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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 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

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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.

INSTRUCTIONS to AUTHORS

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

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

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.

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- **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

INSTRUCTIONS to AUTHORS

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

INSTRUCTIONS to AUTHORS

Epidemiology

Etiology

Examination

Experimental study

Fusion

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

Infection of the spine

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

Instrumentation

Meta-Analysis

Osteoporosis

1. Bone density
2. Fractures
3. Kyphoplasty
4. Medical Treatment
5. Surgical Treatment

Outcomes

1. Conservative care
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

Physical Therapy

1. Motion Analysis
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

INSTRUCTIONS to AUTHORS

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JOURNAL OF TURKISH SPINAL SURGERY

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ORIGINAL ARTICLES

JOURNAL OF TURKISH SPINAL SURGERY

EDITORIAL

Dear Colleagues,

Being able to publish this, the 3rd issue of our professional journal this year, is a great privilege. I am honored and, at the same time, humbled to be the person responsible for getting this information out to all of you. Sincere appreciation goes to all the reviewers, assistant editors, secretaries and the Galenos publishing team for the efforts they all expended in order to put this issue together. It includes seven clinical research studies. Please review it very carefully, and apply as many new techniques, and as much new information as you can, into your practice.

The first study examines "Morphological Analysis of Thoracolumbar Spine Pedicles in Adolescent Idiopathic Scoliosis". The second study asks "Does Preoperative Neutrophil to Lymphocyte Ratio Affect Preoperative and Postoperative VAS Levels in Patients Undergoing Cervical Disc Surgery?". The third, is a clinical study entitled, "The Effects of Surgeon-Made Preoperative Three-Dimensional Multiplanar Reformatting on Surgeon's Anxiety in Spinal Surgery". The fourth article is "Characteristic Patterns and Publication Rates of Spine Specialty Theses from Postgraduate Orthopedic Residency (2001-2020) Programmes in Turkey", while the fifth study, is a clinical article investigating "Biomechanical Changes in Cervical Spine Sequencing After Rigid Lumbar Stabilization". The sixth study is entitled "Transforaminal Epidural Injections: A Bibliometric Analysis of the 50 Most Cited Articles" In the seventh study, the authors evaluated "Quality of Life Assesment in Adolescent and Young Adults with Scheurmann's Kyphosis".

Once again, these are unusual and difficult times, so I'd like to thank everyone, especially the dedicated reviewers, who worked to get this issue out to our colleagues. I hope everyone understands and appreciates the amount of work that went into this. Please take the time that's necessary to read this issue and incorporate all of the pertinent information into your practice. Our mission remains, as always, to keep you abreast of all the latest developments in our field. Once again, this issue is intended to further that goal. I wish my readers wonderful holiday with their families.

With kindest regards,

Editor in Chief

Metin Özalay, M.D.

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DOI: 10.4274/jtss.galenos.2022.24633

MORPHOLOGICAL ANALYSIS OF THORACOLUMBAR SPINE PEDICLES IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT

Objective: Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity, and pedicle morphology can change on the concave and convex sides of the curvature. This study aimed to evaluate the pedicle morphology of the thoracic and lumbar vertebrae in AIS via computed tomography (CT).

Materials and Methods: Patients diagnosed with AIS between 2019 and 2021 were identified by scanning the Picture Archiving and Communication System. Patients with a scoliosis radiograph and a Cobb angle of 40° or more were included in the study. The pedicle length (PL), axial pedicle angle (APA), endosteal pedicle width (EPW), and cord length (CL) were measured from the T1 to L5 vertebrae from the CT sections of the patients. The Cobb angle, apical vertebral translation distance, and vertebral rotations were measured using standing AP and lateral radiographs.

Results: The mean age of the 30 patients was 16.37±3.0 and 93.3% were females. The mean main-thoracic Cobb angle was 47.87°±7.99°. There was a significant, negatively weak relationship between the Cobb angle and T5 and T6 left PL (r=-0.485 and r=-0.371, respectively), a moderately negative relationship between T7 and L3 left PL (r=0.506 and r=-0.508, respectively). There was no significant correlation between the Cobb angle and endosteal pedicle values (p>0.05). While the correlation between the vertebral rotation and the right endosteal pedicle was moderate at T4, a significant but low correlation was found for T3, T5, T6, T7, and T9 (p<0.05).

Conclusion: The EPW was shorter and the CL was longer on the concave side of the vertebrae in the apical region of the AIS deformity. It is essential to know the pedicle morphology order to avoid complications, especially in pedicle screw implantation in the apical concave region.

Keywords: Morphometry, pedicle, scoliosis, thoracic, lumbar

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is the most common three-dimensional spinal deformity, affecting 2-3% of children between the ages of 10 and 16, and the risk of progression of the curvature is ten times higher in females[1,2]. AIS does not cause an increase in mortality, but if left untreated, the curvature of the spine may progress, leading to abnormal posture, back pain, body image problems, depression, and pulmonary symptoms in large thoracic curves[3]. The exact etiology for AIS is unknown, but it is assumed to be multifactorial with a genetic predisposition[4].

Surgical treatment is generally preferred in patients with a major curvature angle greater than 45°, because curvatures greater than 45° continue to progress even if skeletal maturity is complete[3]. Posterior instrumentation and fusion, which is applied via pedicle screws with a posterior approach, is the most popular method in the treatment of AIS in recent years[5]. In patients diagnosed with AIS, it is very important to determine the morphology of the thoracic and lumbar spine before surgery, because improper placement of pedicle screws can cause serious neurological, vascular or visceral injuries[6-9].

To date, pedicle morphology has been evaluated in many studies on AIS using various measurements and modalities, and asymmetries have been detected at the apex of scoliosis[10-16]. The morphological analysis of vertebrae with two-dimensional radiographs in AIS may be misleading because these radiographs cannot show the true frontal (coronal) or lateral (sagittal) sections of each vertebra[17]. Computed tomography (CT) is widely used to perform a three-dimensional morphological analysis of vertebrae in AIS[18].

The aim of this study was to perform pedicle morphometric measurements and analysis of thoracic and lumbar vertebrae in AIS via CT.

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ORCID ID: orcid.org/0000-0003-4286-7852

MATERIALS AND METHODS

The study was approved by the Institutional Review Board of Ankara City Hospital (approval date: 09/22/2021, approval no: E1-21-2026). Informed consent was obtained from all patients to confirm their participation in the study. Patients with AIS were identified by scanning the Picture Archiving and Communication System between 2019 and 2021. Patients who had a scoliosis radiograph, a cobb angle of ⩾40°, and were evaluated with CT were included in the study.

The CT imaging technique was used to cut sections from T1 vertebra to L5 vertebrae at 1.5 mm intervals in helical mode (GE Reveluation, Waukesha, WI, USA). The position of the BT Gantry was adjusted parallel to the long axis of the pedicles. The reconstruction was shot at 1250 mm intervals and the pitch ratio was 0.750:1. The acquisition parameters were 130 kVp and 260 mAs. Advantage Workstation AW4.6 (General Electric, Boston, MA, USA) software was used to reformat the transverse view.

The pedicle length (PL), axial pedicle angle (APA), endosteal pedicle width (EPW), and cord length (CL) were measured[19] (Figure 1a, b). The PL was measured as the distance between the transverse line drawn at the anterior border of the vertebral foramen and the entry point of the pedicle posterior cortex. The APA was measured as the angle between the sagittal mid-vertebral line and the line drawn perpendicular to the transverse pedicle isthmus. The EPW was measured as the narrowest distance of the endosteal surface of the pedicle in the axial plane. The CL was measured as the distance from the posterior cortex entry point of the pedicle to the anterior cortex along the transverse axis of the pedicle.

Rotations were measured in the coronal and lateral radiographs taken on a 36-inch cassette while the patient was standing[20] (Figure 2). The Cobb angles and apical vertebral translation distance were measured on the preoperative standing radiography (Figure 3). The AIS classification was made using the Lenke classification. All of the measurements were taken by 2 experienced spine surgeons.

The relationship between the Cobb angles and the PL, APA, EPW and CL values were investigated, as was the relationship between the thoracic and lumbar spine vertebral rotation and the APA and EPW values.

Statistical Analysis

The continuous and categorical variables were summarized as the mean ± standard deviation (after examining the normality) and frequency (percentage), respectively. The Spearman Rho or Pearson correlation coefficients between the measurements was calculated. The critical limits for the correlation coefficients were accepted as <0.30: negligible, <0.50: low, <0.70: moderate, <0.90: high, ⩾0.90: very high correlation[21]. The R language[22] packages [DescTools[23] was used to obtain the 95% confidence interval (CI) of the mean, ggplot2[24] was used for drawing the graphs, and correlation[25] was used for correlation analysis] were used with a significance level set at $p<0.05$.

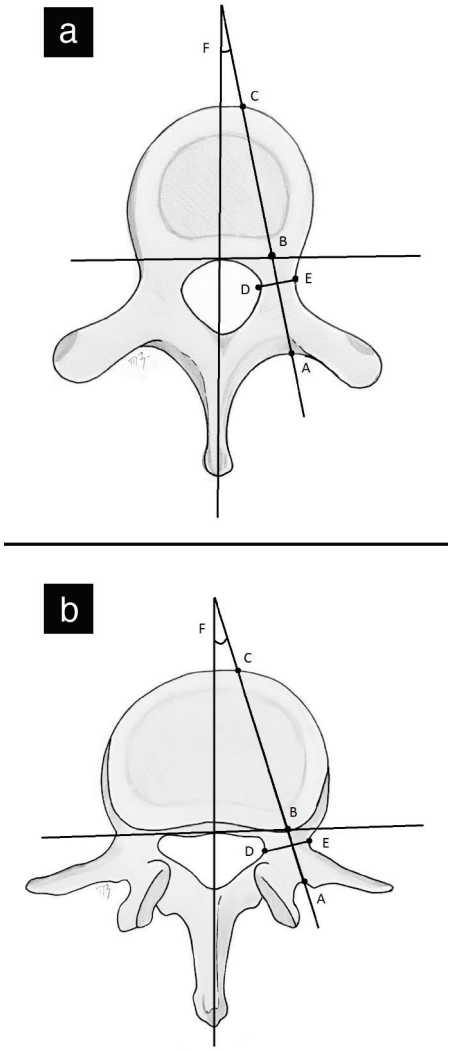

Figure 1. Illustration of pedicle length (AB), endosteal pedicle width (DE), cord length (AC), and axial pedicle angle (F) in the thoracic (a) and lumbar (b) spine

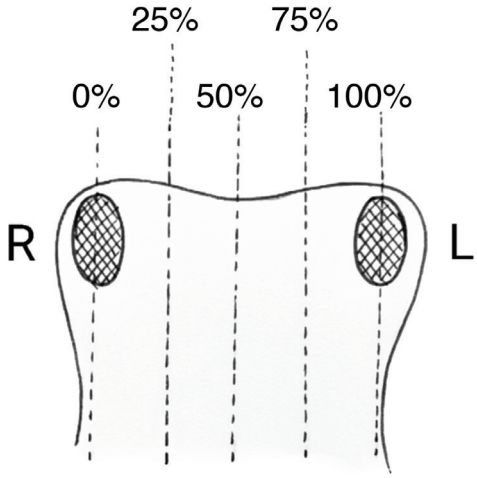

Figure 2. Illustration of the Nash-Moe index used in the grading of vertebral rotation

RESULTS

Of the 30 patients included in the study, 93.3% were female and the mean age was 16.37±3.0 (95% CI: 15.25-17.49, median: 16) years. The mean main-thoracic cobb angle was 47.87°±7.99° (95% CI: 44.89-50.85, median: 46.61°). Other descriptive information about the patients is summarized in Table 1.

The mean and 95% CI of the thoracic and lumbar spine right and left PL, APA, EPW, and CL values are given in Figure 4. The mean T1 left PL was 15.88±1.05 mm, the mean APA was 20.43±3.97°, the mean EPW was 5.49±0.69 mm, and the mean CL was 29.15±2.44 mm (Table 2).

The instrumentation rates of the thoracic and lumbar spines and the percentages of vertebral rotation are presented in Table 3. Especially in the apical region of the curve, the instrumentation percentage of the convex side is much higher than the concave side. It is also seen that the vertebral rotation shifts towards the convex side in the apical regions of both the thoracic and lumbar curvatures.

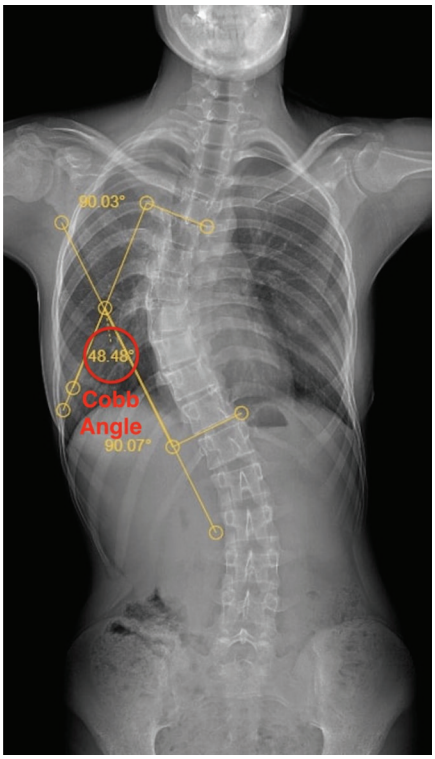

Figure 3. Cobb angle measurement on standing anteroposterior radiograph

The relationship between the Cobb angles of the patients and the PL, APA, EPW, and CL values from the T1 to L5 spine were examined (Table 4). Accordingly, between the Cobb angle and T5-T6 left PL, it is low in the negative direction (r=-0.485 and r=-0.371, respectively), and between T7-L3 left PL in the negative direction is moderate significant relationship was determined (p<0.05, r=-0.506 and r=-0.508, respectively). There was no significant correlation between the Cobb angle and endosteal pedicle values (p>0.05).

The relationship between thoracic and lumbar spine vertebral rotation and APA, EPW values was examined and the correlation coefficients obtained are given in Table 5. There was a low positive correlation between the T4 and L2 right APA measurements and the vertebral rotation (p<0.05). While the correlation between the vertebral rotation and the right endosteal pedicle was moderate at T4, a significant but low correlation was found for T3, T5, T6, T7, and T9 (p<0.05). Only the correlation between L3 spine measurements between left APA and EPW was statistically significant and moderately negative (p<0.05). There was no significant correlation between the right APA and EPW values (p>0.05).

DISCUSSION

In recent years, pedicle screw instrumentation has been a common and accepted treatment for patients with AIS. One of the components accompanying the deformity in AIS is the deformity seen in the vertebral pedicles. This deformity may lead to complications in pedicle screw instrumentation. For this reason, awareness of the specific pedicle structure of AIS can prevent complications.

AIS is the most common three-dimensional spinal deformity, affecting 2-3% of children aged 10-16 years, and it has a 10-fold higher risk of progression in females[1,2]. Approximately 93.3% of the patients included in this study were females, and female gender can be shown as a risk factor for AIS. In a study conducted by Guzek et al.[26] on AIS patients, 38 (67.9%)

Table 1. Demographic information of patients

Parameter	n (%)	Parameter	n (%)
Lenke classification		**Lenke saigttal thoracic modifier**	
1	19 (63.3)	-	5 (16.7)
2	1 (3.3)	N	23 (76.6)
3	8 (26.7)	+	2 (6.7)
5	2 (6.7)		
Lenke lumbar modifier		**Location apex**	
A	18 (60.0)	Thoracic	19 (63.3)
B	3 (10.0)	Thoracolumbar	8 (26.7)
C	9 (30.0)	Lumbar	3 (10.0)

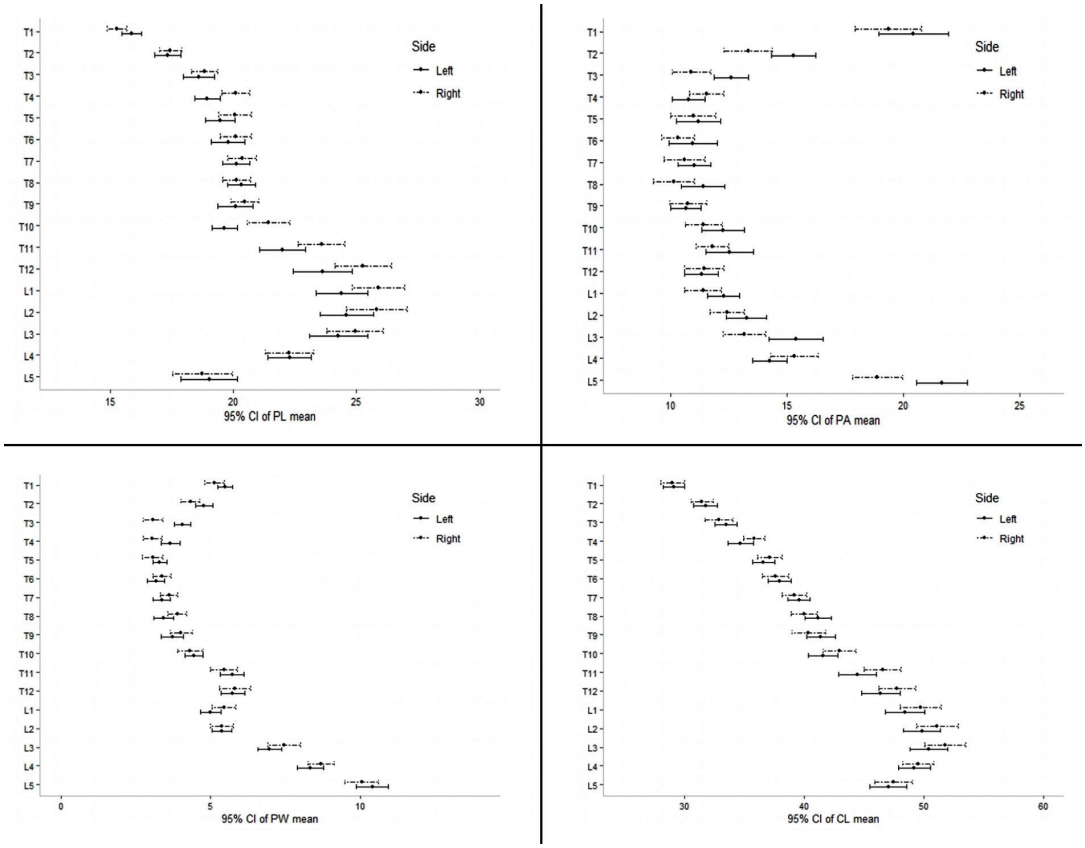

Figure 4. Mean and 95% confidence interval graph for T1-T12, L1-L5 pedicle length, axial pedicle angle, endosteal pedicle width and cord length values

CI: Confidence interval, PL: Pedicle length, PA: Pedicle angle, CL: Chord length

Table 2. T1-T12, L1-L5 pedicle length, axial pedicle angle, pedicle width and chord length values of the patients

	PL (mm)		APA (°)		PW (mm)		CL (mm)	
	Left	Right	Left	Right	Left	Right	Left	Right
T1	15.88±1.05	15.27±1.03	20.43±3.97	19.34±3.80	5.49±0.69	5.13±0.86	29.15±2.44	29.02±2.64
T2	17.34±1.42	17.45±1.24	15.28±2.54	13.32±2.80	4.79±0.78	4.34±0.85	31.80±2.68	31.49±2.54
T3	18.59±1.69	18.83±1.44	12.60±1.96	10.88±2.23	4.07±0.72	3.08±0.81	33.49±2.52	32.92±3.07
T4	18.94±1.40	20.10±1.55	10.76±1.85	11.54±1.96	3.66±0.85	3.06±0.79	34.71±2.79	35.85±2.43
T5	19.48±1.63	20.06±1.78	11.17±2.53	10.96±2.59	3.31±0.63	3.07±0.89	36.63±2.50	37.17±2.73
T6	19.79±1.85	20.11±1.70	10.95±2.81	10.31±1.90	3.18±0.77	3.38±0.82	37.96±2.63	37.65±2.94
T7	20.13±1.47	20.35±1.55	11.01±1.87	10.58±2.38	3.37±0.72	3.62±0.78	39.60±2.45	39.23±2.71
T8	20.14±1.51	20.34±1.51	11.38±2.51	10.12±2.40	3.43±0.88	3.89±0.83	41.20±2.92	40.05±2.92
T9	20.09±1.86	20.46±1.51	10.64±1.74	10.73±2.11	3.73±0.95	4.02±0.97	41.43±3.08	40.40±3.71
T10	19.65±1.39	21.44±2.32	12.23±2.43	11.41±2.15	4.45±0.83	4.32±1.13	41.59±3.27	42.98±3.63
T11	21.98±2.50	23.58±2.53	12.53±2.72	11.79±1.87	5.73±1.09	5.45±1.18	44.45±4.20	46.58±4.18
T12	23.63±3.21	25.26±3.08	11.31±1.94	11.43±2.26	5.74±1.06	5.82±1.38	46.41±4.27	47.78±4.13
L1	24.40±2.80	25.89±2.86	12.26±1.81	11.39±2.12	5.00±0.91	5.45±1.06	48.45±4.48	49.76±4.54
L2	24.60±2.89	25.83±3.27	13.26±2.32	12.42±2.00	5.37±0.90	5.39±1.02	49.86±4.16	51.14±4.62
L3	24.27±3.18	24.94±3.10	15.39±3.12	13.16±2.49	6.98±1.06	7.46±1.47	50.45±4.21	51.81±4.64
L4	22.28±2.38	22.26±2.64	14.25±1.95	15.29±2.74	8.34±1.18	8.69±1.18	49.23±3.64	49.53±3.51
L5	19.03±3.09	18.74±3.23	21.65±2.92	18.87±2.87	10.41±1.47	10.06±1.50	47.07±4.13	47.49±4.14

Data were expressed as mean ± SD. T: Thoracic, L: Lumbar, PL: Pedicle length, APA: Axial pedicle angle, PW: Pedicle width, CL: Chord length, SD: Standard deviation

Table 3. T1-T12, L1-L5 instrumentation and vertebral rotation rates of the patients (%)

	Instrument (n=27)*		Vertebral rotation (n=30)**						
	Right	Left	Left 75%	Left 50%	Left 25%	0%	Right 25%	Right 50%	Right 75%
T1	3.7	0.0			23.3	66.7	6.7	3.3	
T2	7.4	7.4			26.7	66.7	3.3	3.3	
T3	77.8	77.8			20.0	73.4	3.3	3.3	
T4	85.2	88.9			20.0	76.7			3.3
T5	77.8	92.6		3.3	6.7	63.3	23.4		3.3
T6	48.1	33.3			6.7	46.6	30.0	16.7	
T7	63.0	25.9			3.3	26.7	46.7	23.3	
T8	70.4	29.6			6.7	13.3	36.7	43.3	
T9	70.4	25.9			13.3	10.0	40.0	36.7	
T10	85.2	37.0		6.7	3.3	23.3	43.4	23.3	
T11	85.2	55.6		6.7	13.3	26.7	40.0	13.3	
T12	66.7	66.7	6.7	3.3	10.0	46.6	26.7	6.7	
L1	77.8	81.5	6.7	10.0	16.6	40.0	20.0	6.7	
L2	55.6	63.0		23.3	30.0	30.0	16.7		
L3	55.6	59.3		16.7	30.0	36.7	13.3	3.3	
L4	29.6	25.9			23.3	70.0	6.7		
L5	7.4	7.4			10.0	86.7	3.3		

*The proportion of the enstrume were given as percentage. ** Data were summarized as row percentage. T: Thoracic, L: Lumbar

Table 4. Correlations between patients' main thoracic Cobb angles and T1-T12, L1-L5 pedicle length, axial pedicle angle, pedicle width and chord length values*

	PL (mm)		APA (°)		PW (mm)		CL (mm)	
Cobb°	Left	Right	Left	Right	Left	Right	Left	Right
T1	-0.219	**-0.369***	**0.365***	0.339	-0.242	0.148	-0.256	-0.308
T2	-0.203	-0.042	0.228	0.230	0.130	0.187	-0.164	-0.119
T3	-0.329	-0.203	-0.039	0.131	0.206	-0.207	-0.303	0.131
T4	-0.356	-0.273	0.161	-0.015	0.119	-0.242	**-0.478***	-0.248
T5	**-0.485***	-0.226	-0.163	-0.121	0.154	-0.289	-0.331	-0.087
T6	**-0.371***	-0.030	-0.181	-0.114	-0.073	-0.114	**-0.458***	-0.188
T7	**-0.506****	-0.082	-0.308	-0.152	0.085	0.090	**-0.401***	-0.152
T8	-0.151	-0.045	-0.052	**-0.453***	-0.191	-0.098	-0.074	-0.172
T9	-0.248	-0.242	0.027	**-0.499***	0.003	-0.012	-0.324	-0.112
T10	0.034	0.016	-0.277	-0.273	-0.107	-0.003	-0.206	-0.220
T11	-0.125	-0.164	-0.124	-0.238	0.118	0.059	-0.272	-0.238
T12	-0.110	-0.076	0.211	-0.226	0.250	0.165	-0.101	-0.103
L1	-0.036	0.015	0.150	-0.259	0.214	0.263	-0.042	0.035
L2	-0.284	-0.079	-0.184	-0.199	0.348	0.157	-0.134	0.026
L3	**-0.508****	-0.201	-0.202	-0.110	0.213	0.156	-0.320	-0.045
L4	-0.049	0.147	-0.214	-0.296	0.304	**0.463***	0.014	0.169
L5	0.014	0.030	-0.262	-0.320	0.200	0.047	-0.141	-0.083

The Pearson correlation coefficients written in bold font are statistically significant ($p<0.05$).
Interpreting the size of the correlation coefficients (Mukaka, 2012):
0.00-0.29: Negligible
*: 0.30-0.49: Low correlation
**: 0.50-0.69: Moderate correlation
***: 0.70-0.89: High correlation
****: 0.90-1.00: Very high correlation
T: Thoracic, L: Lumbar, PL: Pedicle length, APA: Axial pedicle angle, PW: Pedicle width, CL: Chord length

of the 56 patients included in the study were females, which supported the results found herein.

In the AIS classification defined by the Lenke classification from types 1 to 6 was defined according to curvature and combined with lumbar modifiers (A, B, C) and sagittal thoracic modifiers (–, N, +)[27]. In the classification made by Farshad et al.[28] on 100 AIS patients, Lenke type 1 AIS was detected with the highest incidence, the most common type A was lumbar modifiers, and the most common type of normocyphosis (N) was determined as thoracic modifiers in the same patients. Similarly, in the current study evaluating 30 AIS patients, Lenke type 1, type A lumbar modifier and type N sagittal thoracic modifier patients were seen most frequently. Since the most frequently detected type 1 curvature was also the main thoracic type, the apex location was determined most frequently in the thoracic region in correlation with this.

EPW is an important factor determining the pedicle screw diameter. Larger diameter screws provide better tensile strength, increasing the stability of the structure[29]. The pedicle screw should be placed within the lateral and medial cortex. In a study conducted on Lenke type 1 AIS patients, it was reported that the EPW on the concave side of the thoracic spine was significantly smaller than on the convex side[6]. Parent et al.[30] examined the pedicle morphology on 325 scoliotic vertebrae, and similarly, the concave side of the thoracic curvature was narrower than the convex side, and they observed the greatest difference was in the T8 vertebra. In this study, the EPW was narrower on the left side with concavity in the thoracic region than on the right side with convexity, which supported the literature results. It was seen that the concave pedicles were narrower, especially in T6-9 vertebrae, where the apex of the thoracic deformity is located. Wang et al.[31] found that the mean distance from the spinal cord to the medial wall of the pedicle on the concave side was significantly less on the main thoracic curves than on the convex side of the apex. Thus, medial penetration of the deformity apex concave side pedicle screw may potentially increase the possible neurological complications.

Another parameter that should be considered when placing a pedicle screw is the APA. In the study conducted by Upendra et al.[12], the APA was higher on the concave side than on the convex side at all levels. Similarly, Hu et al.[6] showed that the APA was higher on the concave side when compared to the convex side, especially in the apical region, and they attributed this to the intervertebral deformation developed as a result of scoliosis rotation. In another study, it was reported that the APA

Table 5. Correlations between patients' vertabral rotation values and T1-T12, L1-L5 axial pedicle angle, pedicle width, and between axial pedicle angle and pedicle width values*

	Vertebral rotation					
	APA (°)		PW (mm)		APA - PW	
	Left	Right	Left	Right	Left	Right
T1	-0.332	-0.184	-0.047	0.336	0.151	-0.149
T2	0.023	-0.160	-0.201	0.080	0.126	0.095
T3	-0.293	-0.154	0.286	**0.400***	-0.239	-0.159
T4	-0.001	**0.393***	0.018	**0.573****	-0.024	0.338
T5	0.328	0.050	0.122	**0.429***	0.138	0.140
T6	0.172	0.156	**0.436***	**0.452***	0.347	0.036
T7	0.143	-0.121	**0.391***	**0.459***	0.287	-0.142
T8	0.229	-0.154	-0.019	0.355	0.058	-0.228
T9	-0.084	-0.270	0.190	**0.372***	0.056	-0.151
T10	-0.306	0.113	-0.268	0.130	0.109	-0.122
T11	-0.062	-0.127	-0.041	0.016	-0.302	-0.027
T12	-0.277	-0.176	-0.091	-0.033	0.110	0.226
L1	0.107	-0.031	0.145	-0.053	0.073	-0.108
L2	0.058	**0.417***	0.034	-0.067	-0.291	0.213
L3	-0.231	-0.150	-0.115	-0.311	**-0.577****	-0.286
L4	0.182	0.037	-0.229	-0.350	0.048	-0.196
L5	0.231	0.231	0.221	-0.074	-0.308	-0.301

The Pearson or Spearman correlation coefficients written in bold font are statistically significant ($p<0.05$).
Interpreting the size of the correlation coefficients (Mukaka, 2012):
0.00-0.29: Negligible
*: 0.30-0.49: Low correlation
**: 0.50-0.69: Moderate correlation
***: 0.70-0.89: High correlation
****: 0.90-1.00: Very high correlation
T: Thoracic, L: Lumbar, APA: Axial pedicle angle, PW: Pedicle width, Rotation: +/- 0-25%-50-75%-100%: [-4, +4]

in the convex pedicle was higher than in the concave side[11]. In the present study, however, no significant difference was found between the concave and convex sides. It was observed that the APA increased in the upper thoracic and lower lumbar vertebrae, with T1 being the highest.

One of the parameters that plays a role in deciding the length of the pedicle screw is the CL. In previous studies, it was recommended to place a pedicle screw with a length of at least 80% of the CL for a strong and stable fixation[32,33]. Hu et al.[6] showed that the CL in the apical region was slightly longer on the concave side compared to the convex side. Similar results were reported in another study on the scoliotic spine[34]. In this study, similar to the literature, a longer CL was measured on the left side, which is the concave side, especially in the apical regions, between T6 and T9.

The Nash-Moe index is a method used to clinically determine vertebral rotation, and it is a classification in which the apical vertebral body is divided into 6 equal parts longitudinally and the degree of rotation of the pedicles is decided according to their relationship with these lines[20]. In the study conducted by Mohanty et al.[35], higher Cobb angle values were measured at higher vertebral rotations compared to the Nash-Moe index. In a recent study, it was observed that the apical vertebral rotation was high, especially at the level of T6 to T9, where the Cobb angle was high.

It was aimed to clarify the relationship between the Cobb angle and pedicle morphology in AIS. In the study conducted by Davis et al.[5], adolescents with and without AIS were evaluated, and no significant relationship was found between the Cobb angle and pedicle morphology in either group. Liljenqvist et al.[11] also reported that there was no correlation between the Cobb angle and pedicle morphology. In the current study, the main thoracic Cobb angles of the patients were compared with the EPW, APA, PL, and CL, and no high correlation was observed at any level. On the other hand, in the current study, the APA and EPW were also evaluated in correlations with each other and with vertebral rotation. Again, no high or significant correlation was found at any level. It is a known fact that environmental and genetic factors are involved in the development and progression of deformity in AIS. Therefore, genetic, biomechanical, hormonal, and neurological factors that cause the AIS etiology of the patients may cause the components of the deformity to cause specific patterns for each patient. AIS can be a disease accompanied by developmental components.

Study Limitations

There are some limitations of this study. First, since the base points when measuring the parameters may vary, this may affect the measurement outcomes. Second, since the Nash-Moe index, which was chosen to evaluate the vertebral rotation, determines the degree of rotation in 25% of slices, it is very difficult to obtain the exact value. Finally, although the number of patients included in the study seemed relatively sufficient, studies with a larger number of patients will yield more precise results.

CONCLUSION

The pedicle morphology must be well defined for proper implantation of pedicle screws during surgical treatment of AIS. It was determined that the EPW was shorter and the CL was longer on the concave side of the vertebrae, especially in the apical region of the AIS deformity. Therefore, the special anatomical structure of this region should be taken into account in order to avoid possible neurological complications, especially in pedicle screw implantation in the apical concave region.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Review Board of Ankara City Hospital (approval date: 09/22/2021, approval no: E1-21-2026).

Informed Consent: Informed consent was obtained from all patients to confirm their participation in the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.A.E.A., Concept: M.A.E.A., Design: M.A.E.A., C.Ç., Data Collection or Processing: C.Ç., M.B., Analysis or Interpretation: P.D., Literature Search: C.Ç., M.B., Writing: M.A.E.A., C.Ç.

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

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DOES PREOPERATIVE NEUTROPHIL TO LYMPHOCYTE RATIO AFFECT PREOPERATIVE AND POSTOPERATIVE VAS LEVELS IN PATIENTS UNDERGOING CERVICAL DISC SURGERY?

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ABSTRACT

Objective: Neutrophil/lymphocyte ratio (NLR) is currently used as a marker for the diagnosis, follow-up and treatment of many diseases. It has been shown immunohistochemically that interleukins and cytokines are released in the disc herniation region. Our aim was to compare visual analog scale (VAS) and NLR values in the patients who have a cervical disc herniation, whom we frequently encounter and operate in neurosurgery practice.

Materials and Methods: This study was conducted retrospectively by scanning the files of 24 cervical disc herniation patients that we operated approximately 2018-2020. Magnetic resonance imaging was used for the diagnosis. Patients with a single level cervical disc herniation requiring surgical intervention according to the clinical and radiological findings at the level of C4-5/C5-6/C6-7 were included in the study. Preoperative and postoperative 6th month VAS values were recorded. The neutrophil and lymphocyte ratios were calculated and recorded by taking routine preoperative morning blood samples before surgery. The relationship between VAS and NLR values was examined.

Results: Preoperative neutrophil values ranged from 1.77 to 9.35, with a mean of 4.97±1.81. Preoperative lymphocyte values ranged from 1.06 to 4.86, with a mean of 2.54±0.88. NLR values ranged from 0.53 to 4.31, with a mean of 2.12±0.92. A statistically significant decrease in the VAS values was found in the postoperative 6th month compared to the preoperative values ($p=0.000$; $p<0.05$). There was a positive (47.7%) and statistically significant correlation between the NLR and preoperative VAS values ($p=0.018$; $p<0.05$).

Conclusion: The relationship between the NLR and VAS scores in the spinal surgery cases has been evaluated in many series. In our study, we found a positive and significant relationship between the preoperative VAS score and the NLR values, which is consistent with the literature.

Keywords: Neutrophil to lymphocyte ratio, cervical disc herniation, biomarker

INTRODUCTION

Cervical disc herniation (CDH) is one of the most common causes of neck and/or arm pain in the community. Axial neck pain, pain spreading to the arms depending on the side of the hernia, paresthesia, and loss of motor power can be detected in the upper extremity muscle groups. Neutrophil/lymphocyte ratio (NLR) is been used for the diagnosis of systemic inflammatory diseases. It is an inexpensive and easy-to-access examination as it is been evaluated by hemogram analysis. It is a very easy process to see the neutrophil and lymphocyte amounts and calculate the NLR with routine hemogram tests. NLR increases in some diseases such as fibromyalgia, autoimmune diseases, malignancies, infections, metabolic syndrome, renal and cardiovascular diseases. It also can be higher in those with chronic obstructive pulmonary disease, preeclampsia, eclampsia and major depression compared to the healthy population.

When we look at the literature, there have been articles about whether spinal diseases are associated with systemic inflammatory markers recently. Similar to our study, preoperative high NLR values were found in patients with surgically treated lumbar disc herniation and CDH, and the relationship between them was found to be statistically significant[1,2].

In this study, our aim is to compare visual analog scale (VAS) and NLR values in the patients who have a CDH, whom we frequently encounter and operate in neurosurgery practice.

MATERIALS AND METHODS

This study was conducted retrospectively by scanning the files of CDH patients that we operated between 2018-2020. Magnetic resonance imaging (MRI) was used for the diagnosis. Patients with a single level CDH requiring surgical intervention according to the clinical and radiological findings at the level of C4-5/C5-6/C6-7 were included in the study.

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The other causes that can increase the rate of NLR even if they have a single level CDH were excluded from the study; cancer, renal and cardiovascular disease, hypertension and diabetes, major depression, rheumatoid arthritis.

Data such as age, gender, routine neurological examination findings, level of herniation, preoperative and postoperative 6th month VAS values were recorded. The neutrophil and lymphocyte ratios were calculated and recorded by taking routine preoperative morning blood samples before surgery. The relationship between VAS values and NLR values was examined.

Ethical approval for the study was obtained from the University of Health Sciences Turkey, İstanbul Haydarpaşa Numune Training and Research Hospital Ethics Committee (reference number: E-62977267-903.99)

Statistical Analysis

Statistical analysis was performed using Microsoft Excell and the SPSS 22.0 statistical package software. Results were compared with Kolmogorov-Smirnov and Wilcoxon tests. Correlation coefficients were calculated using Spearman's analysis and were accepted as 0.05. P<0.05 was considered statistically significant.

RESULTS

The study was conducted with 24 patients aged between 30-66. Sixteen (66.7%) of the patients were male and 8 (33.3%) of them were female. The mean age of the patients is 41.38±8.98.

Preoperative neutrophil values ranged from 1.77 to 9.35, with a mean of 4.97±1.81. Preoperative lymphocyte values ranged from 1.06 to 4.86, with a mean of 2.54±0.88. NLR values ranged from 0.53 to 4.31, with a mean of 2.12±0.92. The number of patients with disc herniation according to the level is shown in Table 1. A statistically significant decrease of the VAS values was found in the postoperative 6th month compared to the preoperative values (p=0.000; p<0.05) (Table 2). There was a positive (47.7%) and statistically significant correlation between the NLR and preoperative VAS values (p=0.018; p<0.05) (Table 3 and Figure 1).

DISCUSSION

Nerve root pain caused by disc herniation is attributed to both chemical and mechanical factors[3-5]. As a chemical effect, it has been shown to induce an inflammatory-like reaction experimentally in the nerve root after the rupture of the nucleus pulposus (annulus fibrosus) which is located inside the disc [6]. It has been shown immunohistochemically that interleukins and cytokines such as pro-inflammatory tumor necrosis factor-a are released in the disc herniation region[7]. These cytokines increase the release of the chemokines from the degenerated disc, and increase the infiltration and activation of T and B cells, macrophages and mast cells[8].

Table 1. Distribution of operating parameters

	Min.-Max.	Average ± SD
NEU	1.77-9.35	4.97±1.81
LYM	1.06-4.86	2.54±0.88
NLR (Preop)	0.53-4.31	2.12±0.92
	n	**%**
Level		
C4-5	1	4.2
C5-6	8	33.3
C6-7	14	58.3
C7-T1	1	4.2

NEU: Neutrophil, LYM: Lymphocyte, NLR: Neutrophil/lymphocyte ratio, SD: Standard deviation, Min.: Minimum, Max: Maximum

Table 2. Evaluation of postoperative 6th month VAS change according to preoperative

VAS	Min.-Max.	Average ± SD
Preop	3-10	5.92±2.24 (5)
Postop 6.m	0-3	0.96±0.95 (1)
p		0.000*

Wilcoxon sign test *p<0.05
VAS: Visual analog scale, SD: Standard deviation, Min.: Minimum, Max: Maximum

Table 3. Evaluation of the correlation between NLR and preoperative and postoperative 6th month VAS levels

VAS		NLR
Preop	**r**	0.477
	p	0.018*
Postop 6.m	**r**	0.288
	p	0.172

Pearson correlation analysis *p<0.05
NLR: Neutrophil/lymphocyte ratio, VAS: Visual analog scale

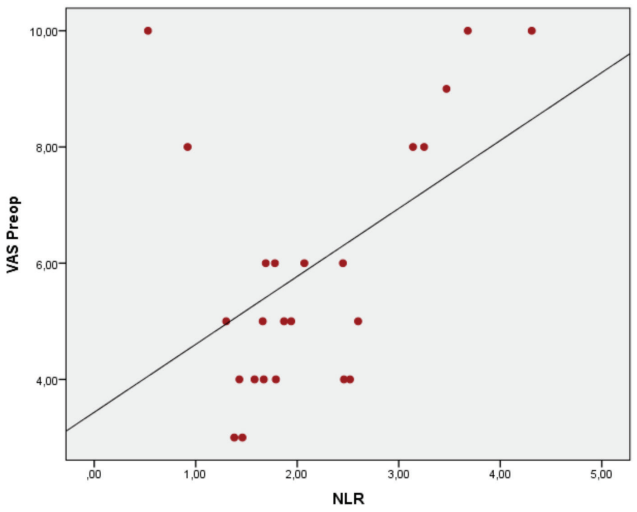

Figure 1. Positive correlation between NLR and preop VAS values
NLR: Neutrophil/lymphocyte ratio, VAS: Visual analog scale

IL-21 plays an important role in the persistence and differentiation of both T and B cells[9]. Xue et al.[10] compared the serum IL-21 and serum IL-17 levels in the healthy control group and patients with lumbar disc herniation (LDH) and showed that they were significantly higher in LDH patients. VAS scores were positively correlated with serum IL-21 levels, and inflammation was responsible for the LDH-related pain[10]. In another study, a relationship was reported between high-sensitivity C-reactive protein (CRP) levels and severe pain[11].

A few studies in the literature have examined the relationship between CDH and serum inflammatory markers. Yılmaz et al.[12] reported 394 patients with lumbar disc hernia and low back pain that shows the NLR was an independent predictor in the patients, recently. On the contrary, Dagistan et al.[13] found no significant difference between serum NLR levels of the LDH patients and the healthy controls.

Another study showed that preoperative and postoperative pain was more severe among the patients with lumbar disc hernia and a higher NLR level, as an indicator of inflammation. The NLR is the ratio of cells that mediate two distinct immune pathways. The initial line of immunological defense is comprised of neutrophils, which secrete a variety of inflammatory mediators, mainly cytokines, which cause phagocytic and apoptotic effects. Due to cell dysfunction and oxidative stress, inflammation brought on by cytokines might bring on further inflammation. While lymphocytes provide a regulatory or protective function, they are particular inflammatory mediators. A low lymphocyte count indicates poor overall health and physiological stress. A few research have looked at the connection between CDH and serum inflammatory markers in the literature. NLR was recently found to be an independent predictor in patients with disc hernia and discomfort by Yılmaz et al.[12].

Similarly, a study showed that patients with extruded disc hernia had significantly higher mean serum hs-CRP levels than patients with bulging disc hernia and significantly higher mean serum IL-21 levels than patients with protruded disc hernia, which the authors speculated may be caused by inflammation near the nerve roots[14].

In short, an inflammatory-like reaction occurs and many interleukins and cytokines are released due to disc herniation. It is possible to detect these parameters with routine blood tests. These values and ratios change can guide in the disease in diagnosis and treatment. Studies have shown that the change of the NLR is significant. According to the literature, we found that similar studies on the spinal degenerative diseases were reported for the patients with lumbar disc herniation. We wanted to examine what kind of change occurred in the patients who were operated for CDH. Although the number of our patients was not enough due to the pandemic process, we obtained statistically significant results. With the VAS scores increasing, the NLR value is also increased.

Study Limitations

The limitation of our study was the small number of patients and the organization of our study was retrospective. Because of that, in the new future prospective multicenter studies with larger patient groups should be planned.

CONCLUSION

NLR is currently used as a marker for the diagnosis, follow-up and treatment of many diseases. The relationship between the NLR and VAS score in the spinal surgery cases has been evaluated in many series. In our study, we found a positive and significant relationship between the preoperative VAS score and the NLR values, which is consistent with the literature. When we associate normal NLR values with the normal cervical MRI imaging, we think that this may help us in the follow-up and treatment of the patients in the clinic.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from the University of Health Sciences Turkey, İstanbul Haydarpaşa Numune Training and Research Hospital Ethics Committee (reference number: E-62977267-903.99).
Informed Consent: Retrospective study.
Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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THE EFFECTS OF SURGEON-MADE PREOPERATIVE THREE-DIMENSIONAL MULTIPLANAR REFORMATTING ON SURGEON'S ANXIETY IN SPINAL SURGERY

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ABSTRACT

Objective: Spine surgery harbors high risks because of its complexity. This causes serious cognitive anxiety and distress during the perioperative period. We investigated the effectiveness of a surgical preoperative planning method in reducing the cognitive anxiety of the surgeon.

Materials and Methods: A training was given the study participants to create 3D MultiPlanar Reformat (MPR) images from raw DICOM files with a software. This training is named '3D MPR done by the surgeon himself/herself training (3DMPRT).' At the 6th month after the training and clinical practice, a survey was carried. The benefits of training and the cognitive anxiety status of the consultant surgeons were evaluated.

Results: Seven male spinal surgeons participated in this study. In the survey, all participants reported that they did not have the opportunity to assess preoperative spinal anatomy with radiologists and that they did not require consultation after 3DMPRT, suggesting that 3DMPRT reduced their mental distress and cognitive anxiety. After 3DMPRT, surgeons reported a change in screw insertion habits for anatomically risky pedicles during surgery.

Conclusion: 3DMPRT has a positive effect on reducing the cognitive anxiety of the surgeon and can be an alternative to costly technological devices.

Keywords: Stress, anxiety, mental distress

INTRODUCTION

Spine surgery is a risky specialty because of its complex anatomy and proximity to neurologic and vascular structures. Incorrectly positioned pedicle screws can have significant clinical implications ranging from nerve root irritation, inadequate fixation, leakage of cerebrospinal fluid, perforation of the great vessels, and damage to the spinal cord[1]. Surgical safety can be enhanced by careful preoperative surgical planning, intraoperative computer-assisted navigation, robotic surgery, and three-dimensional printed models to ensure that the implants to be placed do not damage these delicate tissues and provide high bone anchorage[1-3]. Any solution that improves the accuracy of pedicle screw placement and reduces the risk of missing pedicle cannulation will increase surgeon comfort, thereby reducing complications and improving patient outcomes. Unfortunately, it is not possible to access the above systems in every spine surgery clinic around the world. In addition, there is limited evidence to date regarding the cost-effectiveness of these systems compared to traditional pedicle screw applications[1].

The complexity and complications cause significant anxiety for the surgeon in the perioperative period[4,5]. Anxiety can be constructive (an increase in motivation, attention, and motor skills) or destructive[6-8]. Stress management is very important in this respect. One of the most helpful methods in increasing the surgeon's performance and reducing his stress is to be prepared for the surgery and to foresee what may happen during the surgery. At this point, the most ideal methods in terms of reliability in surgical planning in spine surgery today are the use of intraoperative neuromonitoring, intraoperative navigation imaging, and robotic surgery systems (INRSS) [9,10]. These radiologic aid methods are still limited, especially in centers where spinal surgery is routinely performed in developing countries, as their cost is high and their superiority over traditional pedicle screwing techniques is controversial[1]. Cognitive anxiety is thought to have a negative linear relationship with performance and a positive linear relationship with self-confidence[11]. While many publications in the literature discuss the effects of INRSS "on the patient", there is no study that focuses on the cognitive anxiety of the surgeon[1,2]. In our study, we aimed to investigate the efficacy

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of surgical planning with preoperative 3D multiplanar reformation (MPR) in reducing cognitive anxiety, which negatively affects surgeon's surgical performance, and to increase self-confidence and performance.

MATERIALS AND METHODS

Study participants were trained to create 3D MPR (multiplanar reformation, maximum intensity projection, volume rendering, and segmentation) using an imaging program [RadiAnt DICOM Viewer (software). version 2021.1. Jun 27, 2021] using raw axial computed tomography (CT) slices of the entire vertebral column obtained in DICOM format from patients scheduled for spinal deformity surgery. The duration of the training was approximately 1.5 hours. Since the participants were spine surgeons, they already knew how to open DICOM files in appropriate programs. Using the axial images in the existing DICOM file for each vertebral level to be instrumented, surgeons were asked to create reformat images as sagittal, coronal, and axial planes, as well as 3D volume renderings of the entire spine with and without costae[12]. On the axial reformat images obtained, surgeons were asked to measure the pedicle diameter, the intended length of the pedicle screw, and the intended trajectory of the screw and its angle according to the line drawn perpendicular to the posterior corpus line, according to the simple (SF) pedicle screw method[13]. Sagittal and coronal images were arranged as pedicle-wide MIP and axial images as single-voxel MPR in three columns. Hands-on practice was performed using case studies. By having each surgeon perform a 3D MPR from the DICOM file for each vertebral level prior to surgery (this concept is referred to as '3D-MPR performed by the surgeon himself (*3DMPRT*)'), screenshots of these edits are requested to be inserted into a slide presentation using Microsoft PowerPoint® software, in which the relevant spinal segment to be instrumented is identified (Figure 1 and 2), (Appendix). The prepared presentation was reviewed preoperatively by the surgical team

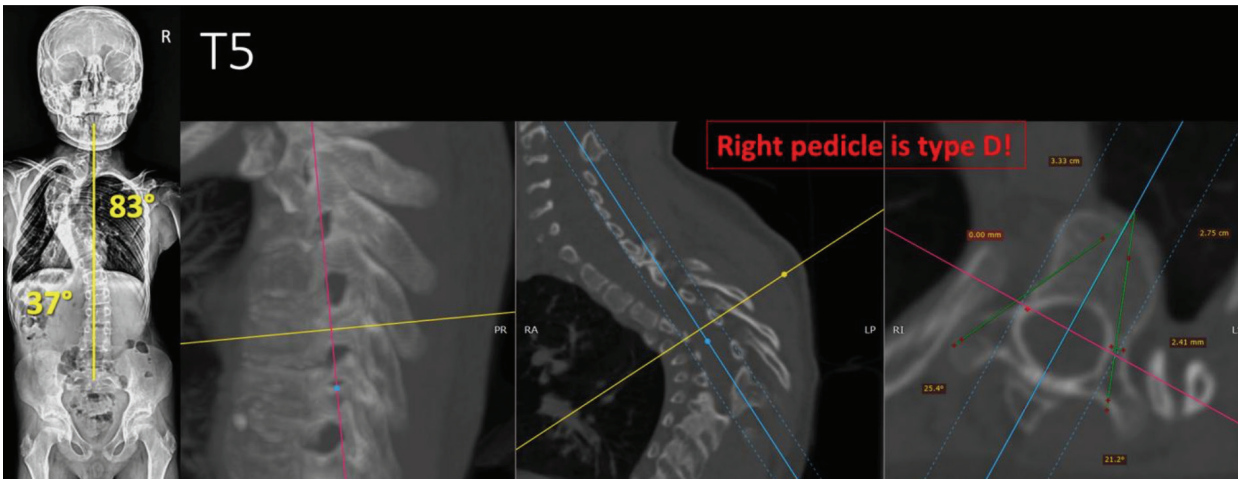

Figure 1. A typical presentation slide for the T6 thoracic vertebral level was made by the surgeon himself. Note that all lines for the orientation of the targeted pedicle screw are positioned along that axis. The right pedicle of the T5 vertebral level was omitted for instrumentation because it was too hypoplastic

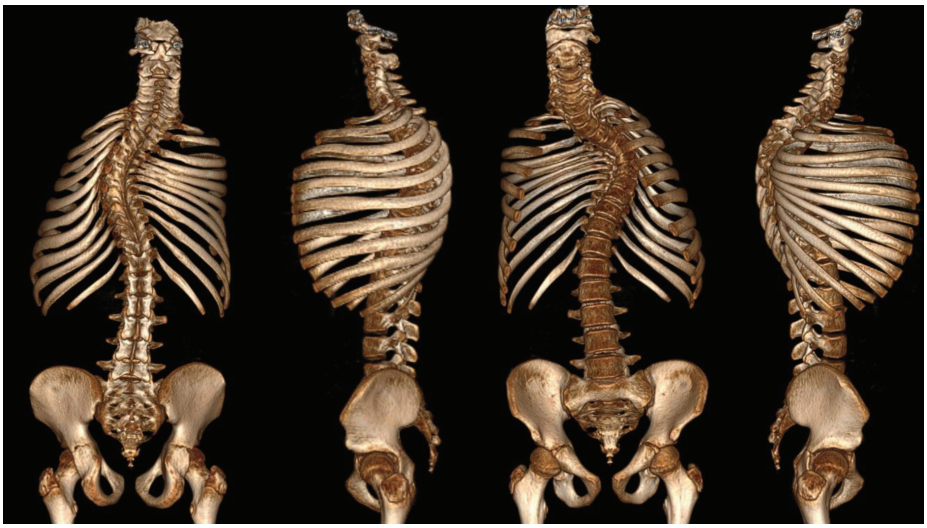

Figure 2. Three-dimensional image of the spine created by the surgeon with 3D volume rendering using axial tomography slices

and kept on the computer screen in the operating room (OR) for intraoperative guidance. Prior to instrumentation of each level, the corresponding slide presentation was inspected by the surgeons, and the screw trajectory was estimated on the case in the appropriate spatial orientation and confirmed with a C-arm scope using a marker if necessary. Screw placement was then completed under intraoperative neuromonitoring and verified with the C-arm.

At month 6 after training and clinical applications with at least 15 AIS cases, a web-based survey with thirty-two questions was conducted via Google forms sent to participants (Table 1). In addition to demographic data, the survey asked questions about the benefits of training before and after, as well as participants' levels of cognitive anxiety and psychological distress. The survey contained 18 statements on a Likert scale to which the participant responded 1 (strongly disagree) to 5 (strongly agree) depending on the statement (Table 2). Likert-type questions include a statement containing an attitude or opinion about the topic under study and options indicating the level of agreement with that statement. Surgeons' self-assessment of their level of satisfaction with 3DMPRT was rated on an analogous scale between the numbers 0 (not satisfied) and 10 (fully satisfied). Informed consent was obtained from each participant before they were asked the survey questions. All seven specialists agreed to participate in the study.

Statistical Analysis

Microsoft Excel and SPSS® Statistics v.24.0 were used for statistical analysis. For descriptive variables, analyzes of number, percentage, mean, and standard deviation were performed. Data were analyzed using non-parametric tests. Paired samples test was used for comparison of pre-and post-training results, and Mann-Whitney U test was used for descriptive characteristics and scale comparisons. A p-value of <0.05 was considered significant in all analyzes. The reliability coefficient of the Cronbach's alpha test was calculated. A Pearson correlation coefficient was calculated by sending the same questionnaire again to participants 3 weeks after the first questionnaire using the test-retest method.

Ethical Consideration

Ethical approval from the University of Health Sciences Turkey, Başakşehir Çam and Sakura City Hospital National Research Ethics Committee was obtained for the research in question (approval no.: 2022-03/94, date: 30.03.2022).

Table 1. Sections and topics of the survey

Section	Question number	Topics
Demographics	1-12	Age, sex, training, experience
3DMPRT	13-31	Likert Type scale survey
Surgeon satisfaction scale	32	Analog scale from 1 to 10

RESULTS

Demographic Features

The sample consisted of seven spine surgeons who voluntarily participated in the study and answered all questions. The average experience of the participants in spine surgery was 10 (2-26) years. Five of the surgeons were spine surgeons from orthopedics and traumatology and two of them were from neurosurgery. All participants were male. The average age of the participants was 43 (31-56) years. The average duration of specialization was 12 (2-26) years. All participants performed spine surgery in their routine practice, and the average number of spine surgery cases per month was 11 (4-30). Five (71%) of the surgeons who participated in the study had a history of spine surgery fellowship training. Three (43%) of the participants had previously worked in a center that routinely used one of the INRSS. None of the participants were actively working in a center that routinely used INRSS. Six of the participants (86%) responded that these systems could not be provided because of financial barriers, and one surgeon (14%) cited the reason for not using INRSS in the centers where he currently worked as not needing these systems.

The same questionnaire was returned to participants in the third week (test-retest method). No statistically significant difference was found between the mean of the first and the retest questionnaire and the participants' comparisons (p>0.05) (Table 3). No statistically significant difference was found when comparing participants' scale scores and subspecialization before and after training (p>0.05) (Table 4). The questionnaire was repeated 3 weeks later, and internal consistency analysis was performed. The Cronbach's alpha coefficient for the first survey was 0.688 and the Cronbach's alpha coefficient for the survey repeated at the third week was 0.744.

Participants indicated their professional satisfaction after 3DMPRT on a scale of 0 to 10 (ten being the most satisfactory number) on a "Surgeon Satisfaction Analog Score Table", was approximately 9.42/10 (minimum 7-maximum 10).

DISCUSSION

All participants in our study agreed that this 3DMPRT method could be an alternative if INRSS were not available and recommended 3DMPRT to other spine surgeon colleagues. The consulting surgeons also agreed that 3DMPRT should be included in routine spine surgery training in both orthopedics and neurosurgery.

Providing radiological images in the OR is routine for spine surgeons. The presentation prepared in this study shows the screw trajectory in the axial/sagittal and coronal planes with a calculated and prepared PowerPoint presentation for each vertebral level, just like the screws placed with an intraoperative

Table 2. The survey questions created according to the Likert-type scaling system are given in the table. The answers given by the participants to the questions were presented numerically

Questions	Strongly disagree	Disagree	No idea	Agree	Completely agree
1. I think that the use of INRSS can reduce the mental distress and cognitive anxiety that may occur in the surgical team who will perform the surgery.				4	3
2. BEFORE 3DMPRT, I did not have the opportunity to personally evaluate each patient's bony anatomy with radiologists a tomography was requested.				3	4
3. AFTER 3DMPRT, I no longer need a face-to-face evaluation with radiologists for every patient I have had a tomographic examination for bony anatomy evaluation.				2	5
4. Before 3DMPRT, I did not know how to make 3D MPR [including axial, sagittal, and coronal multiplanar reforming (MPR), maximum intensity projection (MIP), 3D volume rendering] with a Dicom file with only axial CT images.		1		3	3
5. After 3DMPRT, I learned to make 3D MPR in preoperative surgical planning by myself and it helped me to understand the bony anatomy more in detail.		1			6
6. BEFORE 3DMPRT, I believed that performing 3D MPR in preoperative surgical planning had a positive effect on postoperative patient outcomes.		1	1	3	2
7. I believe that AFTER 3DMPRT, performing 3D MPR in preoperative surgical planning has a positive effect on postoperative patient outcomes.				3	4
8. In a case where I would apply pedicle screws with equal caution to all levels before 3DMPRT, I started to consider strategic screw placement (skipping levels or choosing a smaller diameter screw, etc.) after the training by detecting the vertebrae with hypoplastic pedicles where screw application might be risky.				1	6
9. I think that preoperative planning with 3D MPR, made by the surgeon "himself", is more beneficial in terms of mastering the fine details of the bony anatomy than it is done by OTHERS.				1	6
10. I recommend 3DMPRT to my colleagues.					7
11. 3DMPRT increased my self-confidence by reducing my anxiety and mental distress during the procedures.				2	5
12. After 3DMPRT, in cases without preoperative MPR planning slides done, my anxiety and mental distress were higher (feeling insecure) compared to the cases who had the planning slides ready for the case.				4	3
13. After 3DMPRT, I feel less anxiety and mental distress, and more self-confidence in spinal deformity cases with preoperative MPR made ready on slides.				3	4
14. After 3DMPRT; In a case in which 3D MPR was prepared, "BEFORE the surgery", I think that as the surgeon who will perform the surgery, it reduces my anxiety and mental distress levels.				3	4
15. After 3DMPRT, I think that as the surgeon who will perform the surgery in a case in which 3D MPR was studied, my anxiety and mental distress levels are reduced "DURING the surgery".				2	5
16. In the patient evaluation, 3DMPRT should be included in the routine residency and spine surgery fellowship training in Orthopedics and Neurosurgery.				2	5
17. I think that 3D MPR method can be an alternative when INRSS are not available.				2	5
18. I think that 3D MPR is more cost-effective than INRSS.				1	6

INRSS: Intraoperative navigation imaging or robotic surgery systems, 3DMPRT: 3D MPR done by the surgeon himself/herself training

Table 3. First survey and re-test scale mean scores and comparisons

	n	Mean + SD	Z	*p
First survey	7	82.85±3.58	-1,687	0.092
Re-test	7	79.42±4.23		

*Paired Sample t-test
SD: Standard deviation

Table 4. Comparisons of first questionnaire and re-test scale scores with the sub-specialties

	Department	N	Mean + SD	U	*p
First survey	Orthopaedics	5	84.2±3.34	1.5	0.167
	Neurosurgery	2	79.5±0.71		
Re-test	Orthopaedics	5	79.4±4.1	4	0.696
	Neurosurgery	2	79.5±6.36		

*Mann-Whitney U test
SD: Standard deviation

navigation system such as the simultaneous O-arm™ and StealthStation™[14].

When stress and anxiety take over in situations where a high-risk task is being performed, for example, performing a surgery, it is called "performance anxiety" (PA)[15]. All the participants agreed that the currently used INRSS would reduce the mental distress and cognitive anxiety of the surgeon performing the surgery. While many publications in the literature discuss the effects of INRSS "on the patient", there is no study focusing on the surgeon's cognitive anxiety. For this reason, the method from the perspective of the surgeon, which we proposed in our study, is the first in the literature.

Occupational hazards can put physicians at risk for burnout, anxiety, depression, stress, psychologically induced sleep problems, and other types of mental health issues[16]. All participants stated that 3DMPRT increased their confidence and decreased their anxiety during surgery. According to Lang's tree-part model of anxiety responding, there are three response domains: Cognitive, behavioral, and physiological[17]. Behavioral and physiological responses can be measured with objective data such as changes in blood pressure, heart rate, skin conductance, unconscious reflexes or reactions[18]. The cognitive component of anxiety, which affects judgment and decision making, can be represented in terms of self-reports in the absence of obvious physiological and behavioral responses. Self-reports of anxiety have the potential to bias research toward overt cognitive mechanisms of anxiety[19]. However, even without physical symptoms (increased heart rate, tremors, etc.), there may be changes in the surgeon's psychological well-being, which may affect the surgical outcome[20]. While the literature on stress and anxiety in spine surgery patients is extensive, the literature on the effects of stress on the surgeon is limited[6,21-23].

Multi-detector row CT scanners can produce MPR images that allow non-axial two-dimensional images to be created with data from axial CT images[12]. Images with multiple planes can be thickened into slabs using projection techniques such as averaging, maximum and minimum intensity projection, ray summation, and volume rendering[12]. MPR images are coronal, sagittal, oblique, or curved plane images created from a plane only one voxel thick that intersects a series or "stack" of axial images. Maximum intensity projection (MIP) projects the voxel with the highest attenuation value in each view of the entire volume onto a 2D image. Before the training, only one of the seven participants knew how to create 3D MPR from raw CT images. They reported that 3DMPRT helped them understand the bony anatomy in detail. Hotton et al.[5] emphasized the importance of preoperative planning as a tool for surgical PA coping strategies. Surgeons in our study reported a reduction in surgical anxiety and psychological distress before and during surgery in 100% of cases (35% agreed, 65% fully agreed). This shows that preoperative planning with 3DMPRT can also be a useful tool. After 3DMPRT, all participants also indicated that they felt that 3DMPRT also had a positive impact on patients' postoperative outcomes. With these methods, the 3-dimensional spatial view of the bony structure of the spine can be evaluated in detail preoperatively and intraoperatively. By using this technology effectively, it can be a helpful method for the application of implants such as pedicle screws, which are used with high accuracy and reliability, especially in spinal deformity surgery. This method can be a practical alternative when expensive INRSS are not available.

Cheng et al.[24] showed that the rate of mismatched reads for abnormal CT scans was 16% and 37% were considered clinically significant. Face-to-face rounds can improve communication between radiologists and referring physicians. Its positive value is highlighted in studies as it can prevent errors and significantly impact patient safety[25,26]. All consultant surgeons in our study indicated that they did not have the opportunity to assess the bony morphology of the spine with the radiologists in every surgical candidate. This can be explained by the excessive workload in our clinical routines. After 3DMPRT, participants indicated that they no longer needed this consultation. This conclusion in our study should not be a substitute for valuable contact between radiologists and clinicians when available.

All participants indicated that they felt that 3D MPR performed by the surgeon "himself" was more beneficial in terms of mastering the fine details of bony anatomy than when performed by someone else. When the surgeon performs this assessment himself, in addition to the slides, he has more control over the dynamic three-dimensional "map" of the spine in his head without depending on the pre-set screenshots.

Participants indicated that although they attempted to place screws at each level prior to 3DMPRT, now that they can identify vertebrae with hypoplastic pedicles where screw placement could be dangerous, they tend to prefer strategic screw

placement (not placing screws or choosing a smaller diameter screw, etc.).

Currently, there are not enough studies reporting on the cost of spinal navigation to make an accurate statement about its cost-effectiveness in clinical practice[27]. However, all study participants agreed that 3D MPR was much more cost-effective than INRSS. In the first section of the query, six of the participants (86%) indicated that INRSS cannot be offered in their current centers due to financial barriers. This method does not require expensive equipment with high technical infrastructure. Instead, a radiological imaging program (in our case, free software) and a computer that can perform the reconstruction process from raw data from CT are sufficient.

Once participants learned of the existence of this method, they emphasized that their anxiety level could increase if they did not have this method ready on the wall of the OR. This could be interpreted as a poor outcome due to increased apprehension, but also as an indication of how effective this method actually is. The opposite was true for participants who reported having less anxiety and psychological distress and more confidence when they had slides available.

There was an optional open-ended question like, "Does this application have any weaknesses or aspects that need improvement? Give us your suggestions" to 3DMPRT at the end of the questionnaire. One recommendation from the respondents was that automatic surveying of this system using machine learning and neural networks would be beneficial in the future in terms of a time-saving strategy. The other was that while this method helps to prepare the surgeon for the case and alleviate his anxiety, it cannot replace INRSS systems alone and is a good alternative only when these systems are not available.

Study Limitations

One of the weaknesses of our study is the absence of questions called "yes bias", which are "interspersed between the main questions and encourage the participant to be more consistent" to prevent the participant from automatically giving one positive answer after another[15,19]. However, due to the small number of participants in our study and the fact that they had previously undergone a training process, it was assumed that their responses to the questions were consistent. There is no specific test or questionnaire that has been used as a validated assessment tool for intraoperative PA[15]. Based on this aspect, we created a questionnaire by adapting the Likert scaling system for the topic we studied, a valid method in the scientific literature, and we tested its reliability in a statistical manner. Although the small number of participants in the study seems to be a negative point, the fact that qualified medical professionals are subjected to such a survey after training is a positive aspect of the study. Each participating surgical specialist works in the most developed hospitals in the country in the area where the study was conducted.

Our objective was to evaluate the efficacy of a practical technique we developed in January 2021 in our current clinical practice using Likert scaling in surgeons. This study can be considered a pilot study approved by physicians who are experts in this field. We believe that this method, if taught to more surgeons around the world, will not replace expensive systems but will provide significant benefits.

CONCLUSION

3D MPR imaging, created by the surgeon himself in the preoperative process, can be a method that has a positive effect in the application of implants such as pedicle screws used in spine surgery, with high accuracy and reliability, and can reduce the degree of perioperative cognitive anxiety and psychological stress of the surgeon. This method may be an alternative in centers where the use of an expensive INRSS is not feasible. In our study, we found that surgical planning with 3DMPRT has a positive effect on reducing cognitive anxiety, which negatively affects surgeon performance, and increases confidence and performance.

Ethics

Ethics Committee Approval: The study approval was obtained from University of Health Sciences Turkey, Başakşehir Çam and Sakura City Hospital National Research Ethics Committee (approval no.: 2022-03/94, date: 30.03.2022).

Informed Consent: Informed consent was obtained from each participant before they were asked the survey questions.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

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

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

Appendix: A PowerPoint file example of a typical preop planning case as a digital .ppt file

Link: http://glns.co/1sda0

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ORIGINAL ARTICLE
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CHARACTERISTIC PATTERNS AND PUBLICATION RATES OF SPINE SPECIALTY THESES FROM POSTGRADUATE ORTHOPEDIC RESIDENCY (2001-2020) PROGRAMMES IN TURKEY

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ABSTRACT

Objective: Preparing specialization theses is mandatory for medical residents to complete their education. This study aimed to investigate the residency theses in the field of the spine and evaluate their publication rates in scientific journals.

Materials and Methods: A search of the Council of Higher Education Theses Center database was performed on May 3, 2021. Using a detailed search, the subject division was filtered as "orthopedics and traumatology," time limitation was set between 2001 and 2020. The Web of Science, PubMed, and Google scholar databases were searched to determine the publication status of theses. The index of journals that published theses were divided into three groups: SCI/SCI-E, ULAKBIM, and other peer-reviewed international indexes.

Results: One-hundred and ninety-two theses were included in this study. A total of 75 (39.1%) theses were published. Thirty-eight (19.8%) of theses were published in a journal with SCI/SCI-E index, 19 (9.8%) in the Ulakbim TR index, and 18 (9.4%) in the other peer-reviewed international indexes. Applied science methods had the highest rate of publications (60%). The topic of basic science had the highest rate of publication (52.6%).

Conclusion: The publication rates of spine specialty theses are apparently at an acceptable level compared to other studies. It was assessed that the topic of scoliosis was the most preferred subject and we suggest that original subjects who can contribute to the literature is important for the evolution of the spine. The basic research methods had higher publication rates than the clinical research methods.

Keywords: Orthopaedics, spine, publishing, theses

INTRODUCTION

Preparing a specialization theses and being successful in theses presentation are mandatory for medical residents to complete their specialization[1]. There are different processes around the world. However, the common issue that everyone agrees on is that a specialization theses is necessary for an academic career in medicine[2]. These preparation educates the medical students and residences for the skill of developing scientific methods and a scientific vision. The publication of the theses provides significant contributions to personal, academic career and science. Researchers have suggested that the real value of scientific work lies in its publication in indexed literature[3]. The publication makes research results visible and easily accessible to scientists anywhere in the world[4]. However publication of the theses is a very challenging process, and according to the studies, it is seen that the many specialty theses in medicine remain unpublished[5-8].

The discipline of orthopedic surgery has several subgroups including arthroplasty, trauma, sports medicine, oncology, spine, microsurgery. Koca et al.[9] analyzed the publication rate of all orthopaedic theses without subgrouping. No studies evaluating the publication status of the spine specialty theses published in our country on the scientific journals were found in the literature. The aim of this study was to investigate theses in the Council of Higher Education (YOK) Electronic Theses Archive, which have been made in the field of the spine and evaluate their publication status in scientific journals.

MATERIALS AND METHODS

Ethics Committee approval was not required since data used in our study were obtained retrospectively from the internet which is available for open access. A search of the Council of Higher Education Theses Center database (https://tez.yok.gov.tr/UlusalTezMerkezi/) was performed on May 3, 2021. Using detailed search, the subject division was filtered in "orthopedics

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and traumatology", time limitation was set between 2001 and 2020, and these study design was selected as "specialization in medicine". Theses were excluded if they were not performed at the department of orthopedics and traumatology. Titles of all theses were reviewed and selected if relevant to or focused on spine disorders. Year, center, study design, and topic of theses were analyzed. Centers of theses were consisted of university or teaching and research hospitals. The study design of theses were categorized with an algorithm (Figure 1).

The topic of theses was divided into five subgroups; deformity, trauma, degenerative conditions, basic science (bone healing, bone turnover), and others (tumor, infection, metabolic disorder, practice management). Web of Science, PubMed, and Google Scholar databases were searched in order to determine the publication status of theses with the entry of author name, the title of theses and keywords. The index of journals that published theses were divided into 3 groups: SCI (Science Citation Index) or SCI-E (Science Citation Index Expanded), ULAKBIM, and other peer reviewed international indexes. We did not evaluate the index status of the journal at the time of publication of theses. All theses were screened independently regarding the title and abstract by 2 orthopedic surgeons and one expert spine surgeon.

Statistical Analysis

Statistical analysis was performed with SPSS 22.0 (SPSS Inc., Chicago, IL). Categorical variables were analyzed with Fisher's exact test and the chi-square test was used to detect differences. P<0.05 considered to be statistically significant results.

RESULTS

One thousand nine hundred and thirty-three theses were identified and screened. Sixty-seven theses were excluded because they did not meet the eligibility criteria. Three orthopedic surgeons screened the titles and abstracts of theses and a total of 195 theses were found to be related to spine surgery. Three of them did not contain any abstracts, then they were also excluded. One hundred and ninety-two theses were included in this study. A total of 75 (39.1%) theses were published. Thirty-eight (19.8%) of theses were published in a journal with SCI/SCI-E index, 19 (9.8%) in Ulakbim TR index, and 18 (9.4%) in the other international indexes. It took 4.4±3.1 years (minimum-maximum, 1-18) to publish the theses after writing.

The distribution of the number and center of theses by years was demonstrated in Figure 2. 86.5% (n=116) of theses were written at university hospitals and 13.5% (n=26) of theses were written at teaching and research hospital. The highest number of theses was seen in 2010. On the other hand, there were no theses related to the spine from teaching hospitals for a total of 8 years. Publication rates of university and teaching hospitals were 38.6% (n=64) and 42.3% (n=11), respectively with no statistical difference (p=0.44). Dokuz Eylül University Hospital, Department of Orthopedics and Traumatology had the highest number of theses (n=26, 13.5%), followed by Ankara University (n=15, 7.8%) and Hacettepe University (n=14, 7.3%).

The most preferred study design was clinical research (61.5%). The distribution of publication rates according to the study design was shown in Table 1. There was a statistical difference in study design of theses and their publication rates [basic research 48.6% (n=36) and clinical research 33.1% (n=39), p=0.03]. Besides, applied science methods had the highest rate of publication.

Publication rates based on the subject were given in Table 2. The most common subject was deformity followed by basic science and trauma. The number of theses that contain the topic of scoliosis was 73 (38%). The topic of basic science (bone

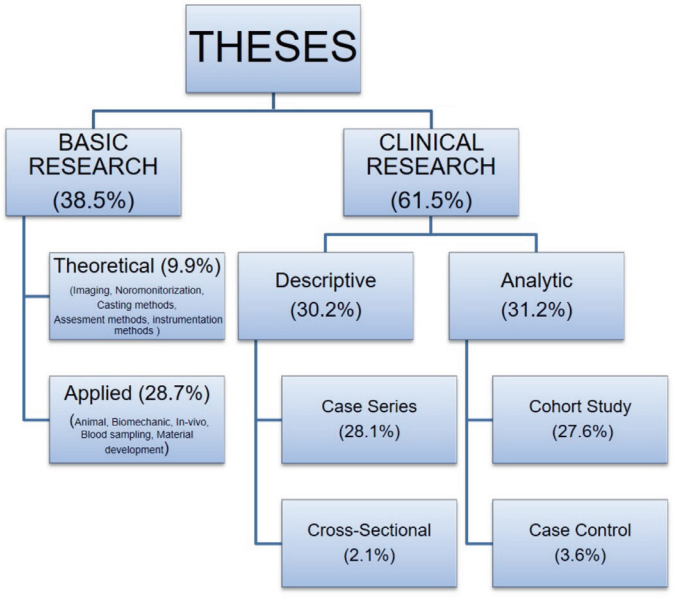

Figure 1. Methodology of published theses

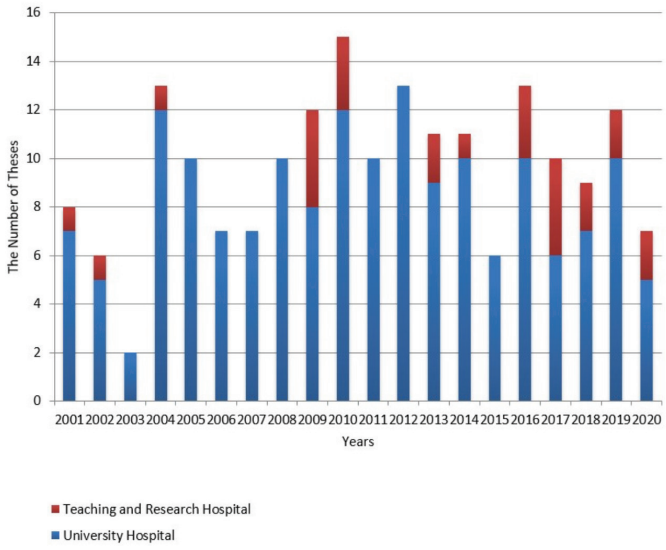

Figure 2. The distribution of the number and center of theses by years

healing, bone turnover) had the highest rate of publication. On the other hand, the publication rates of the theses in SCI/SCI-E journals were 33.3% (n=1) for others (tumor, infection, metabolic disorder, practice management) followed by 31.6% (n=12) for basic science (bone healing, bone turnover).

The distribution of the number of theses related articles by year of publication was demonstrated in Figure 3. Half of all articles were detected between 2009 and 2013. After 2009, a downward trend in the number of publications was seen.

Journals that published theses were listed in Table 3. Seventy-five of 192 theses were published in 37 journals. Fourteen articles were published in the Journal of Turkish Spinal Surgery followed by Acta Orthopaedica et Traumatologica Turcica (n=11), Asian Spine journal (n=4) and The Spine (n=4).

DISCUSSION

In our effort to evaluate the publication of spine specialty theses in our country, we found that the rate of publication of spine theses conducted between 2001 and 2020 in scientific journals was found to be 39.1%. Half of theses were published in scientific journals indexed in SCI/SCI-E. To our knowledge, in literature, this is the first study that analyzes the publication pattern of spine specialty theses in indexed journals.

In our country many studies have investigated publication rates of theses prepared for both basic and clinical science of medicine including public health, emergency medicine, pharmacology, physiology, otorhinolaryngology, microbiology, family medicine and sport science with a range of 1.7-35.6% publication rate[10-17]. There was a wide range of publication rates reported in the current literature (17-60.5%). Ozgen et al.[18] analyzed the publication pattern of Turkish medical theses and found that 6.2% of theses were published in SCI-E indexed journals. Besides, in the same study, the publication rate of orthopaedic theses was found 3.4%. Öğrenci et al.[19] reported that 18% of neurosurgery theses were published in SCI/SCI-E indexed journals.

Lack of publication of thesis-derived papers has also been reported from other countries including, England, France, Croatia, Peru and India[6,20-23].

In a study that included the analysis of orthopedic theses from Turkey, it was seen that the spine was the 6th common in all orthopedic sub-branches, yet the publication rate of spine specialty theses in the SCI/SCI-E indexed journals was higher than the rate of all orthopaedic theses (12.3%) with a statistical difference (p=0.007). When all the results were taken into consideration, spine specialty theses had a higher rate for turning into publication. Gürbüz et al.[24] conducted a study that the bibliometric analysis of orthopedic publications from Turkey and they listed the distribution of the number of articles according to authors and the first five articles in number, belonged to three spine surgeons. In our opinion, these results suggested that a higher publication rate of spine specialty theses were also related to the motivation of the supervisor. Besides the student, if the mentor is also not interested in publishing, the main roles for turning theses to publication, residence and supervisor, become reluctant.

The delay in publication is a window of missed opportunity for postgraduate medical education. Postgraduate medical education is considered to be an initiation to research; the study is missing until the publication of theses. Unpublished researches have potential to get outdated quickly; similar work from other centers may be conduct the same topics. Even though this is common knowledge, very little is being done to promote residences to publish their theses[5,25]. Therefore we recommended residences to prepare the theses including spine topics earlier. In this study, Similar to some studies in the literature that have been conducted so far, a 10-year period was analyzed in our study. We found that 4.4 years was needed for the theses to be published after writing. When all times interval for theses turning into publication were taken into consideration, the mean time interval ranged from 3.15 to 5 years. Although our meantime was longer, yet still in the range of the current literature interval.

Choosing the right journal for submitting the article is one of the main steps for publication. We detected that most papers resulting from the spine specialty theses were published in domestic journals. In addition that the Turkish Journal of Spine Surgery was the most favored journal for publication. This might be due to the journal being well known than the others and possibly because that journal is tolerant to and pays more attention to publishing the spine specialty theses from Turkey.

86.5% of spine theses were written at the university hospitals. However there was no statistical difference between the university and teaching - research hospitals regarding spine specialty theses published as articles in foreign and Turkish journals. On the other hand, we found that theses that prepared at teaching and research hospitals had a higher rate than the university hospitals. Since the lack of theses written in training and research hospitals in the database of the Council of Higher Education was not taken into account in this analysis, a more comprehensive evaluation of the results may be needed as there may be inconsistencies.

Medical and surgical management of idiopathic scoliosis has developed rapidly together with the learning of the pathophysiology of scoliosis and inventing the new spinal segmental instrumentation in the last decade[26]. Studies have shown that the scoliosis prevalence in children under age 16 changes between 0.35% and 5.2%, and it is commonly accepted to have an average of 2-3%[27-30]. There has been a wide-scope study based on school screening conducted in multiple centers in Turkey that found the prevalence of adolescent idiopathic scoliosis was 2.3% in Turkey[31]. As a result of the high prevelance of scoliosis in Turkey, the most preferred topic for writing a spine specialty theses being scoliosis (38%), was not surprising. In addition, it has been anecdotally reported from clinical experience that the surgical treatment of scoliosis is mostly performed in orthopedic clinics, yet the treatment of

other spinal conditions is mostly performed in neurosurgery clinics.

Research methods are one of the factors that directly affect the quality and data of the study. As a research method, the researcher may adopt an observational-clinical or experimental-basic science approach. Considering our study results on this subject, it is seen that most clinical studies (61.5%) are preferred. This situation presents a parallel situation in terms of international publications. In this regard, the rate of observational studies was found to be 68.1% in a study conducted by Ersel et al.[32]. Similarly, independent of the field of specialization, Salmi et al.[6] found that, the rate of observational study as a research method was reported as 69.3% in medical faculties. Koca et al.[9] conducted a study of analysis of orthopedic theses and showed that the most preferred study-design was clinical (71.7%) and followed by non-clinical experimental studies (25.6%). In another study from India, Dhaliwal et al.[22] reported the rate of observational studies was 44.4%. The fact that observational studies are preferred more than experimental studies is due to the convenience in their design and applicability. Laboratory and prospective studies are considered to have higher scientific value when compared with retrospective studies. Accordingly, spine theses prepared using basic research including applied and theoretical methods had higher publication rates than clinical research.

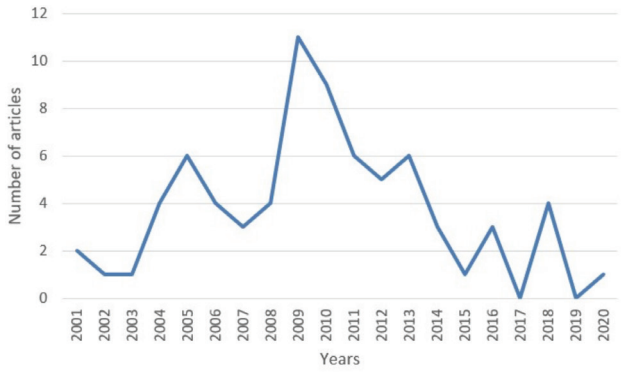

Figure 3. Distribution the number of theses related articles by year of publication

In this study, most published theses were related to basic science (bone healing, bone turnover) which includes animal experimental studies. Eser[15] showed that the rate of publication of experimental studies was higher (78.7%) than other study types [Prospective clinical studies (9.8%), retrospective and survey studies (6.6%), cell culture studies (4.9%)]. In a study published in 2019, the high rate of studies with experiments determined (73.2%) shows that the results are in parallel with our study[16].

Most of the articles were published between 2009 and 2013. After 2009, an obvious decrease in the publication rate of theses was detected. These results were similar to other studies: Koca et al.[9] showed rapidly increase up to 2005 and decreased thereafter. Another study from Turkey that analyze the publication pattern of orthopedic articles showed a significant rise up to 2005 and a mild undulation till 2008, with a rapid decrease thereafter[24]. In our opinion, the main reason for upwards and downwards trends in publication rates of theses is the consequences of regulations for Turkish academician criteria that could not motivate the publication of theses.

Table 1. The relationship between the study study design of theses and publications

Study design of theses	Total number n	Publication of theses n (%)	Publication in SCI/SCI-E indexded journals n (%)
Basic Research			
- Theoretical	19	3 (15.8)	2 (10.5)
- Applied	55	33 (60)	20 (36.4)
Clinical Research			
- Descriptive			
• Case Series	54	18 (33.4)	5 (9.3)
• Cross-Sectional	4	2 (50)	2 (50)
- Analytic			
- Cohort Study	53	19 (35.8)	9 (17)
- Case Control	7	0 (0.0)	0 (0.0)

Table 2. The relationship between the subject of theses and publications

Subject of theses	Total number n	Publication of theses n (%)	Publication in SCI/SCI-E indexded journals n (%)
Deformity	93	31 (33.3)	16 (17.2)
Trauma	33	14 (42.4)	5 (15.2)
Degenerative	25	9 (36)	4 (16)
Basic science (bone healing, bone turnover)	38	20 (52.6)	12 (31.6)
Others (tumor, infection, metabolic disorder, practice management)	3	1 (33.3)	1 (33.3)

Study Limitations

The main limitation of the study is that we only the theses at the National Thesis Center database in Turkey. Therefore, we could have missed other theses and it might be incorrect to generalize results to all theses. In addition, we are unable to detect the change of the title of the thesis transforming to the article and determine that some other theses might have reached publication or are currently under peer-reviewed process or in press. Another limitation is that we intended on published articles and we did not research oral or poster presentations in medical congress.

CONCLUSION

We concluded that the publication rates of spine specialty theses are apparently at an acceptable level compared to other studies. It was assessed that the topic of scoliosis was the most preferred subject and we suggest that original subjects that can contribute to the literature may be important for the evolution of the spine. Basic research methods including applied and theoretical methods had higher publication rates than clinical research.

Table 3. The list of journals where the spine theses were published

Name of journals	Number of publications
Journal of Turkish Spinal Surgery	14
Acta Orthopaedica et Traumatologica Turcica	11
Asian Spine Journal	4
The Spine	4
Spine 1976	3
Joint Diseases and Related Surgery	3
Acta Orthopaedica Belgica	2
Cureus	2
Euroasian Journal of Emergency Medicine	2
European Spine Journal	2
Journal of Pediatric Orthopaedic	2
Journal of Spinal Disorders and Techniques	2
Acta Ortopédica Brasileira	1
Advances in Orthopedics	1
African Journal of Pharmacy and Pharmacology	1
Annals of Medical Research	1
Archives of Clinical and Experimental Surgery	1
BioMed Research International	1
Bosphorus Medical Journal	1
Cumhuriyet Medical Journal	1
Current Therapeutic Research	1
Folio Morphologica	1
Global Spine Journal	1
International Journal of Medical Robotics and Computer Assisted Surgery	1
Journal of International Medical Research	1
Journal of neurosciences in rural practice	1
Korean Journal of Spine	1
Medicine (Baltimore)	1
Medicine Science	1
Neurosurgery Quarterly	1
Spine Deformity	1
Spine Surgery and Related Research	1
The European Journal of Orthopaedic Surgery and Traumatology	1
The Journal of Bone and Joint Surgery - American Volume	1
The Journal of Bone and Joint Surgery - British Volume	1
The Medical Journal of Göztepe Training and Research Hospital	1
Turkish Neurosurgery	1

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Ethics

Ethics Committee Approval: Ethics Committee approval was not required since data used in our study were obtained retrospectively from the internet which is available for open access.
Informed Consent: Retrospective data-analysis study.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: E.Ş., Design: E.Ş., Ö.A., Data Collection or Processing: E.Ş., A.İ.K., Ö.A., Analysis or Interpretation: E.Ş., A.İ.K., Ö.A., Literature Search: E.Ş., A.İ.K., Ö.A., Writing: E.Ş., A.İ.K., Ö.A.
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BIOMECHANICAL CHANGES IN CERVICAL SPINE SEQUENCING AFTER RIGID LUMBAR STABILIZATION

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ABSTRACT

Objective: Surgical stabilization of the thoraco-lumbar spine can induce biomechanical changes in other spinal regions, potentially influencing postoperative outcome. This study detected biomechanical changes in cervical spine sequencing and identify preoperative parameters associated with these changes following rigid stabilization surgery for degenerative lumbar spinal disease.

Materials and Methods: Twenty patients (10 males and 10 females, mean age 64.6 years) with lumbar degeneration receiving rigid stabilization (polyaxial screws and titanium rods) were included in the study. Preoperative and postoperative anterioposterior and sagittal scoliosis x-rays were retrospectively evaluated by an independent researcher using SurgimapR (Nemaris Inc., USA). Preoperative and postoperative cervical spine parameters were compared using Wilcoxon test. A $p<0.05$ was considered statistically significant for all tests.

Results: Among the 20 patients enrolled, 4 each were treated for degenerative disc disease, 5 had spinal stenosis, and 3 had spondylolisthesis, while 5 were treated for the previously operated spinal instability and 3 for spondylolysis. The highest instrumentation level was L1 and the lowest was L5. Radiological measurements were obtained by calibrating Surgimap for each patient using standard techniques. The T1 slope angle was significantly reduced post-surgery ($p<0.05$), and the magnitude of this reduction was enhanced by greater improvement in the lumbar long segment angle after rigid stabilization ($p<0.05$).

Conclusion: Rigid stabilization for degenerative lumbar spine disease can also affect sagittal balance and alter biomechanical loads in postoperative cervical spine sequencing.

Keywords: Rigid stabilization, sagittal balancing, cervical spine, SurgimapR

INTRODUCTION

Curvilinear alignment of the spine is essential for sagittal and coronal balance, and permits intricate movements with minimal energy consumption. Computer-aided measurements have revealed that optimal alignment maintains efficient spinopelvic sequencing by balancing the effects of pelvic and head compensator mechanisms[1,2].

In contrast, spinal deformity due to degenerative bone disease impairs sagittal balance, thereby disrupting motor activity, and may lead to chronic pain and disability[3-5]. Rigid stabilization of the thoraco-lumbar spine is frequently conducted to correct sagittal imbalance, but may also alter the biomechanical properties of other spine segments[6-8]. These reciprocal changes lead to reorganization of the axial load distribution for restoration of sagittal balance, causing the cervical-vertebral balance to approach the gravity line[9].

This study aimed to reveal the effects of rigid stabilization surgery for degenerative lumbar disease on cervical spine alignment and biomechanical parameters, and to evaluate whether these changes are influenced by preoperative sagittal spine alignment disorder. Second, we aimed to identify preoperative parameters that trigger these changes in cervical spine alignment after corrective surgery.

MATERIALS AND METHODS

Patient Population

Ethics committee approval was obtained from İstanbul Medipol University Non-Invasive Clinical Research Ethics Committee (approval no: E-10840098-772.02-5820, date: 11.11.2021). Informed consent was obtained from our patients for our study. Between January 2019 and April 2021, adult patients receiving rigid stabilization surgery (using polyaxial screws and titanium rods) for sequential lumbar spinal degenerative disease were recruited according to the following inclusion criteria: over 50 years of age, with spinal deformity of at least one segment, and receiving two-way scoliosis flat X-rays in the normal standing position both before and after surgery. Patients with neuromuscular disorders, ankylosing

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spondylitis, or spinal deformity due to tumors or infection were excluded. Clinical, surgical, and radiographic records were examined retrospectively (Table 1).

Radiological Measurements

Full-length antero-posterior and lateral scoliosis radiographs were acquired in the standard upright position with arms folded horizontally forward and per shoulder. Radiographic measurements were obtained by calibrating Surgimap (Nemaris Inc., USA) for each patient in accordance with standard techniques. Scoliosis X-rays were acquired 1-2 days before surgery and 2-3 days after surgery (when the patients were mobilized). The C2 occiput angle (Occ-C2) was measured from the line drawn between the line drawn along the C1 front belt and the lower margin of the C2 body and the occiput inferior tip. The C1-C2 angle (C1-2) was measured from the line between the front arcus of C1 and the rear arcus of C2 to the line along the lower margin of body C2. The C2-C7 angle (C2-7) was measured along the line along the rear body of C2 extending to the back body of C7. The T1 slope angle was measured between the upper endplate of T1 and the horizontal reference line. The C7 sagittal vertical angle (C7 CSB) and C2 sagittal vertical angle (C2 CSB) were defined as horizontal distances from the back end of the upper sacral endplate to the center of the C7 corpus and C2 corpus respectively (Figures 1, 2).

Table 1. Demographic information and diagnosis of patients

Patient no	Age	Sex	Level	Diagnosis
1	71	M	L4- L5	Spinal stenosis
2	70	M	L3- L4	Spondylolysis
3	65	M	L2- L5	Spinal instability (operated)
4	61	F	L4- L5	Degenerative disc disease
5	68	F	L4- L5	Spinal stenosis
6	52	M	L3- L4	Spondylolisthesis
7	68	F	L4- L5	Spinal stenosis
8	62	M	L3- L5	Spinal instability (operated)
9	73	F	L4- L5	Spinal stenosis
10	66	M	L3- L4	Degenerative disc disease
11	72	F	L2- L5	Spondylolysis
12	56	F	L4- L5	Spondylolisthesis
13	58	M	L4- L5	Spondylolisthesis
14	72	F	L3- L5	Spinal instability (operated)
15	56	M	L4- L5	Degenerative disc disease
16	69	F	L1- L5	Spinal instability (operated)
17	53	M	L2- L5	Spinal instability (operated)
18	72	F	L4- L5	Spinal stenosis
19	67	F	L3- L5	Spondylolysis
20	62	M	L4- L5	Degenerative disc disease

Study Design and Statistical Analysis

All data were analyzed using IBM SPSS Statistics 25. Datasets were first tested for normality using the Kolmogorov-Smirnov test, Shapiro-Wilk test, histogram observation, or coefficient of variation. Parameters were compared before and after surgery by the Wilcoxon signed-rank test. A $p<0.05$ was considered statistically significant for all tests.

RESULTS

The demographic characteristics and diagnoses of the 20 enrolled patients are summarized in Table 1. The study group included 10 males and 10 females of mean age 64.6 years, of which 4 were diagnosed with degenerative disc disease, 5 with spinal stenosis, 5 with previously operated spinal instability, 3 with spondylolisthesis, and 3 with spondylolysis. The highest stabilized spinal level was L1 and the lowest level was L5. There was a significant difference in T1 slope angle post-surgery compared to preoperative baseline ($p<0.05$) and the change appeared proportional to the improvement in global lumbar angle (Tables 2 and 3). Therefore, the relationship between the single-segment T1 slope angle and the angle of the long segment with rigid stabilization was examined. We speculated that a greater improvement in global lumbar angle within the long segment would result in a larger reduction in T1 slope angle. Indeed, a larger global lumbar angle after rigid stabilization was associated with a smaller postoperative T1 slope angle ($p<0.05$) (Table 3 and Figure 3).

DISCUSSION

Deterioration of one spinal segment may alter the biomechanical properties of other segments. In bipedal animals, lordotic and kyphotic slopes balance the spine load[10]. During daytime, the spine is usually maintained in the balanced sagittal position, so deterioration of the lower spine will naturally affect upper spine posture. Similarly, patients with pathologies of the pelvis, hip joints, or lower extremities may adopt an alternate spinal posture as a compensatory mechanism to maintain balance. If this adaptation is small (within normal physiological limits) and successfully helps maintain balance, gait, and movement, no symptoms are likely to develop. If the required compensation is extreme or unsuccessful, however, spinal balance may be disturbed[11,12]. For instance, substantial deterioration or deformity of the lumbar region will alter the positions of the thoracic spine, cervical spine, and head, while pathologies of the thoracic region usually affect the cervical spine and head, and cervical abnormalities will affect the position of the head. Various lumbar, thoracic, and cervical spine parameters have been defined for diagnosis and treatment evaluation. Further, lumbar-thoracic parameters changes at lower levels. For instance, the sacral slope angle is replaced by the thoracic slope angle and pelvic tilt by the thoracic tilt angle. The thoracaal groan angle corresponds to the pelvic incision and is calculated

as the sum of the thoracaal slope and neck tilt angle. These parameters are critical for evaluation of lumbar and thoracic pathologies and effects on the cervical spine[3,8].

Thoracic and cervical regions are greatly affected by lumbar degeneration and ensuing alterations in sagittal equilibrium[3,13]. A similar sagittal equilibrium disorder occurs after instrumentation surgery if lumbar lordosis is not protected[3]. In cases where the underlying movement is disrupted, the upward effect is clearly visible. However, the effects of lumbar stabilization on the cervical region has not been investigated until now. When posture is disrupted, the C0-C2 angle of the upper cervical region may be increased[14-16], but we found no significant differences between cases with and without postural disorder, suggesting that posture distortion alone is insufficient to affect this area.

We found no changes in other subaccesive parameters except lumbar rigid stabilization, such as in cervical slope angle, thoracic inlet angle, and cervical tilt angle, among individuals without sagittal equilibrium problems. Naturally, cervical tilt and thoracic moment angle are increased, while cervical slope angle is reduced in these cases, possibly to maintain horizontal gaze. This may have caused a biomechanical improvement in

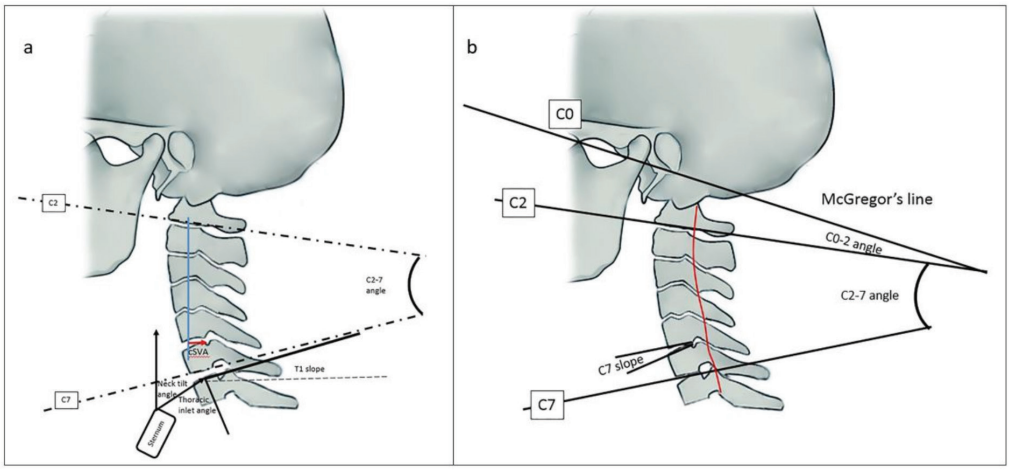

Figure 1. a) Thoracic kyphosis angle. C0-C2 angle and C7 slope angle are shown b) thoracic inlet angle, cervical tilt angle, cSVA and C2-7 angle measurements

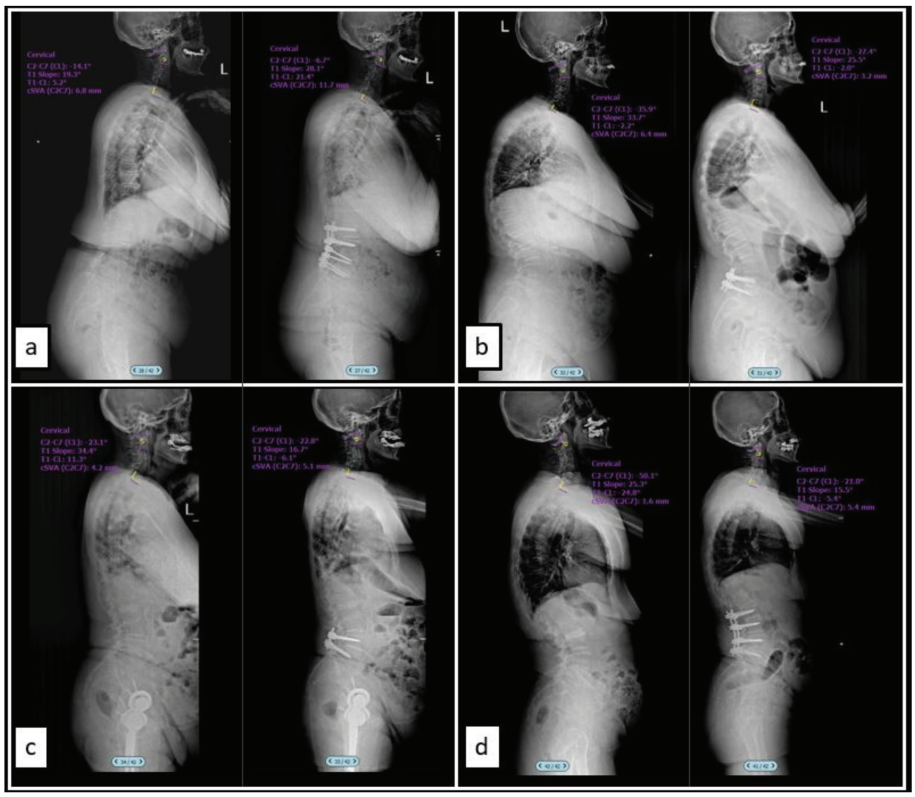

Figure 2 a-d. Preoperative and postoperative cervical biomechanical measurements

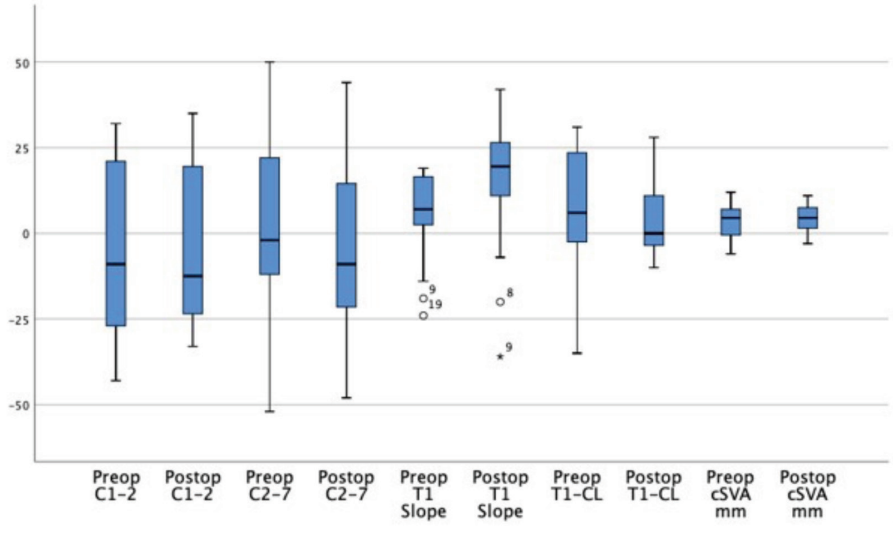

Figure 3. Statistical result cervical biomechanical parameters of patients

Table 2. Examined cervical biomechanical parameters of the patients

Patient no	Preop C1-2	Postop C1-2	Preop C2-7	Postop C2-7	Preop T1 Slope	Postop T1 Slope	Preop T1-CL	Postop T1-CL	Preop cSVA mm	Postop cSVA mm
1	-16	-32	23	20	7	22	31	28	6	5
2	-22	-13	-5	-31	11	33	23	1	9	2
3	-6	-12	-16	-19	7	17	-5	-2	5	8
4	-29	-14	1	-1	16	28	25	28	10	9
5	-12	-22	-37	-36	19	25	-18	-10	-4	8
6	-5	10	-52	44	3	17	-35	10	-1	-3
7	-43	-33	-11	-4	5	15	26	11	12	3
8	28	31	21	15	-14	-20	7	-5	3	7
9	21	16	6	40	-19	-36	-12	4	-1	-3
10	28	35	5	-18	17	34	18	11	5	1
11	-41	-13	10	-12	4	14	24	-1	5	4
12	-12	-30	-11	14	11	8	0	22	0	5
13	-25	21	-13	-21	13	24	0	0	0	4
14	-29	-29	-14	-6	17	28	5	21	6	11
15	-38	20	-11	8	19	7	7	0	8	0
16	21	-25	35	-27	3	25	2	-2	-6	3
17	24	-12	23	-22	2	23	-11	-6	1	5
18	32	19	-8	28	19	-7	10	-2	8	0
19	21	32	26	-48	-24	42	2	-5	-3	8
20	9	-16	50	-21	2	15	24	-5	4	5

Table 3. Significant difference in T1 slop angle

Test statistics[a]	Postop C1-2 - Preop C1-2	Postop C2-7 - Preop C2-7	Postop T1 Slope - Preop T1 Slope	Postop T1-CL - Preop T1-CL	Postop cSVA mm - Preop cSVA mm
Z	-0.081[b]	-0.765[c]	-2,186[b]	-0.624[c]	-0.542[b]
Asymp. Sig. (2-tailed)	0.936	0.444	0.029	0.532	0.588

There is a significant difference between Postop T1 Slope and Preop T1 Slope ($p<0.05$). There is no significant difference between other parameters.
[a]: Wilcoxon Signed Ranks Test, [b]: Based on negative ranks, [c]: Based on positive ranks
Asymp. Sig.: Asymptotic significance

cervical spine sequencing. These values changed in parallel as the level of rigid stabilization increased. When the global lumbar lordosis angle was optimally configured, the T1 slope angle was reduced, resulting in improved cervical spine structure.

Study Limitations

This study has several limitations. First, the sample size was small. Second, the retrospective design does not allow for assessment of causality. Larger-scale prospective studies are warranted. Patient global CSB changes were not examined and will be the subject of another article. By measuring lordosis angle in each segment, it may be possible to evaluate how each change contributes to the decrease in cervical T1 slope angle. Dynamic systems could also be considered in a separate patient group, or such patients could be evaluated together with patients receiving rigid system stabilization.

CONCLUSION

It is essential to preserve lumbar lordosis in the rigidly stabilized spine, even if it is in the segmenter. Although loss of lordosis may not impair back function in youth, it can lead to serious problems in older age. Such effects emerge first in the cervicothoracic region, likely to protect neck posture.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from İstanbul Medipol University Non-Invasive Clinical Research Ethics Committee (approval no: E-10840098-772.02-5820, date: 11.11.2021).
Informed Consent: Informed consent was obtained from our patients for our study.
Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.T.B., A.F.Ö., Concept: A.T.B., Design: A.T.B., Data Collection or Processing: A.F.Ö., Analysis or Interpretation: M.A.Ö., Literature Search: A.T.B., M.A.Ö., A.F.Ö., Writing: A.T.B.
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TRANSFORAMINAL EPIDURAL INJECTIONS: A BIBLIOMETRIC ANALYSIS OF THE 50 MOST CITED ARTICLES

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ABSTRACT

Objective: Evaluating the articles with the highest citations provides the authors with more detailed information about transforaminal injection, and we think that it will contribute to the production of high-quality articles in their future studies.

Materials and Methods: In between February-March 2022, Web of Science (WOS) was used as the data search source. Journals from 1900 to 2022 were searched in the database. The following keywords were used in related "Topic" searches: Nerve root injection, root injection, transforaminal injection, transforaminal epidural injection, selective nerve root block, root block. WOS citations, year of publication, country of origin and content of article were evaluated.

Results: The total number of citations of the Top 50 articles was 5817 and the average number of citations was 118.7. Of the Top 50 articles, 24 refer to lumbar transforaminal injection, 22 to cervical transforaminal injection, and 4 to cervical and lumbar transforaminal injection. It was seen that the articles that received the Top 50 citations were most frequently produced by the anesthesia department, and the second most frequently produced by the orthopedics and neuroscience department. Fourthy percent (n=20) of the articles were about complications such as intraarticular injection, spinal cord infarction, paralysis, paraplegia, and death that developed after transforaminal injection.

Conclusion: In our study, the first 50 most cited articles about transforaminal injections were evaluated and a resource was tried to be created by including detailed information. Our work will help readers benefit from the most influential and important articles out of hundreds of articles.

Keywords: Transforaminal, citation, root injection, epidural injection

INTRODUCTION

Radicular nerve root pain is a condition that can adversely affect a person's quality of life[1]. Sciatica often occurs due to lumbar disc herniation and lumbar stenosis. These problems can cause pain along with nerve root inflammation[2]. For this reason, corticosteroid injections can be used in the treatment of pain by reducing inflammation[3,4].

Epidural injections have been practiced since the 1900s[5,6]. Epidural injections can be administered in 3 ways: Transforaminal, caudal and interlaminar. These 3 methods were found to be effective in the treatment of pain, but the amount of corticosteroid required for transforaminal injection was less[7]. Transforaminal injection is the process of injecting a long-acting steroid together with a local anesthetic into the neural foramen where the nerve root comes out. It can relieve pain by reducing inflammatory reactions around the nerve root and joint.

Bibliometrics such as impact factor and citation number are frequently used to evaluate the importance, value and scientific level of the article. Although the traditional method used to measure the quality of an article is the impact factor, the number of citations is also frequently used[7,8].

We evaluated the citation power of articles on transforaminal epidural steroid injection with the Web of Science (WOS) program. Evaluation of the most cited articles will also assist the authors in obtaining detailed information about transforaminal injections.

To the best of our knowledge, there is no bibliometric study of transforaminal injections so far. We performed citation analysis with the WOS program to identify high-value articles. Evaluating the articles with the highest citations provides the authors with more detailed information about transforaminal injection, and we think that it will contribute to the production of high-quality articles in their future studies.

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MATERIALS AND METHODS

WOS was used as the data search source in February 2022. Journals from 1900 to 2022 were searched in the database. More than 10000 journals were reviewed for the highest citation rating to perform bibliometric analysis of transforaminal injection. The following keywords were used in related "Topic" searches: Nerve root injection, root injection, transforaminal injection, transforaminal epidural injection, selective nerve root block, root block. All of the journals were in the SCI-Expanded category. The 50 publications with the highest citation are listed. Ethics committee approval was not required. Studies related to laboratory research or basic science were excluded. As a result of the searches, a database was created and the evaluation of the articles was carried out by two independent observers (author 1 and 2). In case of disagreement, a common solution was obtained through discussion among the authors. WOS citations, year of publication, country of origin and content of article were evaluated. If more than one country contributed to the article, the country of the first author was taken into consideration.

RESULTS

The total number of citations of the Top 50 articles was 5,817 and the average number of citations was 118.7. Table 1 shows the Top 10 articles with the highest citation. All articles in the Top 50 were published between 2000 and 2014. The list of journals with more than one article in the top 50 on transforaminal injection is shown in Table 2. Of the Top 50 articles, 24 refer to lumbar transforaminal injection, 22 to cervical transforaminal injection, and 4 to cervical and lumbar transforaminal injection. It was observed that four countries contributed to the production of more than one publication. At the same time, it was seen that the articles were mostly produced in the USA (Table 3). It was seen that the articles that received the Top 50 citations were most frequently produced by the anesthesia department, and the second most frequently produced by the orthopedics and neuroscience department (Table 4). Fourthy percent (n=20) of the articles were about complications such as intraarticular injection, spinal cord infarction, paralysis, paraplegia, and death that developed after transforaminal injection.

DISCUSSION

Many methods are used to determine the importance of the article in bibliometric studies. Determining the number of citations is one of the methods used. Although the power of an article is not always determined by the number of citations, it is widely used to determine the impact power of the researcher and the journal. To our knowledge, there is no bibliometric study on transforaminal injection so far.

The article with the highest citation (n=338) was Riew et al.'s[9] article named "The effect of nerve-root injections on the need for operative treatment of lumbar radicular pain - A prospective, randomized, controlled, double-blind study" published in the journal of "Journal of Bone and Joint Surgery-American Volume". They showed that the results of the patients who received steroid root injection were significantly

Table 1. Top 10 articles with the highest citation

Rank	First author	Article title	WOS citations	Journal	Year
1	Riew	The effect of nerve-root injections on the need for operative treatment of lumbar radicular pain -A prospective, randomized, controlled, double-blind study	338	Journal of Bone and Joint Surgery-American Volume	2000
2	Vad	Transforaminal epidural steroid injections in lumbosacral radiculopathy - A prospective randomized study	336	Spine	2002
3	Buenaventura	Systematic Review of Therapeutic Lumbar Transforaminal Epidural Steroid Injections	221	Pain Physician	2009
4	Ghahreman	The Efficacy of Transforaminal Injection of Steroids for the Treatment of Lumbar Radicular Pain	204	Pain Medicine	2010
5	Scanlon	Cervical transforaminal epidural steroid injections - More dangerous than we think?	203	Spine	2007
6	Baker	Cervical transforaminal injection of corticosteroids into a radicular artery: a possible mechanism for spinal cord injury	176	Pain	2003
7	Riew	Nerve root blocks in the treatment of lumbar radicular pain - A minimum five-year follow-up	169	Journal of Bone and Joint Surgery-American Volume	2006
8	Kennedy	Paraplegia Following Image-Guided Transforaminal Lumbar Spine Epidural Steroid Injection: Two Case Reports	162	Pain Medicine	2009
9	Rozin	Death during transforaminal epidural steroid nerve root block (C7) due to perforation of the left vertebral artery	160	American Journal of Forensic Medicine and Pathology	2003
10	Rathmell	Cervical transforaminal injection of steroids	155	Anesthesiology	2004

better than the patients who received local anesthetic. The article with the highest annual citation average (n=16.8) was Vad et al.'s[10] article named "Transforaminal epidural steroid injections in lumbosacral radiculopathy - A prospective randomized study" published in the journal of "Spine". They compared the transforaminal steroid injection and saline-containing trigger point injection. They found that steroid injection was statistically significantly effective in reducing pain. The oldest article in the Top 50 (n=24) is the article by Slipman et al.[11], published in the "Archives of Physical Medicine and Rehabilitation" in 2000, about selective root injections for cervical spondylotic radicular pain. They stated that fluoroscopically guided therapeutic selective nerve root block is a clinically effective intervention in the treatment of atraumatic cervical spondylotic radicular pain. The most recent article (2014) in the Top 50 (n=48) was Manchikanti et al.'s[12] article named "Transforaminal Epidural Injections in Chronic Lumbar Disc Herniation: A Randomized, Double-Blind, Active-Control Trial" published in the journal of "Pain Physician". They reported the lack of superiority of steroids compared with local anesthetic at 2-year follow-up.

Table 2. The list of journals with more than one article in the Top 50

Pain Medicine	11
Spine	7
Archives of Physical Medicine and Rehabilitation	4
Pain Physician	4
Journal of Bone and Joint Surgery-American Volume	2
Pain	2
Anesthesiology	2
Regional Anesthesia and Pain Medicine	2
PM&R	2

Table 3. The nations of origin of the Top 50 articles about transforaminal injection

USA	35
South Korea	4
England	3
Australia	3
New Zeland	1
France	1
Switzerland	1
Sweden	1
Norway	1

Table 4. Departments of the articles that produced the Top 50 article

Anesthesia	24
Orthopedics and Neurosurgery	13
Physical Therapy and Rehabilitation	8
Radiology	3
Rheumatology	2

It was mostly seen that the production of articles was the USA origin (70%). In previous bibliometric studies, it was seen that there were most frequently USA original studies[13-15]. Less often it has been seen that in our study articles producted in South Korea (8%).

It has been determined that the complications that occur in the transforaminal injection procedure have a high citation capacity. The study with the highest citation (n=203) about complications was published by Scanlon et al.[16] "Cervical transforaminal epidural steroid injections - More dangerous than we think?" was published in the journal of "Spine" in 2007. They reported that accidental intra-articular administration of particulate steroids affects the embolism cascade. They also recommended the use of non-particulate steroids such as dexamethasone, the use of blunt needles, the use of short-acting local anesthetics such as lidocaine, and the administration of a test dose of local anesthetic before steroid administration. The second most frequently cited study on complications is the "Paraplegia Following Image-Guided Transforaminal Lumbar Spine Epidural Steroid Injection: Two Case Reports" by Kennedy et al.[17] published in the journal of "Pain Medicine".

Paraplegia developed in both cases and they thought that particulate steroid caused the development of paraplegia. They also recommended testing with Digital Subtraction Angiography for intra-arterial injection and local anesthetic prior to cortisol injection. Rozin et al.'s[18] study "Death during transforaminal epidural steroid nerve root block (C7) due to perforation of the left vertebral artery" was published in the "American Journal of Forensic Medicine and Pathology" and received 160 citations in total. They reported the death of a 44-year-old female patient after massive cerebral edema due to left vertebral artery dissection while performing C7 nerve root block with a 25-gauge spinal needle, as a very catastrophic complication.

Study Limitations

There are several limitations of our study. First of all, it can be expected that the number of citations of older articles is higher than that of new articles. In addition, the articles published after our article search process may have changed the citation order, but this change is not expected to happen quickly. As another limitation, self-citation or not citing another competitor is another factor that can affect the results. There are also strengths of our study. First of all, this study is the first citation study about selective transforaminal root injection. It also provides physicians with access to high-quality articles on this specific topic.

CONCLUSION

In our study, the first 50 most cited articles about transforaminal epidural injections were evaluated and a resource was tried to

be created by including detailed information. Our work will help readers benefit from the most influential and important articles out of hundreds of articles.

Ethics

Ethics Committee Approval: Ethics committee approval was not required.
Informed Consent: Not applicable.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: E.B., Y.K., Design: E.B., Y.K, Data Collection or Processing: E.B., Y.K, Analysis or Interpretation: E.B., Y.K., Literature Search: E.B., Y.K, Writing: E.B., Y.K.
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Conflict of Interest: The authors have no conflicts of interest to declare.

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QUALITY OF LIFE ASSESMENT IN ADOLESCENT AND YOUNG ADULTS WITH SCHEURMANN'S KYPHOSIS

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ABSTRACT

Objective: In this study, Scheuermann's kyphosis patients with 80° or more kyphotic deformities were evaluated both for correcting the deformity and effects of changes in the life qualities.

Materials and Methods: Mean age was found to be 18.6±2.4 years and patients with minimum 2 years follow-up were evaluated. In 10 patients below 17 years of age (27%), segmental compression was applied through the apex and correction was obtained. In the remaining 27 patients (73%) correction was obtained with Ponte osteotomies performed at the apex of the kyphosis and the same fixation and maneuver as the first group. Patients thoracic kyphosis angles if concomitant scoliosis was present scoliosis angles were measured via the Cobb method preoperatively, postoperatively and during the last control visit. Patients were evaluated preoperatively with SRS-22 questionnaire. Mean values of the preoperative, postoperative and in the last control visit were compared statistically (p=0.05).

Results: Preoperative mean kyphotic angles were measured as 84.9°±5.0°. Postoperative mean kyphotic correction angles were measured as 40.7°±6.5° and in all patients' physiological kyphotic angles were obtained (p=0.0001). Preoperative SRS22 questionnaire mean score was 3.17±0.3 while postoperatively increased to 4.95±0.1 which was found to be statistically significant (p=0.0001). Almost all patients were satisfied with the pain improvement, look, function, mental status and satisfaction from the treatment was measured as 4.5 to 5 that is almost perfect. Kyphotic correction angles were found to be statistically similar between patients under and over 18 years of ages (>0.05).

Conclusion: As a result, SRS-22 scores which was used for the first time in Scheuermann's Kyphosis patients undergone surgery, a statistically meaningful result was obtained in quality of life scores and relief of mechanical pain.

Keywords: Scheuermann's kyphosis, surgical treatment, posterior instrumentation, Ponte osteotomy, SRS-22 questionary

INTRODUCTION

Scheuermann's kyphosis is the most common disease due to structural kyphosis in adolescents. Diagnosis is confirmed with the increase in kyphosis angles 5 degrees at each vertebral segment in minimum 3 consecutive vertebrae and, existence of Schmorl nodules radiological[1]. Lack of sharp kyphosis angle, and existence of a moderate kyphosis (round back) causes a delay in diagnosis and treatment of the pathology[2].

Findings like back pain and an increase in kyphosis, presence of shoulders and the head in front of the torso which are not more common than the normal population clinically, attract attention of the families[3]. Orthotic treatment applied during preadolescent period is found to be effective but during adolescence, progression can be seen[1,4,5]. Minimal increase or remission in kyphosis angles can be seen in adulthood. Surgery is indicated when kyphosis angle is greater than 80° in the thoracic spine or 50 degrees in the thoracolumbar spine[2].

Kyphosis of patients aged over 18 treated with minimum 2 maximum 3 segments of Ponte osteotomy with posterior spinal instrumentation and patients aged between 14 and 17 years of age treated with posterior spinal instrumentation and cantilever maneuver. A total of 37 patients were included in the study and SRS 22 questionnaire was used for the outcomes of the surgery in life qualities of the patients[5].

MATERIALS AND METHODS

In our study, 37 patients who had kyphosis angle increase in consecutive 3 thoracic vertebrae and who had been shown to present Schmorl nodules radiological and diagnosed as

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Scheuermann's Kyphosis and whose mean age was found to be 18.6±2.4 years with minimum 2 years follow-up were evaluated (mean follow-up: 61.5±29.0). Eleven patients were female and female to male ratio was 11/26 (Table 1).

Patients were evaluated preoperatively; thoracic MRI and preoperative radiographs were obtained to exclude congenital and other causes of kyphosis. Patients' thoracic kyphosis angles if concomitant scoliosis was present scoliosis angles were measured via Cobb method preoperatively, postoperatively and in the last control visit. Patients were evaluated preoperatively with SRS-22 questionnaire.

Five domains including pain mental status, function, appearance, and satisfaction from previous treatments were evaluated and mean SRS-22 values were obtained. Questionnaire which was validated with Alanay et al.[6] were used.

Patients were positioned prone under general anesthesia and a long midline incision was performed and paravertebral muscles were stripped and vertebrae were visualized. All patients were monitored with Neuromonitoring combined electromyography (EMG), somatosensory evoked potential (SEP) and motor evoked potential (MEP) were measured during the surgery.

In 10 patients below 17 years of age (27%) instrumentation was done at each vertebral segment and multidirectional corrective transpedicular screws were introduced and pre-bend hard rods bent in 30 to 50 degrees of thoracic physiological kyphosis angle were introduced starting from the distal screws and with cantilever maneuver segmental compression was applied through the apex and correction was obtained.

Remaining 27 patients (73%) correction was obtained with Ponte osteotomies performed at the apex of the kyphosis and pre-bend hard rods with transpedicular fixation and cantilever maneuver with segmental compression through the apex was applied.

Proximally screws were introduced into the T-2 vertebrae in 32 patients (86.5%), and T-3 in 5 patients (13.5%). Each vertebral segment was instrumented starting from the most proximal screw distally in 27 (72.9%) patients at L-1 level and 9 (24.3%) patients at the level of L-2 (27%) and 1 (2.8%) patients with Scheuermann's Kyphosis placed apical vertebra in the thoracolomber at the level of L-3 (Figure 1).

Local autographs mixed with cancellous allografts were introduced at the fusion area and Neuromonitoring was used at each segmental fixation and corrective manipulation phase. No neurological deficit was seen in any patients preoperatively or postoperatively.

Table 1. Demographic data's [Mean age of the patients was 18.6±2.4 (14-24) years-old]

	TOTAL	<18 years (n=10)		≥18 years (n=27)	
	Mean ± SD	Mean ± SD	Median (Min.-Max.)	Mean ± SD	Median (Min.-Max.)
Age	18.6±2.4	15.5±1.2	16 (14-17)	19.7±1.5	19 (18-24)
Follow-up	61.5±29.0	103.5±13.0	106 (82-120)	45.9±13.2	44 (24-72)
Sex (F/M)	11/26	4/6		7/20	
Complication n (%)	4 (10.8)	1 (10.0)		3 (11.1)	

SD: Standard deviation, F: Female, M: Male, Min.: Minimum, Max.: Maximum

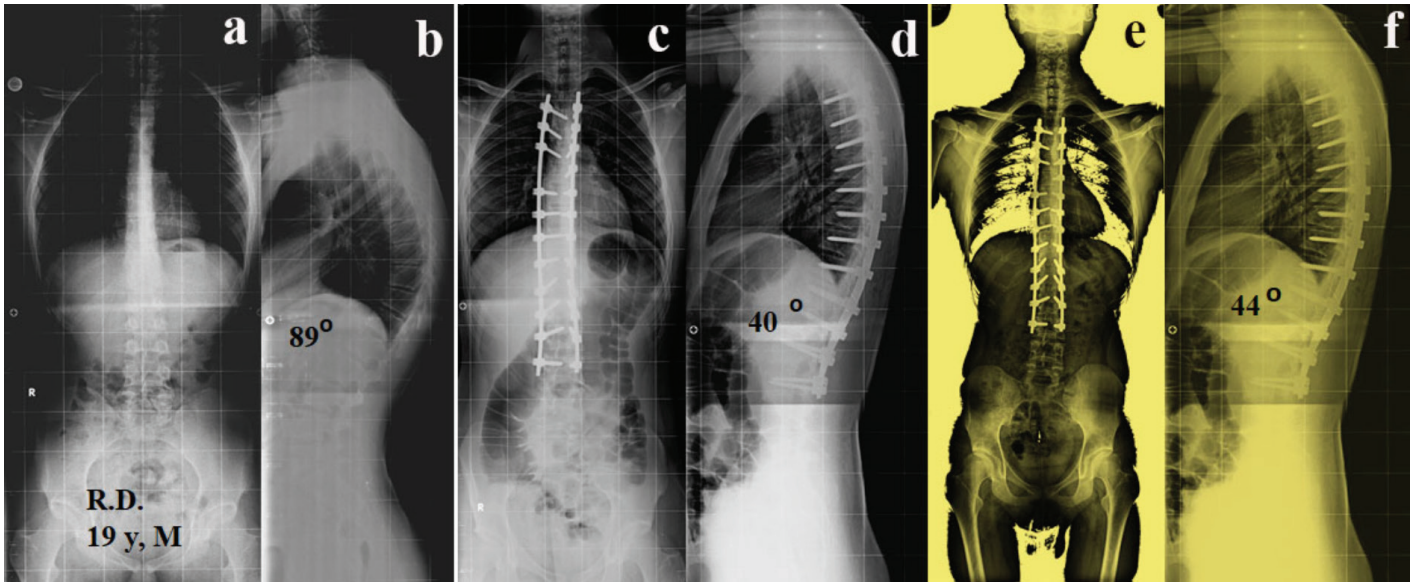

Figure 1. (a-b) Preoperative, (c-d) postoperative and (e-f) last control AP and lateral X-rays of the patient who is 19 years-old male with the thoracolumbar Scheuermann's Kyphosis

AP: Anteroposterior

Postoperative thoracic kyphosis and scoliosis angles, early SRS22 evaluations were noted. Last follow-up of the patients were done in January 2022. In the last policlinic visit SRS22 evaluations, thoracic kyphosis and scoliosis angles were calculated and complications were noted, also while evaluating life quality patients' marital status, and continuation of the education were noted and evaluated proportionally.

Our study was approved by İstanbul University, İstanbul Faculty of Medicine Ethic Committee in 19th April, 2022 (approval no.: 850601). Informed consent forms of all patients in this study were taken.

Statistical Analysis

Statistical analysis was made with SPSS 21.0 program. Mean values for preoperative postoperative and last control data were tested for importance in similar groups (Wilcoxon signed-rank test). In all patient's correction with posterior segmental instrumented only patients in 14-17 years' age group, patients over 18 years of age in whom Ponte osteotomy with posterior segmental instrumentation and correction were made, comparison of sagittal kyphosis and coronal scoliosis and SRS 22 values were done. Probability value of p was selected as 0.05.

RESULTS

Thoracic Kyphosis and Concomitant Scoliosis

Thirty-seven patients with 18.6±2.4 years of mean age were followed up for 61.5±29.0 (24-120) months. Preoperative mean kyphosis angles were measured as 84.9°±5.0° and statistically significant correction of 40.7°±6.7° was accomplished and postoperatively was measured as 40.7°±6.5° (p=0.0001). Postoperative kyphosis angles were measured in physiological limits (40°-50°) in all patients[7]. Last follow-up measures yielded a slight increase in thoracic kyphosis average values were measured as 41.3°±6.5°, but no statistical difference could be measured according to the postoperative values (p>0.05) (Table 2).

Coronal plane scoliosis deformities were measured as 8.2° (0°-24°) preoperatively and were corrected fully postoperatively. Last follow-up Cobb angles yielded a slight difference but was not found to be statistically significant (p>0.05) (Table 3).

SRS-22 Scores

Mean values for SRS-22 values were 3.17±0.3 preoperatively while postoperative values were measured as 4.95±0.1 which was found to be statistically significant (p=0.0001). Almost all patients were satisfied with the results, taking into account with pain, function, mental status and appearance, almost obtaining a perfect score around 4.5 to 5 and a mean 66.7% (21.9-78.6%) increase in SRS-22 score was measured. Last follow-up scores yielded a slight decrease of 0.0-0.3 which was not found to be significant (p=1.0) (Tables 2, 3).

Assessment According to Age Groups

In this study two groups according to age was separated and evaluated. Ten patients under 18 years of age and 27 patients over 18 years of age were compared. Corrective instrumentation only was applied to patients under 18 years of age and as it is suggested in the literature[8]. Ponte osteotomies (2- 3 segments) were added to posterior instrumentation in patients over 18 years of age.

Statistically two age groups were similar in case of follow-up period, preoperative and postoperative and last control values and mean age values (p>0.05). Both groups revealed statistically improved results in postoperative kyphosis angles Cobb angles and SRS-22 values (p<0.05) (Table 3), and no significant difference could be measured between postoperative and last follow-up values (p>0.05).

6 patients (16%) who were actively working before the surgery continued work life after 28 patients who were students at the

Table 2. Preoperative, postoperative and last control kyphosis angels in the sagittal plane, Cobb angles of the scoliosis in the coronal plane and SRS-22 scores, loss of correction of <18 and ≥18 years-old patients

	Total	<18 years-old (n=10)	≥18 years-old (n=27)	p-value
Preoperative Kyphosis	84.9±5.0	84.6±4.4	85.1±4.9	0.389
Postoperative Kyphosis	40.7±6.7	44.2±4.6	40.4±7.9	0.057
Values of the correction	40.7±6.5	39.2±4.2	42.4±6.4	0.005
Kyphosis in the last control	41.3±6.5	45.4±4.9	41.3±6.7	0.078
Preoperative Cobb angles	8.2 (0-24)	8 (0-17)	10 (0-24)	0.960
Postoperative Cobb angles	0 (0-8)	0 (0-0)	0 (0-8)	0.408
Lose of correction degree	0 (0-8)	0 (0-0)	0 (0-8)	0.408
Preoperative SRS-22	3.17±0.3	3.18±0.3	3.17±0.3	0.853
Postoperative SRS-22	4.95±0.1	4.90±0.2	4.97±0.1	0.371
% Correction	66.7 (21.9-78.6)	54.8 (25.0-66.7)	66.7 (21.9-78.6)	0.105
Lose of correction degree	0 (0.0-0.3)	0 (0.0-0.2)	0 (0.0-0.3)	1.00

n: Number of patient

time of surgery continued their schools, remaining 3 girls who were single were married before the last follow-up and 1 was engaged. No changes were noted in marital status of working and patients going to school at the time of last follow-up yet.

Complications

No intraoperative, postoperative and last follow-up control complications regarding bleeding, neurological damage or systemic complications were noted. Average 103.5±13.0 (24-120) months of follow-up was obtained. No patients were diagnosed as cervico-thoracic or thoracolumbar junctional kyphosis. Total complication rate was measured as 10.8% (4 patients). Under 18 years of age 1 patient and patient over 18 years of age 3 patients were assessed as complication and no significant difference was measured in between complication rates regarding age groups (Table 1).

Screw malposition was seen in one in each groups counting to 2 patients totally. In patient under 18 years of age screw malposition was occurred during compression maneuver but no Neuromonitoring change was seen so no revision was done (Figure 2). Patient over 18 years of age was diagnosed a malposition of screw with the computed tomography obtained routinely postoperatively and pedicle screw disturbed the medullary canal medially but no neurological deficit or pain was noted so no revision was planned (Figure 3).

One patient had iatrogenic brachial plexus strain but monoparesis and mild hypoesthesia resolved spontaneously

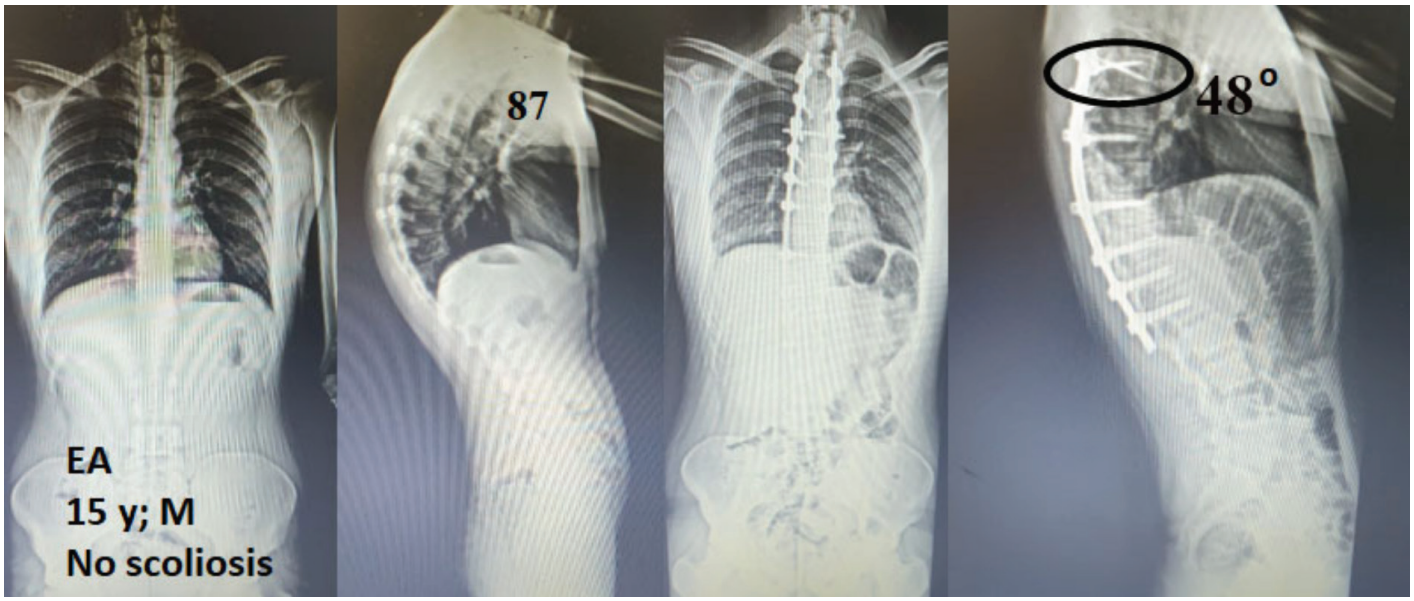

Figure 2. (a-b) Preoperative, (c-d) postoperative AP and lateral X-rays of the patient who is 15 years-old male. Preoperative Kyhosis was 87° and was corrected to 48°. There was malposition of the screws in the level of T-3

AP: Anteroposterior

Table 3. Comparison of the mean preoperative, postoperative and last control kyphosis angels in the sagittal plane, Cobb angles of the scoliosis in the coronal plane and SRS-22 scores, loss of correction with age groups

	Preoperative	Postoperative	Last control	p-value
All of the cases				
Kyphosis	84.9±5.0	40.7±6.7	-	0.0001
Cobb	10 (0-24)	0 (0-8)	0 (0-8)	0.0001
SRS-22	3.17±0.3	4.95±0.1	-	0.0001
<18 years				
Kyphosis	84.6±4.4	44.2±4.6	-	0.006
Cobb	9 (0-17)	0 (0-0)	0 (0-0)	0.0001
SRS-22	3.18±0.3	4.90±0.2	-	0.005
≥18 years				
Kyphosis	85.1±4.9	40.4±4.0	-	0.0001
Cobb	10 (0-24)	0 (0-8)	0 (0-8)	0.0001
SRS-22	3.17±0.3	4.97±0.1	-	0.0001

Wilcoxon signed-ranks test, p<0.05

in postoperative 3rd month. A smoking patient had wound complication and culture revealed *Staphylococcus aureus* which was eradicated with antibiotics and debridement with instrumentation retention. Postoperative 45th month follow-up yielded no persistent or new infection.

DISCUSSION

In patients with Scheuermann's Kyphosis, growth hormone or hormone transmitters responsible for growth and modulation of paravertebral musculature are thought to have role in etiology[9]. Currently, there is not a cause specific treatment as the etiopathogenesis could not be defined thoroughly. Generally conservative measures are accepted in Scheuermann's Kyphosis treatment[5,10].

There are some publications in which orthotic corset treatment and some exercise programs are found to be successful in preadolescent and adolescent ages regardless of the kyphosis angles[1,4,11,12]. Corset treatment's acceptance by the patient and family and treatment time for several years decreases the adherence to treatment[5]. Reports have been made about aggressiveness and irritable personality changes and psychological inconsistencies in the patients[2]. In some publications in adherence to corset treatment causing an increase in kyphosis deformity was also reported[2,13].

According to Lowe surgical treatment in adolescents and young adults should be considered if there is documented progression, refractory pain, loss of sagittal balance, or neurologic deficit[5]. However, Bettany-Saltikov et al.[7] reported that no significant progression was observed in patients who had 55 to 80 degrees of kyphosis angles treated with conservative measures. Beside several complications were observed in patients who had undergone surgery[7].

A study regarding general attitude in kyphosis deformity treatment around 80 degrees, almost 90% of the patients were treated surgically between 2003 and 2012. This high level of evidence study also revealed an increase in postoperative and follow-ups complication rates[8].

Main goal in surgical treatment in kyphosis is to obtain a postoperative kyphosis angle between 40-50 degrees. Junctional kyphosis is inevitable in patients whose kyphosis angle was reduced under 30 degrees[13,14]. Lowe and Line[2] recommends kyphosis angles to be at least 80 degrees before. Lin et al.[15] suggested pedicle subtraction osteotomies to be successful in very rigid deformities. Cho et al.[16] reported that according to sagittal stable vertebrae concept, instrumentation should be started at T2 or T3 at most proximal level and should be ended in the L1 or L2 most distally.

In our study all patients had undergone an instrumentation starting from T2 or T3 distally ending at L1 or L2. Compression was applied to T2-T3 and T12-L1 levels for decreasing probability of junctional kyphosis formation. Thus no junctional kyphosis was seen in our series.

Canikli et al.[17] compared different posterior instrumentation types in their study and best results were obtained in patients with pedicular fixation at all levels when Ponte osteotomy added. With other instrumentation systems while a 75° kyphosis angle was reduced to 45 degrees postoperatively, at last follow-up progression was seen and kyphosis angles were measured as 57.4 degrees. Besides, in patients in whom all level pedicular fixation with Ponte osteotomy were done, preoperative mean 80 degrees of kyphosis angles were reduced to 41.7 degrees and last follow-up control yielded a minimal correction loss[17].

In our study as suggested by Lowe and Line[2], patients with kyphosis deformities of 80 degrees or more were instrumented at each level and a cantilever maneuver was applied and correction was obtained and local auto-grafts and allografts were introduced to gain fusion. While patients between 15 and 17 years of age were instrumented only, patients over 18 years of age with rigid deformities, Ponte osteotomies were added[2].

Preoperative mean kyphosis angles measured as 84.9°±5.0° were reduced postoperatively to 40.7°±6.5° and normal physiological thoracic kyphosis were obtained. Last control and early postoperative mean kyphosis angles did not yield a significant difference and minimal correction loss was seen while posterior fusion was gained in all patients. Preoperative

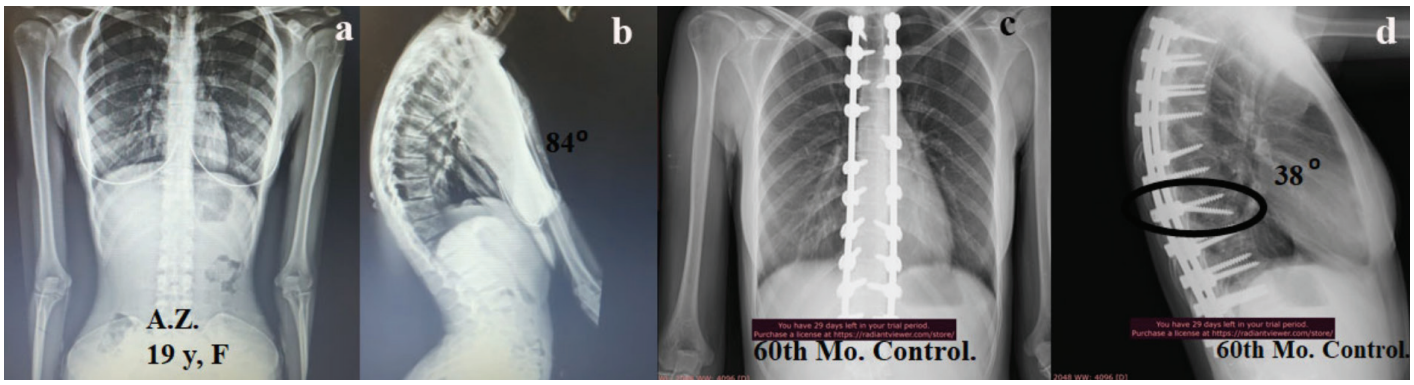

Figure 3. (a, b) Preoperative, (c, d) 60th months AP and lateral X-rays of the patient who is 19 years-old female. Preoperative Kyhosis was 84° and was corrected to 32°. There was malposition of the screws in the level of T-3. In the last control visit, thoracic kyphosis was 36°. She has no pain and neurologic deficit

AP: Anteroposterior

scoliosis angles were measured as 8.2° average was reduced to 0 degrees postoperatively. Obtained results were in concordance with the literature[2].

Bradford et al.[18] claimed that there was no difference in results of patients who were treated with anterior and posterior approaches. Etemadifar et al.[19] suggested concomitant anterior and posterior fusion surgery was better than posterior only surgery in patients in whom growth was not completed in adolescent period to minimize correction loss.

Our general practice under 18 years of age is corrective only instrumentation and as suggested in the literature corrective instrumentation with 2-3 levels of Ponte osteotomies added in patients over 18 years of age. Ten patients in adolescent age group had preoperative mean kyphosis angles of 84.6°±5.0° and postoperative mean values of 44.2°±4.6° was obtained which was statistically significant (p=0.007). Twenty-seven patients over 18 years of age had preoperative mean kyphotic angles of 85.1°±4.9° while a mean postoperative mean kyphosis angle of 40.4°±4.6° was obtained which is also statistically significant (p=0.0001).

There was no difference regarding preoperative, postoperative and last control kyphosis and scoliosis angles and SRS-22 values in between these two groups (p>0.05). Ponte osteotomy added to corrective posterior instrumentation is thought to have a role in this situation. Correction losses observed in last control while no significant statistical results were obtained were seen more in adolescent age group. Solid posterior fusion was obtained in allograft groups.

The major postoperative complication after surgical treatment is junctional kyphosis proximally or distally, which is usually related to not including all levels of the kyphosis or overcorrection of the deformity (>50%)[5]. In our study proximal and distal end vertebrae were selected as T2 or T3 and L1 and L2 as suggested in the literature. Compression was applied at last two segments to prevent junctional kyphosis and by avoiding overcorrection; we did not observe any cervicothoracic or thoracolumbar junctional kyphosis.

Neurological deficit was reported in 2% of patients in surgical treatment of Scheuermann's Kyphosis[14]. In our study we did not observe any neurological deficit after surgical correction. We do think that combined usage of SEP, MEP and EMG Neuromonitoring plays an important role. One patient had transient upper extremity brachial plexus sprain due to prone positioning which resolved in 3 months so after this complication to avoid traction injury we positioned the patients prone with arms positioned besides the torso.

Postoperative infection rates were reported as 3% while in our study we had one patient (2.7%) with deep infection treated with debridement and antibiotic therapy[2,14]. In our study group we had two patients with screw malposition's by chance which did not cause any neurological deficit. Follow-up of patients did not yield any pain no revision surgery was planned.

SRS-22 questionnaire used in our study is a life quality assessment tool in the literature. Pain, appearance, mental status, function and satisfaction from the treatment is evaluated and by having an average of these domains score is calculated over 5 points. SRS-22 Turkish questionnaire which was described and validated by Alanay et al.[6] were used in our study. Regarding all patients preoperative mean values of 3.17±0.3 was raised to 4.95±0.1 postoperatively and was found to be statistically significant (p=0.0001). Patients had no limitations in returning to school or work.

Study Limitations

The most important limitation of this study is a few numbers of patients involved in the study. Second limitation of the study is the follow-up periods of adolescent group was 103.5±13.0 months while follow-up period was 45.9±13.2 months in young adult group. This is because we do not perform any Scheuermann Kyphosis surgery regardless of kyphosis angles in 5 years recently.

CONCLUSION

As a result, in patients with kyphotic angles over 80 degrees, modern instrumentation in which correction obtained via each level segmental instrumentation with pedicle screws and pre-bend hard rods and cantilever maneuver to gain physiological kyphosis and concomitant scoliosis deformity correction is reported to be successful.

Scheuermann's Kyphosis patients treated surgically were assessed with SRS-22 questionnaire, regarding quality of life and pain reduction depicted a statistically significant result in which this questionnaire was firstly used.

Ethics

Ethics Committee Approval: Our study was approved by İstanbul University, İstanbul Faculty of Medicine Ethic Committee in 19th April, 2022 (approval no.: 850601).

Informed Consent: Informed consent forms of all patients in this study were taken.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Concept: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Design: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Data Collection or Processing: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Analysis or Interpretation: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Literature Search: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K., Writing: F.Ş., M.O.A., E.B., T.A., İ.T.B., D.K.

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