in the differential diagnosis[5-8]. 85% and over of people will suffer myofascial pain at least once in their lifetime. Men and women are affected equally. Acute strain, sudden-overload, accumulated trauma, emotional stress, poor posture, immobilization for a long time, spinal curvature, mineral and vitamin deficiency, metabolic and endocrine

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diseases, sleep disorders are some of the reasons that cause MPS formation and its continuation. The diagnosis is made by physical examination and detailed history. MPS is often confused with FMS[9,10]. Degenerative changes of the thoracic spine have seemed in approximately half of the asymptomatic cases. Thoracic disc protrusions are much less widespread clinically than those in the lumbar spine due to greater stiffness of the thoracic spine. This is partly a result of the stabilizing effect of the rib cage on the thoracic spine and partly due to thinner thoracic intervertebral discs due to a less voluminous nucleus pulposus (NP). Therefore, the extension and flexion movements of the thoracic spine are in a smaller range. The TSP can also cause pain radiating along the ribs and chest pain. Pain may increase in situations that increase intra-abdominal pressure, such as deep breathing and coughing. May be confused with a heart attack or angina. Using magnetic resonance imaging (MRI), interpretation and scoring of structural changes of disc degeneration, narrowing of disc space, endplate changes, disc protrusion, facet arthropathy, osteophyte formation, NP and annulus fibrosus shape are accepted to assess the degree of disc degeneration.

However, there is no clarity as to the relationship of such changes to the severity of back pain. In addition, the relationship between degree of degeneration on imaging and pain intensity remains unclear[11].

In our study, we aimed to evaluate the characteristics and diagnoses of our patients with dorsalgia and the findings of the patients who were evaluated radiologically.

MATERIALS AND METHODS

Between 2019 and 2020, 200 patients who applied to our clinic with TSP were retrospectively screened. Acıbadem University Ethics Committee (ATADEK-2019/19) approved the study, and each individual signed a detailed written informed consent form for the study (2019-19/2).

Participants

Demographic data (age, gender), clinical characteristics (pain duration, pain that wakes you up at night, neuropathic pain component) and the diagnosis of the patients were recorded.
Pain duration was rated as acute <3 months, chronic >3 months. In terms of pain intensity, we recorded pain duration and night pain. Neuropathic pain component (pricking, tingling, pins and needles; electric shocks; hot or burning sensations; and pain evoked by light touching) was recorded.

Thoracic Direct Radiography Imaging Protocol

Anterior-posterior (70-80 kVp and 25-40 mAs) and lateral (80-100 kVp and 40-80 mAs) views the thoracic spine were evaluated. Kyphosis angle, Cobb angle and vertebral heights were evaluated as thoracic direct radiography findings. The angle of kyphosis between 20-45° was accepted as normal. It was evaluated as <20° hypokyphosis, 45°> hyperkyphosis. Cobb angle was evaluated as <10° spine curvature and >10° as scoliosis. Vertebra height was measured. Height loss of over 25% was recorded as a vertebral fracture.

Magnetic Resonance Imaging Protocol

Modified Pfirmann grading system, Modic changes (MC) and disc herniations were used to detect degenerative intervertebral disc changes via MRI. A 1.5-T MRI scanner was used to obtain data. T2-weighted sagittal images (TR=3500 ms, TE=120 ms, slice thickness=4 mm, flip angle=140, matrix=512x512, field of view=480x480, NEX=2), T1-weighted sagittal images (TR=450 ms, TE=20 ms, slice thickness=4 mm, flip angle=90, matrix=512x512, field of view=480x480, NEX=2), T2-weighted axial images (TR=3500 ms, TE=120 ms, slice thickness=4 mm, flip angle=140, matrix=256x256, field of view=240x240, NEX=2) were evaluated.

Statistical Analysis

The data were analyzed with IBM SPSS V23. Conformity to the normal distribution was evaluated using the Shapiro-Wilk test. The chi-square and Fisher's Exact tests were used to compare categorical data according to groups. The Mann-Whitney U test was used to compare the age that was not normally distributed according to the kyphosis angle, and the Kruskal-Wallis test was used to compare the age that was not normally distributed according to the cobb angle. Analysis results mean ± S for quantitative data. The categorical data as deviation and median (minimum-maximum) were presented as frequency (percentage). The level of significance was taken $p<0.050$.

RESULTS

When the general characteristics of 200 patients who applied to our clinic due to dorsalgia were examined, it was seen that 66% were female and the average age was 34.6. It was found that the pain duration of 68.3% of the patients was <3 months. It was observed that 35.8% of the patients woke up with back pain at night and 32.3% of the patients had a neuropathic pain component. It was found that 82.5% of the patients were diagnosed with posture disorder and myofascial pain syndrome. Radiological imaging was requested from 80 of 200 patients. Whole vertebral column radiography was requested for 43 of 80 patients. In 14% of these patients, the kyphosis angle was measured as 20° and below. Scoliosis was found in 16.2% of the patients (Cobb angle >10°), and spine curvature was found in 20.9% (Table 1).
There was no statistically significant difference between the distribution of the characteristics of the patients according to the angle of kyphosis ($p>0.050$).
A statistically significant difference was found between the distributions of pain duration according to the Cobb angle ($p=0.029$). 80% of patients with a cobb angle >10° and 11.1% of patients with a Cobb angle of <10° were found to have chronic pain.

There is no statistically significant difference between the distributions of other variables according to the cobb angle (p>0.050) (Table 2).

MRI was requested from 37 of 200 patients. A statistically significant difference was found between the distributions of the phirmann grades system according to age groups (p<0.001). 2% of the patients between the ages of 31 and 40 were found to be grade 2 and 5.6% as grade 5. While 10.8% of the patients >41 years were obtained as grade 2, 1.7% of them were evaluated as grade 5.

A statistically significant difference was found between phirmann grade distributions according to the duration of pain (p=0.002). 1.2% of those with acute pain and 4.1% of those with chronic pain were achieved as grade 4. It was obtained as Grade 5 in 5.4% of those with chronic pain.

Table 1. General characteristics of the patients

	Frequency (n)	Percent (%)
Gender		
Female	132	66.0
Male	68	34.0
Age (mean ± SD)	34.6±12.0	33.0 (10.0-90.0)
Pain duration		
Acute (<3 months)	136	68.3
Chronic (>3 months)	63	31.7
Pain that wakes you up at night		
No	124	64.2
Yes	69	35.8
Neuropathic pain component		
No	130	67.7
Yes	62	32.3
Diagnosis		
FMS	5	2.5
Posture disorder and MPS	165	82.5
Scoliosis	7	3.5
Cervical disc herniation	4	2
Thoracic disc herniation	14	7
Zona	2	1.0
Compression fracture	3	1.5
Kyphosis angle		
Normal	37	86.0
<20°	6	14.0
Cobb angle		
Normal	27	62.7
>10°	7	16.2
<10°	9	20.9

FMS: Fibromiyalgia syndrome, MPS: Myofacial pain syndrome, SD: Standard deviation

A statistically significant difference was found between the phirmann grading system according to the presence of pain that awakens from sleep at night (p=0.003). 4.3% of the pain that awakens from sleep at night and 1.4% of those without night pain were found to be grade 4. 5.3% of those with night-time pain and 0.7% of those without night pain were achieved as grade 5.

A statistically significant difference was found between the distributions of phirman grades according to the presence of neuropathic pain (p=0.001). While 2.4% of those without neuropathic pain and 6.7% of those with pain were grade 1, 5.3% of those without pain and 15.8% of those with pain were achieved as grade 2.

A statistically significant difference was found between the distributions of phirmann grades according to gender (Table 3).

A statistically significant difference was found between the distributions of Modic types according to age groups and pain duration (p=0.02). Eleven of the patients <30 years old were seen as Modic type 1, 12 of the patients aged 31-40 years as modic type 2, and 5 patients >41 years as Modic type 1. Modic type 2 degeneration was detected in 14 patients with chronic back pain (Table 4).

There was no statistically significant difference between the distribution of disc herniation types according to the characteristics of the patients (p>0.05) (Table 5).

There is no statistically significant difference between the distributions of thoracic levels according to Phirmann grades and Modic types (p>0.050) (Table 6 and 7).

DISCUSSION

Spinal pain results in significant disability and work time loss. Very few studies have been done in the general population to define the etiology and prevalence of TSP. In the study of Udby et al.[3], one of the causes of thoracic pain was found to be myofascial pain syndrome in 85%[4]. In our study, 82.5% of our patients were diagnosed with posture disorder and myofascial pain syndrome. An osteoporotic compression fracture in 3 patients, hypokyphosis in 6 patients, scoliosis in 7 patients, and spinal curvaturein 9 patients were detected by direct radiography. 80% of patients with scoliosis were found to have chronic pain.

Fouquet et al.[12], in their study with 3710 worker, found that the frequency of TSP in women was associated with biological predisposition and repetitive loading. They found that TSP is 7 and 30% in men and between 9 and 38% in women, as in our study[4].

Dorsalgia is relatively low in young and middle-aged people and increases with age. Most of the vertebral fractures are asymptomatic and have been detected in 20% of postmenopausal women. It is most commonly seen as a wedge-type compression fracture[4]. A cross-sectional study of men and women aged >50 years found signs of degeneration at least one vertebral level in 84% of men and 74% of women[13].

Muscle weakness and degenerative changes in the spine cause hyperkyphosis. Also, at least 40% of people with hyperkyphosis have a vertebral fracture, and the angle of kyphosis increases by 3.8° with each vertebral fracture[14]. In our study, we looked at the angle of kyphosis based on this aspect, but there was no patient with hyperkyphosis.

In recent years, MRI is the imaging method of option for examining the thoracic spinal canal. It provides a quality image along the entire length of the spine and can determine the morphology of the discs and cord. It has become a widely used diagnostic imaging modality for patients suffering from back pain and related disability. Certain imaging findings, such as nerve entrapment and severe canal narrowing, show a strong association with patient-reported outcomes, while other signs of degeneration found on MRI have a more dubious clinical relevance. Disc degeneration (DD), MC and facet joint

Table 2. Relationship of patients' characteristics with kyphosis and Cobb angle

	Kyphosis angle <20°	p	Cobb >10°	<10°	p[1]
Gender					
Female	5 (83.3)	1.000[1]	4 (57.1)	7 (77.8)	0.510
Male	1 (16.7)		3 (42.8)	2 (22.2)	
Pain duration					
Acute (<3 months)	5 (83.3)	0.192[1]	2 (28.5)[b]	8 (88.9)[a]	**0.029**
Chronic (>3 months)	1 (16.7)		5 (71.4)	1 (11.1)	
Pain that wakes you up at night					
No	5 (83.3)	0.375[1]	5 (71.4)	4 (44.4)	0.432
Yes	1 (16.7)		2 (28.5)	5 (55.6)	
Neuropathic pain component					
No	4 (66.7)	0.611[1]	7 (100)	5 (55.6)	0.143
Yes	2 (33.3)		0 (0)	4 (44.4)	
Age					
<30 years	3 (50)		3 (42.8)	2 (22.2)	0.625
31-40	1 (16.7)	0.4032	4 (57.1)	4 (44.4)	
>41	2 (33.3)		0 (0)	3 (33.3)	

Kyphosis angle: [1]Fisher's Exact test, [2]Chi-square test
Cobb angle: [1]Chi-square test, [a,b]: There is no difference between groups with the same

Table 3. Patients characteristics and Pfirrmann grading system relationship

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	p[1]
Gender						
Female	13 (3.4)	30 (7.8)	3 (0.8)	8 (2.1)	11 (2.9)	0.629
Male	4 (3.7)	9 (8.3)	2 (1.8)	5 (4.6)	2 (1.8)	
Age						
<30 years	9 (5.1)	22 (12.5)[a]	1 (0.6)	5 (2.8)	0 (0)[a]	
31-40	6 (3)	4 (2)[b]	1 (0.5)	5 (2.5)	11 (5.6)[b]	**<0.001**
>41	2 (1.7)	13 (10.8)[a]	3 (2.5)	3 (2.5)	2 (1.7)[ab]	
Pain duration						
Acute (<3 months)	10 (4)	21 (8.3)	2 (0.8)	3 (1.2)[a]	0 (0)[a]	**0.002**
Chronic (>3 months)	7 (2.9)	18 (7.4)	3 (1.2)	10 (4.1)[b]	13 (5.4)[b]	
Pain that wakes you up at night						
No	10 (3.5)	28 (9.8)	4 (1.4)	4 (1.4)[a]	2 (0.7)[a]	**0.003**
Yes	7 (3.4)	11 (5.3)	1 (0.5)	9 (4.3)[b]	11 (5.3)[b]	
Neuropathic pain component						
No	9 (2.4)[a]	20 (5.3)[a]	4 (1.1)	8 (2.1)	11 (2.9)	**0.001**
Yes	8 (6.7)[b]	19 (15.8)[b]	1 (0.8)	5 (4.2)	2 (1.7)	

[1]Chi-square test, [a,b]: There is no difference between groups with the same letter

degeneration (FJD) are spinal imaging findings and possible causes. Several different grading systems have been used to classify the severity of these degenerative changes[11,15]. In the study of Udby et al.[3], lumbar spine DD and FJD were not associated with long-term disability. In our study, 37 of the patients required evaluation with MRI. Phirmann grades and modic classification were used to evaluate degenerative changes. 5,6% of the patients between the ages of 31-40 were found to be grade 5. While 1.7% of the patients aged >41 were obtained as grade 5. 11 of the patients <30 years old were seen as Modic type 1, 12 of the patients aged 31-40 years as Modic type 2. Nine of the patients had bulging, 1 had extrusion and 8 had protrusion. There was no statistically significant difference between the distribution of disc herniation types according to the characteristics of the patients.

Recent studies have also confirmed that symptomatic thoracic disc prolapses are between 0.15 and 4% of all intervertebral disc prolapses. However, the clinical diagnosis is often not

Table 4. Patients characteristics and Modic clasiffication relationship

	M1	M2	M3	p[1]
Gender				
Female	17 (4.9)	15 (4.3)	0 (0)	0.155
Male	2 (2.2)	3 (3.3)	1 (1.1)	
Age				
<30 years	11 (7.3)[a]	5 (3.3)	0 (0)	**0.020**
31-40	3 (1.7)[b]	12 (6.7)	0 (0)	
>41	5 (4.5)[ab]	1 (0.9)	1 (0.9)	
Pain duration				
Acute (<3 months)	10 (4.3)	4 (1.7)[a]	0 (0)	**0.047**
Chronic (>3 months)	9 (4.3)	14 (6.7)[b]	1 (0.5)	
Pain that wakes you up at night				
No	11 (4.4)	6 (2.4)	1 (0.4)	0.176
Yes	8 (4.2)	12 (6.3)	0 (0)	
Neuropathic pain component				
No	8 (2.4)[a]	17 (5)	0 (0)	**<0.001**
Yes	11 (11)[b]	1 (1)	1 (1)	

[1]Chi-square test, [a,b]: There is no difference between groups with the same letter

Table 5. Patients characteristics and disc herniation relationship

	Bulging	Protrusion	Extrusion	p[1]
Gender				
Female	7 (46.7)	7 (46.7)	1 (6.7)	0.779
Male	2 (66.7)	1 (33.3)	0 (0)	
Age				
<30 years	4 (57.1)	3 (42.9)	0 (0)	0.782
31-40	3 (42.9)	3 (42.9)	1 (14.3)	
>41	2 (50)	2 (50)	0 (0)	
Pain duration				
Acute (<3 months)	4 (44.4)	5 (55.6)	0 (0)	0.447
Chronic (>3 months)	5 (55.6)	3 (33.3)	1 (11.1)	
Pain that wakes you up at night				
No	5 (55.6)	3 (33.3)	1 (11.1)	0.447
Yes	4 (44.4)	5 (55.6)	0 (0)	
Neuropathic pain component				
No	6 (46.2)	6 (46.2)	1 (7.7)	0.758
Yes	3 (60)	2 (40)	0 (0)	

[1]Chi-square test

Table 6. Phirmann grade and thoracic spine levels

	Grade 1	Grade 2	Grade 3	Grade 4	P[1]
Toracal level					
T1-T2	0 (0)	1 (2.6)	1 (20)	0 (0)	
T2-T3	1 (5.9)	5 (12.8)	1 (20)	1 (7.7)	
T3-T4	3 (17.6)	2 (5.1)	0 (0)	2 (15.4)	
T4-T5	2 (11.8)	5 (12.8)	0 (0)	3 (23.1)	
T5-T6	2 (11.8)	5 (12.8)	0 (0)	2 (15.4)	
T6-T7	1 (5.9)	4 (10.3)	0 (0)	3 (23.1)	0.984
T7-T8	2 (11.8)	5 (12.8)	1 (20)	1 (7.7)	
T8-T9	2 (11.8)	4 (10.3)	1 (20)	1 (7.7)	
T9-T10	2 (11.8)	3 (7.7)	0 (0)	0 (0)	
T10-T11	1 (5.9)	2 (5.1)	0 (0)	0 (0)	
T11-T12	1 (5.9)	3 (7.7)	1 (20)	0 (0)	

[1]Chi-square test

Table 7. Modic and thoracic spine levels

	M1	M2	M3	p[1]
T1-T2	0 (0)	1 (5.6)	0 (0)	
T2-T3	1 (5.3)	1 (5.6)	0 (0)	
T3-T4	0 (0)	2 (11.1)	0 (0)	
T4-T5	2 (10.5)	4 (22.2)	1 (100)	
T5-T6	4 (21.1)	2 (11.1)	0 (0)	0.687
T6-T7	2 (10.5)	1 (5.6)	0 (0)	
T7-T8	3 (15.8)	1 (5.6)	0 (0)	
T8-T9	2 (10.5)	3 (16.7)	0 (0)	
T9-T10	3 (15.8)	1 (5.6)	0 (0)	
T10-T11	2 (10.5)	2 (11.1)	0 (0)	

[1]Chi-square test

identifiable, and patients are often classified as suffering from intercostal neuralgia, neuritis, cardiac neurosis, or pleurodynia. Thoracic disc protrusions are clinically much less common than those in the lumbar spine due to greater stiffness of the thoracic spine. This is partly a result of the stabilizing effect of the rib cage on the thoracic spine and is due to the thinner thoracic intervertebral discs. Therefore, the extension and flexion movements of the thoracic spine are in a smaller range. Small thoracic disc lesions are most common between T4 and T8. Those with cord compression are usually in the lower half of the rib cage. About 70% are between T9 and T12, the most common level (29%) is T11. In our study, 14 patients had thoracic disc herniation and 4 patients had cervical disc herniation. Also, In our study, no correlation was found between spinal levels and Modic types, disc herniation and phirmann grading[3,16].

Study Limitations

We had some limitations. One of the limitation was not recording the occupations of the patients. Another limitation of our study was that comorbid diseases were not evaluated. In the study of Rabal-Pelay et al.[17] they found that office workers arise pain in the upper back significantly at the end of the day. de Luca et al.[18] found that individual comorbid chronic diseases were significantly associated with spinal pain and a correlation between increased number of comorbidities and spinal pain. Our study may be a precursor for prospective studies with larger number of patients.

CONCLUSION

In conclusion, we defined the characteristics of the patients presenting with dorsalgia in our study. We wanted to point about the differences in the neck and lumbar spine pain. Posture disorder and myofascial pain syndrome is the most common cause of back pain. The imaging method can be used as further examination in the diagnosis. However, there is no clarity as to the relationship of such changes to the severity of back pain. Methods for the recognition, prevention and reporting of pain should be developed.

Ethics

Ethics Committee Approval: Acıbadem University Ethics Committee (ATADEK-2019/19) approved the study.
Informed Consent: Each individual signed a detailed written informed consent form for the study (2019-19/2).
Peer-review: Internally peer-reviewed.
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ORIGINAL ARTICLE
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TRADITIONAL TRAINING VERSUS VIRTUAL REALITY AND HAPTIC ENABLED SIMULATION TRAINING FOR POSTERIOR CERVICAL SCREW PLACEMENT

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ABSTRACT

Objective: Simulation-based training is a technique, which evokes or replicates substantial aspects of the real world in a fully interactive fashion and replaces and amplifies real experiences with guided ones, which are generally immersive.

Materials and Methods: Twenty-five junior surgeons (20 orthopedic, 5 neurosurgeon) who were not involved in previous posterior cervical spine instrumentation participated in this study. Before the procedures, all surgeons received 2-hour lecture about cervical spine anatomy and screw insertion techniques. Group 1 (10 surgeons) underwent virtual reality simulation with haptic feedback for 20 min, group 2 (15 surgeons) were attended video sessions with experienced surgeons for 20 min for posterior cervical instrumentation training. After, all junior surgeons applied C1-2 screw, C3-4-5 lateral mass screws, and C6-7 cervical pedicle screws to saw bones. All saw bones underwent computerized tomography (CT) imaging and a blinded radiologist reviewed the CT images.

Results: Group 1 applied 70 screws and group 2 applied 105 screws. Group 1 showed a 12% misplacement ratio, while group 2 showed a 19% misplacement ratio and 4% rate of a possible vertebral artery trace penetration (p=0.026).

Conclusion: According to the results acquired from this study, we observed a lower cervical spine screw misplacement ratio in those who trained with VR based haptic enabled simulation before performing cervical posterior instrumentation.

Keywords: spine, virtual reality, cervical, posterior instrumentation, screw placement

INTRODUCTION

Surgical complications cost lives, and the economic impact of only the annual 1 million training-related orthopedic complications is $5 billion per year. There is no standardization in surgical training worldwide, thus many complications can be related to insufficient training and practice. The measurement and assessment in medical education cannot be done objectively, as there are no standard metrics available. According to the reported studies, we tend to forget 80 percent of what we learn in three days, unfortunately. This information can also be considered in resident education and training because it is difficult for young surgeons to repeat what they learn[1-3].

Simulation is not a new invention thus pilots are training with simulators since the 1980s. The swift technological advances of the 21st century enable us to create portable, feasible and reachable virtual-reality simulators with tactile feedback to use in medical education[3-5]. Simulation-based training allows learning and relearning as often as needed to correct mistakes, enabling the trainee to perfect steps and fine-tune skills to optimize clinical outcomes. Moreover, the trainee has the advantage of being in a familiar environment and do not need to take days off and to travel, which means saving money and time[6-9].

Simulation by virtual reality (VR) in orthopaedic surgery and neurosurgery for educational, preoperative planning, and intraoperative utilization continues to improve with technological advances in computer processing[2,10]. VR utilizes a computer processing unit with a head-mounted display to provide visual and auditory cues coupled with haptics to provide immersive, multisensory experience with creation of touch, vibration, and motion[3-5]. In this study, we aimed to

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compare traditional training and VR based and haptic enabled simulation for posterior cervical screw placement to the saw bone. We hypothesized that VR based training will result in better outcomes in terms of screw placement.

MATERIALS AND METHODS

After İstinye University Clinical Research Ethics Committee approval (3/2022.K-33) we obtained written informed consent for participation from all participants. Twenty-five junior surgeons (20 orthopaedic surgeons, 5 neurosurgeons) who had no previous experience in posterior cervical spine instrumentation procedure were participated in the current study. Before the procedures, all surgeons received 2-hour lecture about cervical spine anatomy, C1-C2 lateral mass and cervical pedicle screw application methods by expert senior surgeons who have more than 20 years of spine surgery experience. Then the surgeons were randomly divided into two groups. Group 1 comprised 10 junior surgeons that underwent 20 minutes VR simulation with haptic feedback posterior cervical instrumentation training. Fifteen junior surgeons were in Group 2 who underwent 20 minutes video demonstration by experienced surgeons. Then both two groups applied C1-2 screw placement by Harm's technique[11], C3-4-5 lateral mass screw placement by Magerl's Technique[12] and C6-7 cervical pedicle screw placement by Abumi's technique[13] to the cervical spine saw bone.

Features of the VR System

The simulator software (*Noya Enterprise,* İstanbul, TURKEY) is able to run on a standard notebook that consisted of suitable graphic hardware. *Oculus Rift* (*Oculus VR*, Facebook Technologies, CA, USA) headset was used for VR display. *Touch* (*3D systems*, CA, USA) haptic device is used for tactile simulation (Figure 1). The simulation software simulated hard tissues like bone and soft tissues like fat, muscle, and skin (Figure 2). The haptic system was not used to enhance psychomotor skills, but it was used to create an immersive environment through the use of tactile feedback.

Sawbones (*Sawbones®,* WA, USA) represent normal bony and disc structure from occiput to C7 vertebrae. Sawbones were used in prone position that embedded to foam model holder. Surgeons can only able to see the posterior surface of the model. Screws and rods (*Stryker*, MI, USA) were implanted strictly by freehand method (Figure 3). Surgeons implanted the screws by himself without any instructions by senior surgeons.

Radiological Evaluation

All saw bones were sent to the radiology department and axial, sagittal and coronal computed tomography (CT) images were taken. An expert radiologist who was blinded to the study groups reviewed all CT images and recorded the numbers of pedicle screw misplacements (Figure 4). In the axial plane, malposition of the screws was graded as; grade 0 (G-0): Correct placement, grade 1 (G-1): Malposition by less than half screw diameter, grade 2 (G-2): malposition by more than half screw diameter. The direction of malposition was classified into four categories: Medial, lateral, superior and inferior[14]. For lateral mass screw positioning, the location of the screw in relation to the edge of the root foramen and to the facet joint was assessed[15].

Statistical Analysis

Statistical analysis was performed by using SPSS 25.0 (SPSS Inc., IBM, NY, USA). Chi-square test was used to compare frequencies and a p-value of <0.05 is considered as statistically significant.

RESULTS

The number of pedicle screws implanted were 70 in Group 1 and 105 in Group 2. The screw misplacement ratio was 12% in Group 1 and it was significantly higher in Group 2 with a ratio of 19% (p=0.026). Within the misplaced screws in Group 2, 4% of the screws were directly damaging the vertebral artery trace.

DISCUSSION

The most important finding of this study was observing a significantly lower cervical pedicle screw misplacement ratio in those who trained with VR based and haptic enabled simulation before performing posterior cervical screw placement. Our null hypothesis can be easily accepted that we observed a better screw placement in those who trained with VR simulation before applying cervical posterior screw placement. A recent systematic review which evaluated VR based training in spinal

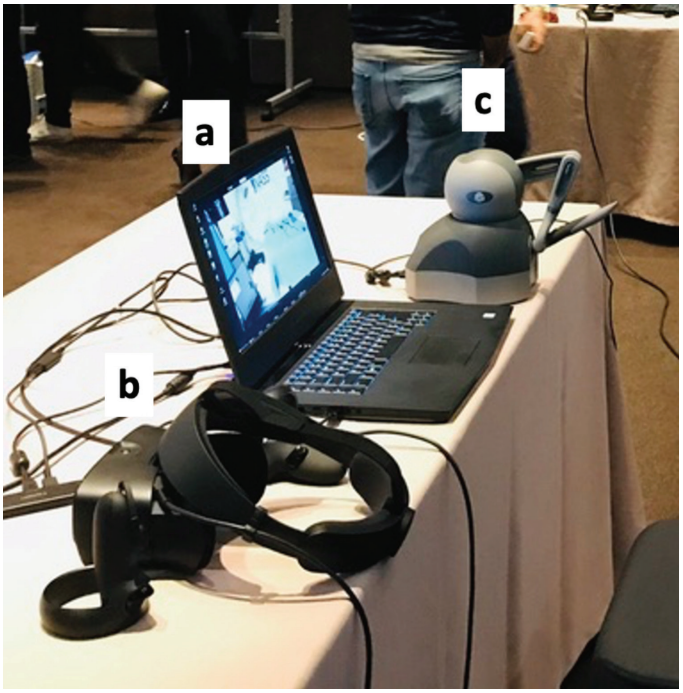

Figure 1. The devices used in simulation; (a) notebook, (b) headset for VR display, and (c) haptic device
VR: Virtual reality

surgery also remarked the importance of VR based training and recommended its use for training in spine surgery[9].

The main advantage of VR based training with haptic enabled simulation is providing an entirely immersive, multisensory operating room environment for training. A surgeon using this simulator can do pedicle screw, lateral mass screw placement in posterior cervical spine with unlimited repetition. In medicine, there is an ancient rule; "Primum non

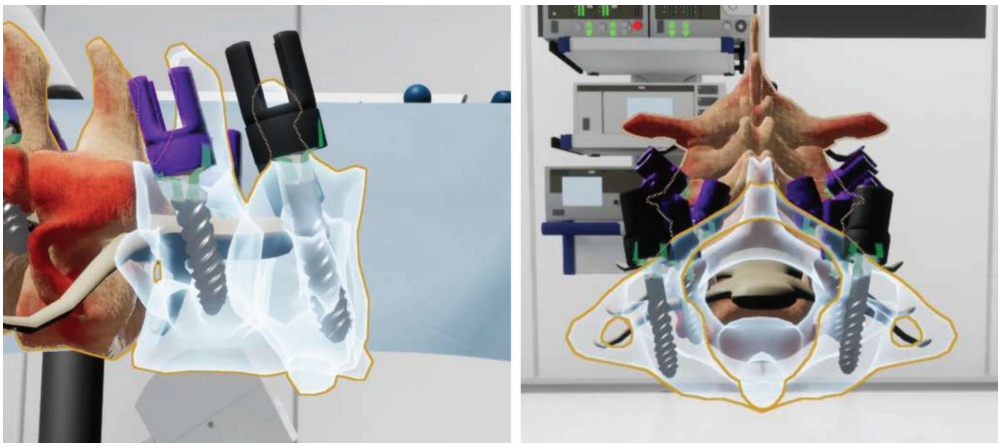

Figure 2. The screen shot image of cervical pedicle screw placement application

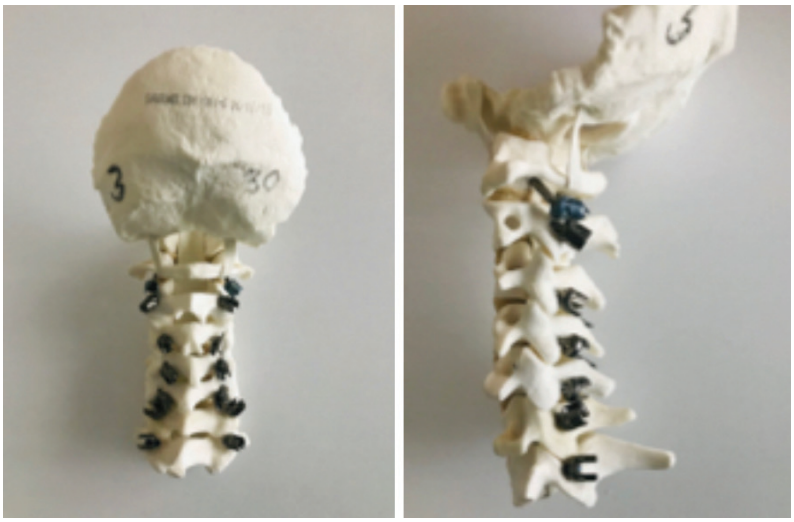

Figure 3. Applications of C1-2 screw with Harm's technique, C3-4-5 lateral mass screw with magerl technique and C6-7 cervical pedicle screws with Abumi technique to the saw bones without any instruction

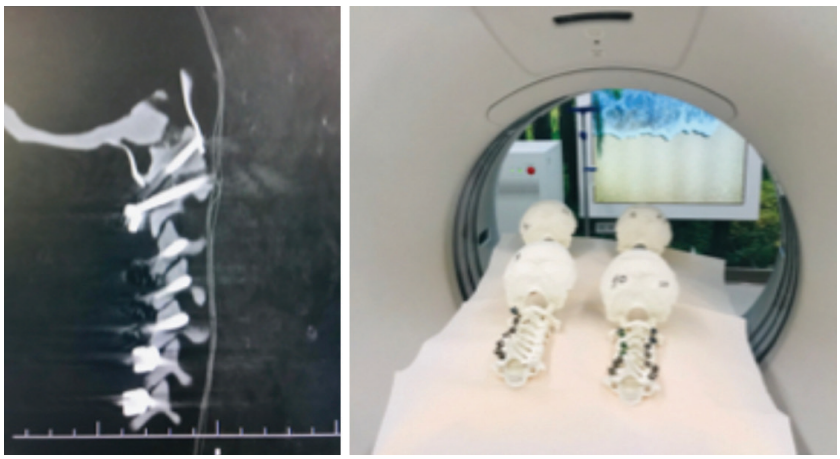

Figure 4. All saw bones underwent CT imaging and all screw pathways analyzed

CT: Computed tomography

nocere" meaning "First do no harm", while attending a patient. For this rule, it is essential to get the necessary training and experience. World Health Organization reports that 60% of surgical complications are due to not following surgical protocols. In order to not break the ancient rule, surgeons need to be trained intensively, and comprehensively. Medical professionals need to be trained so that they follow medical procedures step by step that need to be repeated many times to engrain it into their memories. We, therefore, need a practical; easy to reach and low-cost training method[10]. Professional development is an ongoing process in all walks of life. Unlike most, medical education and training not only requires vast amounts of knowledge but also interaction with patients. Briefly, education/training is the act and systemic instruction process of imparting or acquiring and validating particular competencies. These learned competencies are factual knowledge, know-how, operational skills, and overall attitude towards patient treatment.

Repetition is a crucial part of learning. It solidifies new skills, improves speed, increases confidence, and strengthens the connections in the brain. Most importantly, it draws attention to minor details. So, practice is the best way to solidify data that you need to keep in your mind and retrieve when required[11]. Reports of high complication rates in early adaptation in spine surgery may adversely steer established surgeons from performing these procedures. As the evidence grows for simulation training techniques in this field, it will reverse the current practice and training behaviors[2]. Those simulators should be commercially available and unique for every person. Simulation-based training allows learning and re-learning as often as needed to correct mistakes, enabling the trainee to perfect steps and fine-tune skills to optimize clinical outcomes. It is possible to filter and select trainees for further procedural competency-based training. Simulation-based medical education protects patients from unnecessary risks while developing health professionals' knowledge, skills, and attitudes. Future studies should attempt standardization of these simulation training techniques, clinical outcomes, supporting well conducted randomized trials of simulators use in spine surgery field. These outcomes should be combined with radiographic parameters with patient reported outcome measures.

Study Limitations

The main limitation of this study was evaluating a limited number of orthopaedic junior surgeon, so it is difficult to reach a higher level of evidence and statictical power. However, our study is the first study in the literature comparing VR training and traditional training in cervical spine posterior screw placement which can be considered as one of the most difficult procedure in spine surgery. In addition to that it is obvious that a better outcome due to an efficient training cannot be ignored. Therefore, our study can guide further studies and training centers to increase the quality of resident education.

CONCLUSION

In conclusion; according to the results acquired from this study, we observed a lower cervical spine screw misplacement ratio in those who trained with VR based haptic enabled simulation before performing cervical posterior instrumentation.

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Ufuk Aydınlı report that he affiliated with Noya Enterprise which financially sponsored to our study. These grant was used for simulator system, sawbones and computerized tomography.

Ethics

Ethics Committee Approval: Ethics committee approval was received for the study from İstinye University Clinical Research Ethics Committee (3/2022.K-33).

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

Peer-review: Internally peer-reviewed.

Authorship Contributions

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

Conflict of Interest: The authors have no conflicts of interest to declare.

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