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Dear Colleagues,

We sincerely wish the happy and healthy days to all my colleagues and their families. We are happy to accomplish the second issue of 2017.

There are 7 clinical research articles in this issue. Two experimental study were presented in this issue. The first article is about the pathogenesis of idiopathic scoliosis. In the second article, the effect of human stem cell injection on thoracic spinal cord injury had been evaluated. In the third study, the result of the finite element analysis is presented. In the fourth study, surgical result of convex derotation maneuver on lumbar lordosis in the patients with Lenke Type-5 idiopathic scoliosis. In the fifth study, late results of open door laminoplasty for cervical ossifying posterior longitudinal ligament is presented. In the sixth study, analysis of the cervical sagittal parameters are evaluated in the radiographies. Seventh study is about the balloon kyphoplasty in osteoporotic patients with spontaneous vertebral compression fractures. We believe that all those studies will quietly interest the readers.

In this issue, a case report was presented. It is about the femoral entrapment syndrome.

In this issue, two review article were included. First of them is about the pulmonary function test in the adolescent idiopathic scoliosis. In the second, the management of the blood transfusion in the spinal surgery.

In this issue, in the "Frontiers of the Spinal Surgery" section, the biography was presented about the Prof. Ufuk Aydınlı. The author of this article is Prof. İ. Teoman Benli.

The preparation of the 12th International Congress of Turkish Spinal Surgery was completed. We are waiting all member of TSS for the congress.

We wish healthy, successful and peaceful days to Turkish Spinal Surgery family and we present our deepest respects.

Prof. Dr. İ. Teoman BENLİ
JTSS Editor

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Volume: 28, Issue: 2, April 2017 pp: 75/82 ORIGINAL ARTICLE / ORJİNAL MAKALE

DO BOTULINUM TOXIN-A INJECTIONS INTO THE PARASPINAL MUSCLES CREATE AN IDIOPATHIC LIKE SCOLIOSIS: AN IN VIVO STUDY ON RATS

PARASPİNAL KASLARA BOTULİNUM TOKSİN-A ENJEKSİYONU İLE İDİOPATİK BENZERİ SKOLYOZ ELDE EDİLEBİLİR Mİ? RATLARDA İN VİVO ÇALIŞMA

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SUMMARY:

Objective: Scoliosis is a spine deformity and also involves some adaptive changes of in paraspinal muscles and ligaments. Some studies found paraspinal EMG activity differences, thus, we hypothesized that blocking the muscle activity of paraspinal muscles in one side of the spine may produce a scoliotic curve.

Methods: 15 female Sprague-Dawley rats were divided into 3 groups as R, L and C. After intraperitoneal anesthesia, for Group R, Botulinum toxin-A was injected to right lumbar paraspinal muscles with the help of EMG. For Group L, Botulinum toxin-A injections were applied in the same manner, into the left paraspinal muscles. In Group C, 1 cc saline injection was applied to the right paraspinal muscles.

Results: In the R Group, left apex lumbar curve was observed in 3 rats. In the L Group, right apex lumbar curve was observed in 3 rats. In the C Group, no one developed any coronal curves. When we evaluated the curves under fluoroscopy, we realized that all of the curves were disappeared under counter-bending maneuver opposite to curves which has caused us to think that that curves were not structural curves.

Conclusion: In this study, we aimed to create a non-surgical scoliosis model in rats by injecting botulinum toxin-A into the paraspinal muscles. To our knowledge, this was the first scoliosis model used botulinum toxin-A injection. Unfortunately, we did not achieve successful results. Future studies with longer follow-up period, larger number of animals, repeated injections and higher dose of Botulinum toxin-A may create a scoliosis model.

Key words: scoliosis; animal model; rat; botolinum toxin-A

Level of Evidence: Experimental animal study, Level II

ÖZET:

Amaç: Skolyoz paraspinal kas ve ligamanlarda da bazı adaptif değişikliklerin olduğu bir deformitedir. Bazı çalışmalar paraspinal EMG aktivitelerinde bazı değişiklikler tespit etmişlerdir. Bu yüzden, bu çalışmadaki hipotezimiz paraspinal kasların bir tarafının kas aktivitesinin bloke edilmesi ile skolyotik bir eğrilik elde edilebileceğiydi.

Metod: 15 dişi Sprague-Dawley rat, R, L ve C olma üzere 3 gruba ayrıldı. İntraperitoneal anestezi sonrası, Grup R'deki ratların sağ lomber paraspinal kaslarına EMG yardımı ile Botulinum Toksin-A enjekte edildi. L grubundaki ratların sol paraspinal kasalrına aynı işlem uygulandı. C grubunun sağ lomber paraspinal kaslarına ise 1 cc salin enjekte edildi.

Sonuçlar: Grup R'de 3 ratta apeksi sol tarafta olan eğrilik oluştuğu görüldü. Grup L'de 3 ratta apeksi sağ tarafta olan eğrilik oluştuğu görüldü. Grup C'de herhangi bir koronal eğrilik görülmedi. Floroskopi altında yapılan değerlendirmede, eğrilik gözlenen ratlar eğriliğin karşı tarafına doğru eğilerek bekletildi ve eğriliklerin kaybolduğu görüldü. Bu da bize eğriliğin yapısal bir eğrilik olmadığını düşündürdü.

Çıkarımlar: Bu çalışmada ratların paraspinal kaslarına Botulinum Toksin-A enjeksiyonu yaparak cerrahi-dışı bir skolyoz modeli oluşturmayı amaçladık. Bizim bilgimize göre bu çalışma Botulinum Toksin-A kullanılan ilk skolyoz modelidir. Ne yazık ki başarılı bir sonuç elde edemedik. Daha uzun takibin yapıldığı, daha fazla hayvanın kullanıldığı, tekrarlayan injeksiyonlar ve daha yüksek dozda Botulinum Toksin-A kullanılan ileriki çalışmalarda yapısal bir skolyoz modeli elde edilebilir.

Anahtar kelimeler: skolyoz; hayvan modeli; rat; botulinum toksin-A

Kanıt Düzeyi: Deneysel hayvan çalışması, Düzey II.

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INTRODUCTION:

Adolescent idiopathic scoliosis (AIS) affects 1-3 % of the population and the etiology and pathogenesis remains still unknown. The development of this deformity may be related to development [8], genetics [7,29], muscular dysfunction [11,30], metabolic and chemical problems [31] and nervous system [3-5,27]. To better understand idiopathic scoliosis, researchers have been developing a variety of animal models to promote this three-dimensional deformity. Von Lesser [18], first described an experimental scoliosis by unilateral dissection of the phrenic nerve in rabbits and produced a thoracolumbar scoliosis. Thereafter, several experimental procedures have been reported in various animals.

The 3D deformity of AIS involves some adaptive changes of each side of the curvature in muscles and ligaments [25]. Thus, researchers tend to investigate the muscle electrical activities by surface electromyography (SEMG) in these patients.

Some studies found increased paraspinal EMG activity in the convex side [6,33].

As inspired from these muscle activities of scoliotic patients, we hypothesized that blocking the muscle activity of paraspinal muscles in one side of the spine may produce a scoliotic curve due to existing muscle activity of the other side and finally pulling and rotating the vertebrae away from the midline. Thus, we aimed to inject botulinum toxin-A to rat paraspinal muscles to create a new scoliosis model.

MATERIAL AND METHODS:

This experimental study included 15 female Sprague-Dawley rats with an age of 3-4 weeks and weight of 130-150 g, obtained from the Animal Laboratory Unit of Acibadem University. Institutional Animal Care and Use Committee approval was obtained before study initiation (ethics committee permission number 2015/27). The rats were divided randomly into 3 groups, 5 in each, as R, L and C.

For anesthesia, all the rats were administered an intraperitoneal injection of 5 mg/kg ketamine/xylazine. Before botulinum toxin-A injections, anteroposterior (AP) and lateral fluoroscopic images were taken to rule out any possible spinal anomalies and curves.

In taking the images in the AP view, the rats were placed in a head-down position, by strapping the hindlimbs and tails to the C arm tube with an adhesive tape, and rotating the C-arm 45° from the horizontal plane to eliminate the gravity effect and prevent positional curves **(Figure-1).**

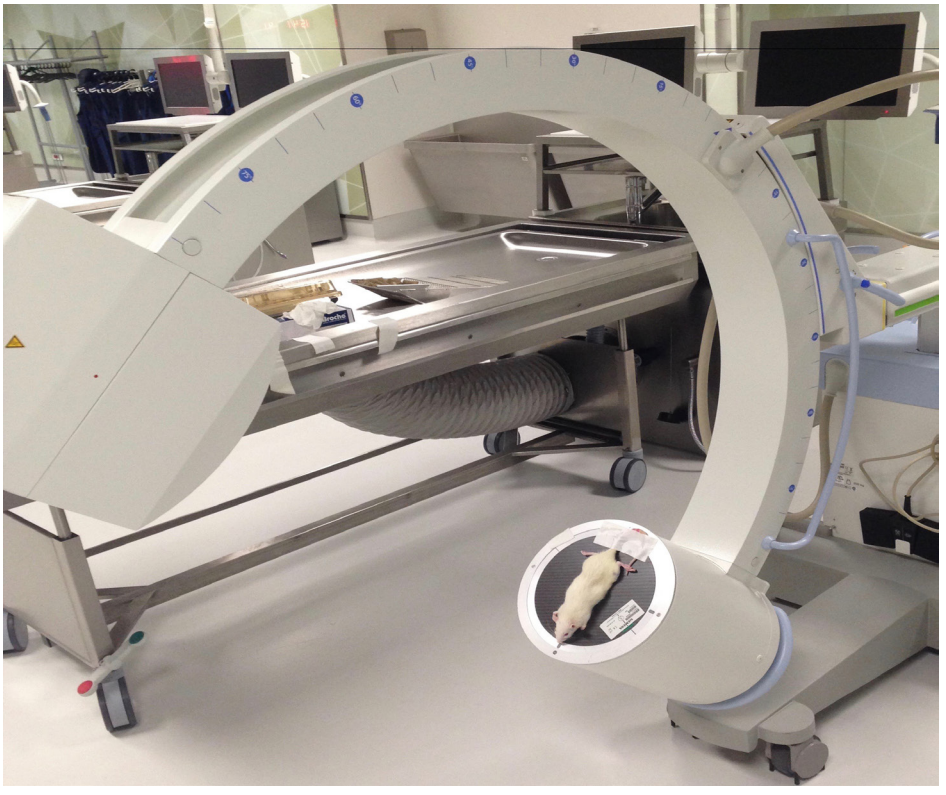

Figure-1. To eliminate the gravity effect and prevent positional curves, fluoroscopic views were taken by placing the rats in a head-down position and strapping the hindlimbs and tails to the C arm tube with an adhesive tape, and rotating the C-arm 45° from the horizontal plane.

In Group R, 3 U/kg (15) of Botulinum toxinA (Botox, Allergan, Irvine, CA) was injected to right lumbar paraspinal longissimus and ilio-costalis muscle group with the help of EMG (MP150, BIOPAC Systems Inc., Camino Goleta, California) guidance **(Figure-2).**

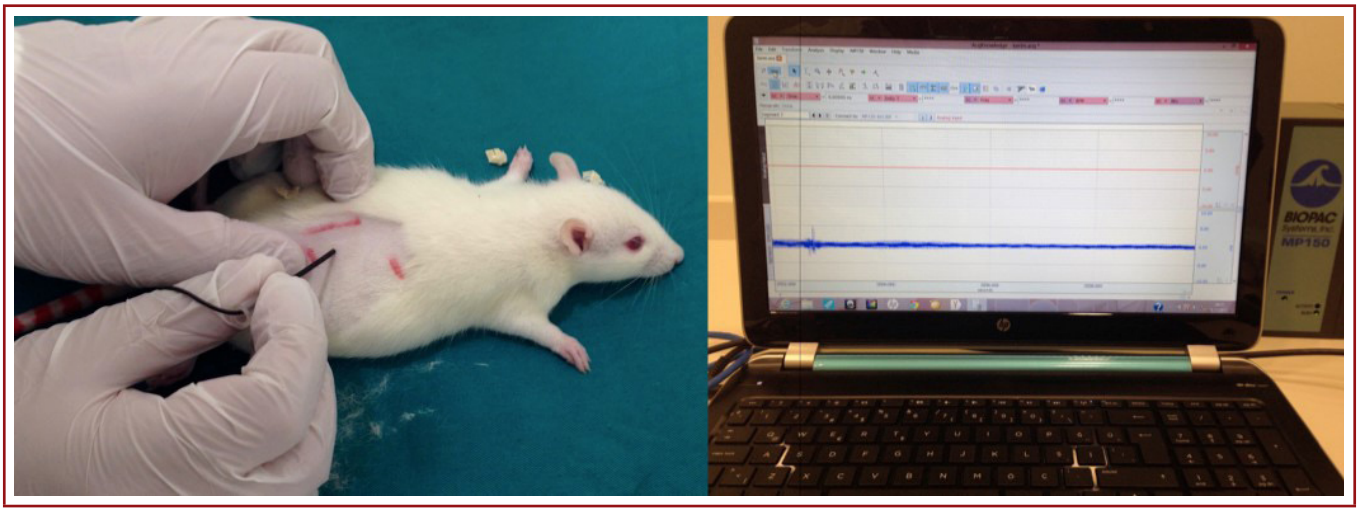

Figure-2. Botulinum toxin-A was injected to paraspinal longissimus and ilio-costalis muscle group with the help of EMG

In Group L, Botox injections were applied in the same manner, into the left paraspinal muscles. In Group C (control group), 1 cc saline injection was applied to the right paraspinal muscles and followed if they develop a curve during the follow-up period.

Rats were housed in group cages in an air-conditioned room with controlled lighting (lights off from 7.00 p.m. to 7.00 a.m.) and given *ad libitum* access to food and water. After 3 months, following intraperitoneal ketamine/xylazine injection, fluoroscopic images were taken for all rats in the same manner mentioned above.

RESULTS:

In the R Group, left apex lumbar curve was observed in 3 rats. Two rats did not develop any curves and showed a straight spine in the AP view **(Figure-3).**

In the L Group, right apex lumbar curve was observed in 3 rats, however, 2 rats did not show any scoliotic curve **(Figure-4).**

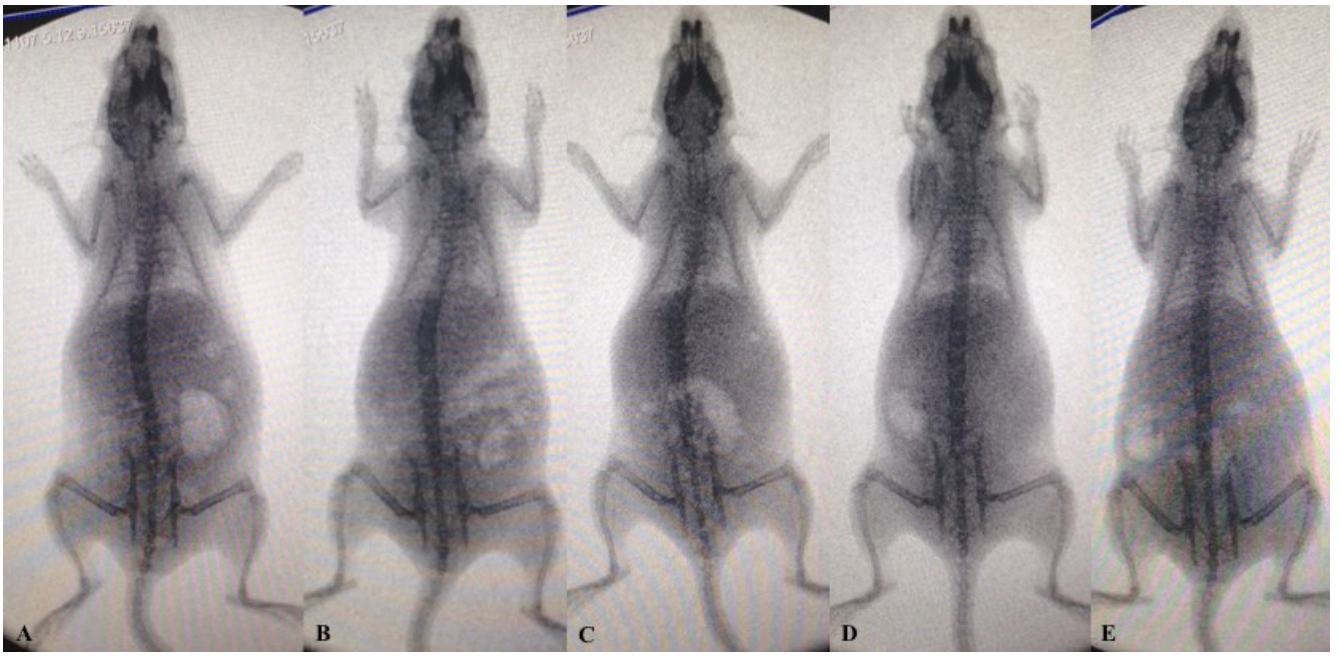

Figure-3. Fluoroscopic views of Group R, 3 months after botulinum toxin-A 432 injection.

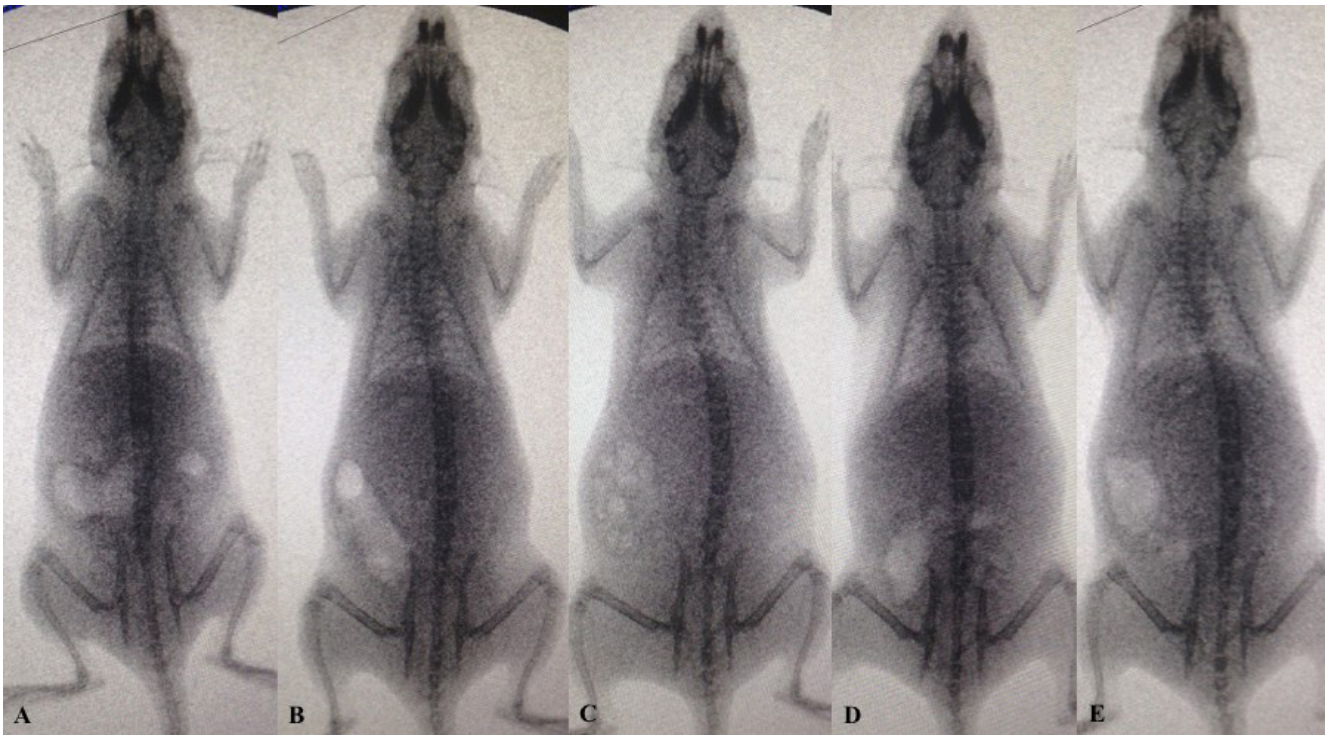

Figure-4. Fluoroscopic views of Group L, 3 months after botulinum toxin-A 435 injection.

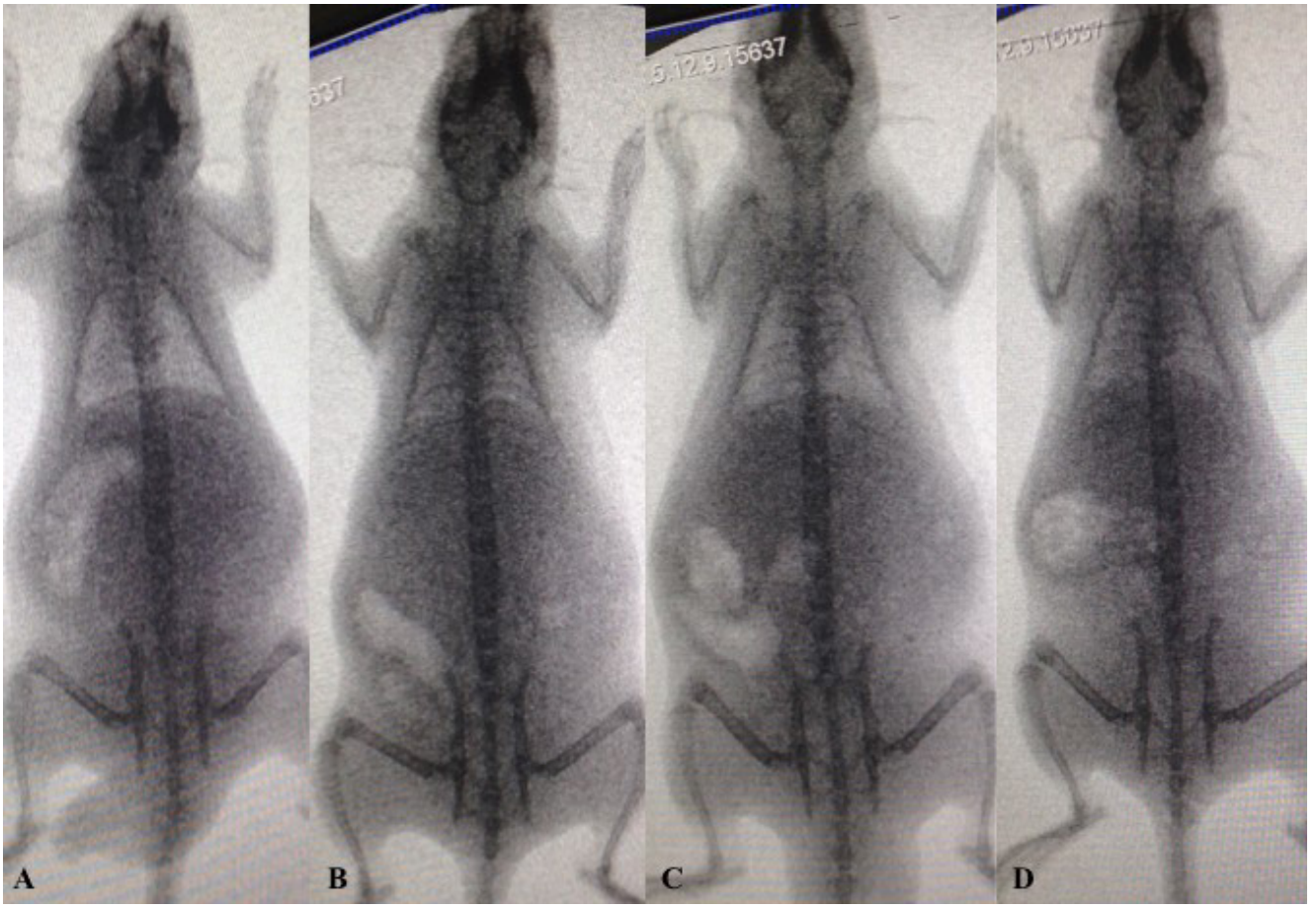

Figure-5. Fluoroscopic views of Group C, 3 months after botulinum toxin-A 438 injection.

In the C Group, one rat died one-day after saline injection due to an unexplained cause. Remaining 4 rats, did not develope any coronal spinal curves during the follow-up period. **(Figure-5).**

When we evaluated the curves under fluoroscopy, we realized that all of the curves were disappeared under counter-bending maneuver opposite to curves which has caused us to think that that curves were not structural curves.

DISCUSSION:

Despite the various studies of AIS, the etiopathogenesis is still unknown and studies continue to enlight this issue. Animal models are frequently used to investigate the etiology, however, there is no animal model that replicates this deformity in its multiple characteristics [23].

In a review about animal models, Janssen et al [17], found that chicken is the most widely used experimental animal for scoliosis research, followed by the rabbit, rat and mouse. Primates, sheep, pigs, goats, cows, frogs and dogs also had been used. Although chickens are frequently used, despite the fact that chicken is bipedal, the anatomy and biomechanics is completely different from human [17]. In our research, we used rats, because of their low cost and easy handling. The disadvantage of these rodents is the fact that they are quadrupedal. To create a bipedal model, Goff and Landmesser [12], amputated the forelegs and tail in newborn rats and mice. Rats rapidly developed an upright erect walking. Subsequently, many researches used bipedal rats in scoliosis research, and found that bipedal rats and mice showed higher incidences of scoliosis compared with quadrupedal counterparts [2,19-21,24,34]. However, it is clearly known that even the spine of bipedal rats and mouse is not loaded in a similar way as the standing human spine due to humans' fully extended knee and hip upright ambulation biomechanics [17]. Additionally, it has been demonstrated that scoliosis is not exclusive to bipedalism [13]. Thus, to investigate our hypothesis, we used quadrupedal rats in this preliminary study.

Different scoliosis animal models, such as genetic, neuroendocrine, neurologic, growth disturbance, mechanical, teratogenic and spinal cord injury models were used in the literature [23]. Most of the scoliosis animal models are invasive procedures such as pinealectomy, brain stem damage, resection of posterior elements, epiphysiodesis, intercostal nerve resection, spinal cord damage, hemilaminectomy and posterior tethering has been widely used. The disadvantages of these procedures were that they are invasive. Damaging the paraspinal tissues may lead to subjective results about the scoliosis model. Although most of the animal studies which focus on producing experimental studies are invasive and surgical procedures, rare noninvasive experimental scoliosis models exist [17].

Poussa et al [28] used an external split in skeletally immature rabbits and obtained scoliosis in over 50 % of the animals. Similarly, Hakkarainen [14] produced scoliosis by a three-point plaster cast in rabbits.

Silva et al [32] immobilized the rats by two wests (scapular and pelvic) which were attached to each other externally, and bend them to right side, and finally they achieved scoliosis after 12 weeks. The advantages of noninvasive scoliosis models were that they do not use any type of surgery, they are very simple and do not affect the surrounding tissues of the spine. Additionally, these non-invasive models can be easily prepared and applied to a large number of animals in a short time period with low costs.

Previous studies showed paraspinal electomyographic activity differences between the convex and concave sides of the scoliotic curve [6,35-36]. This may be related to muscular weakness or paravertebral muscle stretching on the convex side. However, it is not clear that these electomyographic changes are due to scoliosis or they cause scoliosis. In a clinical study, Acaroglu et al [1] investigated calmodulin and melatonin levels in adolescent idiopathic scoliosis patients' paravertebral muscles, samples taken during the surgeries and, found higher calmodulin at the convex side and lower at the concave side. Melatonin ratios were not found to be significantly different.

Botulinum toxin is a neurotoxic protein produced by the Clostridium species. It acts by binding presynaptic cholinergic nerve terminals and decreasing the release of acetycholine, causing a neuromuscular block. It is also developed for medical, cosmetic and research use. As a therapeutic use, is can be used for spasticity, dystonia, involuntary muscle activity, chronic muscle pain, strabismus, muscle hyperactivity disorders and cosmetic problems [16]. In light of the paraspinal muscle activities in scoliotic curves, we hypothesized that blocking the muscle activity of paraspinal muscles in one side of the spine may produce a scoliotic curve, thus we planned this animal study, however we did not obtain structural curves. This may be related with inadequate follow-up time or low dose of Botulinum toxin-A injection.

This study has several limitations. First, this is an in vivo animal study and can not simulate an in vivo human characteristics due to different phylogenetic, biomechanics and anatomic features. To create a scoliosis model with higher incidence, bipedal rats could be used, however, it is clearly shown that in scoliosis can be produced in quadripedal animals. It can be a future study to use bipedal rats with similar methodology. The rats could be followed longer than 3 months, however, the reported selective blocking effect of botulinum toxin A usually wears off 3-4 months after injection [10] and current accepted inter-injection interval is generally 12 weeks or more [22], thus we followed the rats 3 months, which was the botulinum toxin-A maximum effect duration. Lastly, we injected 3 U/kg

botulinum toxin-A, and higher doses could be used up to 18 U/kg safely according to previous studies [9,26].

Animal scoliosis models have been widely used to understand the etiology of scoliosis. In this current animal study, we aimed to create a non-surgical scoliosis model in rats by injecting botulinum toxin-A into the paraspinal muscles, unfortunately, we did not achieve successful results. Future studies with longer follow-up period, larger number of animals, repeated injections and higher dose of Botulinum toxin-A may create a scoliosis model.

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Volume: 28, Issue: 2, April 2017 pp: 83/90 ORIGINAL ARTICLE / ORJİNAL MAKALE

HUMAN MESENCHYMAL STEM CELL THERAPY IN THORACIC SPINAL CORD INJURY AND EVALUATION OF THE RESULTS-AN EXPERIMENTAL STUDY IN RATS

SIÇANLARDA TRAVMATİK ALT TORASİK OMURİLİK YARALANMASINDA İNSAN KAYNAKLI MEZENKİMAL KÖK HÜCRE TEDAVİSİ VE SONUÇLARININ DEĞERLENDİRİLMESİ

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SUMMARY:

Objective: The aim of this study is to investigate the hyper-acute and acute effects of mesenchymal stem cell (MSC) therapy on traumatic spinal cord injury (SCI) in an experimental animal model.

Materials and Methods: The study was carried out on 60 male Sprague-Dawley rats weighing 400- 500 grams. The subjects were separated into six groups. In-group 1, only thoracic 10 laminectomy was performed. In-group 2, trauma was applied to the spinal cord by using modified Allen trauma model after T10 laminectomy. In group 3, T 10 laminectomy and spinal cord injury was immediately followed by injection of 0.9 % 10 NaCl. In group-4 "1.1- Dioctadecyl-3.3.3´.3´-tetramethyllindocarbocyanine" labeled MSC derived from male human bone marrow was implanted to injury site immediately after spinal injury. In group-5, the MSC was implanted nine hours after spinal injury. In the last group 0.9 % NaCl was administered nine hours after T 10 laminectomy and spinal injury at this segment. All groups were sacrificed at the end of four weeks. The neurologic status was checked at Days 1,7,14,21 and 28 using BBB (Basso-Beattie, Bresnahan) locomotor rating scale and inclined plane values. Hematoxylin eosin, and Masson trichome staining were used to assess the degree of inflammation and fibrosis. In order to confirm the Y chromosome signal content of the cells, Y-18 chromosome specific centromere probe was used.

Results: Our results showed that MSC therapy has the potential of reducing the degree of inflammation and contributing to functional improvement following SCI. There was statistically significant difference between the hyperacute and nine hours delayed treatment groups.

Conclusion: The results of this research is in agreement with the findings of previously published studies indicating the neuroprotective nature of MSC.

Key Words: Mesenchymal stem cell, Thoracic spinal cord injury, treatment

Level of evidence: Experimental study, Level I

ÖZET

Travmatik omurilik yaralanmasında yüksek morbidite ve mortaliteye sebep olan önemli bir sağlık sorunudur. Travma sonrası ortaya çıkan fonksiyon kaybı, hem birincil yaralanmaya hem de birincil yaralanmanın tetiklediği ikincil yaralanma mekanizmalarına bağlıdır. son yıllarda TOY'ında kök hücre kullanımının umut verici sonuçlar vermiştir. TOIY'nda farklı kaynağı olan nöronal progenitör hücreler, nöronal kök hücreler, embriyonik kök hücreler veya mezenkimal kök hücreler kullanılamkatadır. Biz çalışmamızda ratlarda travmatik alt torasik yaralanmasında insan kaynaklı MKH tedavisi ve sonuçlarını inceledik.

Anahtar Sözcükler: mezenkimal kök hücre, torasik spinal kord yaralanması, tedavi.

Kanıt Düzeyi: Deneysel çalışma, Düzey I

INTRODUCTION

Spinal cord injury is a major cause of morbidity and mortality. The level and extent of injury are the main factors determining the outcome. Traumatic SCI occurs mostly at low cervical and thoracolumbar junction segments. Males are more frequently affected by traumatic SCI than females. In USA estimated annual incidence of SCI, not including those who die at the scene of accident, is nearly 40 cases per million population as of June 2009 or approximately 12000 new cases each year. Motor vehicle accidents account for 42.1 % of SCI, followed by falls (26.7 %), act of violence (15.1 %) and sports injuries (7.6 %). Only 11.5 % of traumatic SCI patients have been able to return to their regular jobs one year after trauma. The life-long therapeutic expenses of a 25 years old tetraplegic patient is approximately 1,800,000 $ [13].

In Turkey 18,000 new cases are added each year and a total of 54,000 neurologically disabled individuals survive as a result of SCI. Surgery seems to have little beneficial effect in SCI and in most cases neurologic improvement is limited. Decompression and instrumentation procedures aim to stabilize the spinal column thus allowing early mobilization and rehabilitation.

Fehlings and associates have conducted an international cohort study and have found that early decompression reduced secondary injury in SCI. However, with surgical therapy only 19.8 % of the 313 patients included into the study showed two or more grades of improvement in American Spinal Injury Association status [10].

In spite of all efforts, neuroprotection and spinal regeneration are not successful so far. The three properties of effective adjuvant therapy for SCI were mentioned as immunomodulation, neurotrophic properties to stimulate axonal growth and ability to replace injured cells [29]. Stem cell therapy seems to be a potentially beneficial mode of therapy in the management of traumatic SCI.

MATERIALS AND METHODS

The study was approved by the Ethic Committee of the Başkent University (January 17, 2011, DA 11/24) and was conducted at the Animal Breeding and Experimental Research Laboratory of Başkent University. A total of 60 Sprague-Dawley male rats weighing 400-450 grams were used. The general health of the subjects was checked prior to study. Each animal was marked according to its group. The subjects were kept in cages at room temperature of 25 º C on a 12 h light-12 h dark cycle. There was no food or water restriction. Bladders were emptied regularly. Subjects were subjected to overnight fasting before anesthesia. Anesthesia was induced by intraperitoneal injection of 60 mg/kg Ketamin (Ketalar® Pfizer) and 10 mg/kg Xylazine (Rompon®- 2 % Bayer). Anesthesia provided unresponsiveness to pain while spontaneous respiration was maintained. Additional doses were administered when necessary. The body temperatures were controlled by rectal temperature probes and was kept constant at 37° C. During the procedure, O2 at a rate of 1.5 lt./min was administered by mask. After the study the subjects were kept at room temperature of 23-25º C. After recovery from anesthesia the rats were shaved on the back and were placed on the operating table.

Povidine-iodine (Betadine®) was used for local antisepsis. A median skin incision has been made. Subperiostal blunt dissection of paravertebral muscles was followed by exposure of T 9 and T 10 laminae. T 10 laminectomy was performed with the help of rongeur. The spinal cord was exposed. Care was taken not to injure the spinal cord during surgical manipulations. Unintentionally injured animals were excluded from the study. Dura was left intact in group 1. In groups 2-6 spinal cord injury was induced by using the modified Allen method.

This method required 5 gr. steel weights specially designed for rats which were dropped perpendicular to the spinal cord through a 10 cm. long glass tubes. In groups IV and V " 1.1-Dioctadecyl-3.3.3´.3´-tetramethyllindocarbocyanine" labeled MSC derived from male human bone marrow was implanted. In groups III and VI % 0.9 SF was injected. Behavioral analysis (BBB) was checked on day 1, 7, 14, 21 and 28 in the late sacrificed subjects.

Sacrifice was done under deep anesthesia by drawing blood from the heart and intra-cardiac perfusion-fixation method.

Summary of groups:

Group I control group: only T 10 laminectomy.

Group II trauma group: T 10 laminectomy and SCI.

Group III hyperacute trauma group: T 10 laminectomy, SCI and 3x2 µL % 0.9 SF injection at injury site immediately after trauma.

Group IV hyperacute trauma and MSC group: T 10 laminectomy, SCI and male human bone marrow derived 3x2 µL MSC implantation immediately after trauma.

Group V acute trauma and MSC group: T 10 laminectomy, SCI and 3x2 µL MSC implantation 9 h after trauma.

Group VI acute trauma group: T 10 laminectomy, SCI and 3x2 µL % 0.9 SF injection 9 h after trauma.

Statistical analysis

Statistical analysis was performed with SPSS software (SPSS for Windows, Version 11.5, SPSS Inc, Chicago, IL, USA). Univariate parametric variance analysis was used for groups which did not fulfill the requirements of parametric test (ANOVA). Nonparametric data were analyzed with Kruskall

Wallis test. In order to investigate differences between the groups, Tukey test was used for parametric and Dunn test was used for nonparametric data. Statistical significance was defined by $p < 0.05$. The ratios were compared with Z test. $Z < 1.96$ values were regarded as statistically significant.

RESULTS

Tissue inflammation levels: Inflammatory cell levels were measured. Inflammation levels were addressed as none, minimal, moderate and severe. No inflammation was observed in 66.7 % of the subjects in "only laminectomy" group. In both hyperacute trauma group followed by stem cell therapy and acute trauma group followed by injection of SF, 16.67 % inflammation was observed. Severe inflammation was noted in 28.6 % of the subjects in acute and hyperacute trauma groups followed by stem cell therapy . No significant difference was found between the degree of inflammatory cell levels ($p > 0.05$).

Results of tissue inflammation level is shown in Table-1.

Tissue fibrosis levels: Fibrosis was graded as none, minimal, moderate and severe. Fibrosis was absent in 31.6 % of the " only laminectomy" group. In the other groups the rate was 26.3 %, 15.8 %, 10.5 %, 0 % and 15.8 % respectively. In the "acute trauma" plus MSC therapy group 100 % fibrosis was noted. In the "hyperacute trauma" plus MSC therapy group severe fibrosis was 0 %. There was statistically significant difference between the fibrosis levels ($p<0.05$). Tissue fibrosis results are shown in Table-2.

Tissue signal levels: Y chromosome signal was assessed as present or absent in the "acute" and "hyperacute plus MSC therapy" groups. In 88.9 % of the "acute trauma plus MSC therapy" group Y chromosome was present and the rate was 11.1 % in the" hyperacute trauma plus MSC therapy" group. There was statistically significant difference between the Y chromosome signal levels ($p< 0.05$). Tissue signal level results are shown in Table 3.

Light microscopy results: Normal findings were observed in the control group. Moderate amount of inflammatory cells and minimal fibrosis were seen in "only laminectomy" and trauma groups. In the "hyperacute trauma plus SF injection" group, moderate amount of inflammatory cells and minimal fibrosis were observed. In the "hyperacute trauma plus MSC therapy" group inflammatory cells and fibrosis were minimal. In the group with MCS therapy 8 hours after trauma, moderate amount of inflammatory cells and severe fibrosis were observed. In the acute trauma group with SF injection after trauma, moderate amount of inflammatory cells and minimal fibrosis were observed.

Table-1. Tissue inflammatory cell analysis results

	None	Minimal	Moderate	Marked
Control	66.7	14.3	0	0
Trauma	0	14.3	23.8	14.3
Trauma+hyperacute SF	0	14.3	23.8	14.3
Trauma+hyperacute MSC	16.7	19	14.3	28.6
Trauma+acute MSC	0	19	19	28.6
Trauma+acute SF	16.7	19	19	14.3

Table-2. Tissue fibrosis analysis results

	None	Minimal	Moderate	Marked
Control	31.6	3.7	0	0
Trauma	26.3	14.8	0	0
Trauma+ hyperacute SF	15.8	22.2	0	0
Trauma+ hyperacute MSC	10.5	25.9	16.7	0
Trauma+ acute MSC	0	14.8	50	100
Trauma+ acute SF	30	50	20	0

Table-3. Tissue signal level results

	Present	Absnet
Trauma+hyperacute MSC	11.1	81.8
Trauma+acute MSC	88.9	18.2

FISH results: In the "hyperacute trauma" group in which MSC was implanted immediately after trauma, only in one subject X and Y signals were observed. In the "trauma group" in which MSC was implanted 8 h after trauma, X and Y signals were observed in 8 subjects.

Basso-Beattie-Bresnahan(BBB) Locomotor Rating Scale: In the first post-trauma day all subjects experienced marked paresis in their back limbs. In the following weeks, partial recovery was seen. The group receiving MSC therapy 9 hours after trauma showed statistically significant improvement compared to the group receiving MSC therapy immediately after trauma. The improvement has begun on the seventh day and was maintained until the end of the study. Behavioral analysis (BBB) was checked on Day 1, 7, 14, 21 and 28. The BBB results are shown in Table-4.

Inclined plane rating: Coordinated motor functions of the subjects were tested up and down slopes. Front limbs were evaluated during climbing and back limbs were evaluated during down slope. There was no statistically significant difference between the "MSC therapy groups" and "SF injected group" while climbing ($p>0.05$). There was statistically significant difference between the "MSC therapy" groups and "SF injected" group while down slope ($p< 0.05$). This difference started on the first day of the study and maintained until the end. The differences among the MSC therapy groups were not statistically significant ($p>0.05$). Based on behavioral analysis, the positive effects of stem cells on the disturbed motor functions of back limbs due to spinal cord injury were observed.

Inclined plane climbing values and inclined plane down slope values are illustrated on Tables-5 and 6 respectively.

Table-4. The BBB values Av: Average, SE: Standard error of mean, Min: Minimum, Max: Maximum

	Day 1	Day 7	Day 14	Day 21	Day 28
TRAUMA					
Av.±SE	0.69±0.285	3.5±0.377	6.68,00±0.308	8.35±0.340	10,55±0.340
Median	1.00	4.00	7.00	9.00	11.00
Min-Max	0.00-2.00	3.00-5.00	6.00-8.00	8.00-10.00	10.00-12.00
MSC (hyperacute)					
Av.±SE	1.37±0.202	6.25±0.340	10.14±0.340	11.42±0.297	13.71±0.184
Median	2.00	7.00	11.00	14.00	16.00
Min-Max	1.00-2.00	6.00-8.00	10.00-12.00	12.00-14.00	15.00-16.00
MSC acute					
Av.±SE	1.00±0.218	6.14±0.340	10.14±0.260	12.71±0.359	14.85±0.340
Median	1.00	6.00	10.00	12.00	15.00
Min-Max	0.00-2.00	5.00-7.00	9.00-11.00	12.00-14.00	14.00-16.00

Table-5. Inclined plane climbing values Av: Average, SE: Standard error of mean, Min: Minimum, Max: Maximum

	Day 1	Day 7	Day 14	Day 21	Day 28
TRAUMA					
Av.±SE	45.57±2.608	53.28±2.542	55.7.±2.369	60.14±2.142	63.28±2.542
Median	50.00	55.00	60.00	65.00	65.00
Min-Max	35.00-55.00	40.00-60.00	45.00-65.00	50.00-65.00	50.00-70
MSC (hyperacute)					
Av.±SE	51.57±0.922	57.28±0.714	60.85±1.010	64.42±0.922	66.97±0.922
Median	55.00	60.00	65.00	65.00	65.00
Min-Max	50.00-55.00	55.00-60.00	60.00-65.00	65.00-70.00	65.00-70.00
MSC acute					
Av.±SE	51.12±2.608	56.14±1.010	61.12±0.922	63.71±2.020	65.85±1.010
Median	50.00	55.00	60.00	70.00	70.00
Min-Max	40.00-60.00	55.00-60.00	60.00-65.00	60.00-70.00	65.00-70.00

Table-6. Inclined plane down slope values Av: Average, SE: Standard error of mean, Min: Minimum, Max: Maximum

	Day 1	Day 7	Day 14	Day 21	Day 28
TRAUMA					
Av.±SE	11.35±1.844	16.04±2.640	22.32±2.102	23.42±2.102	31.52±2.608
Median	10.00	15.00	20.00	25.00	30.00
Min-Max	10.00-20.00	10.00-30.00	15.00-30.00	20.00-35.00	25.00-40.00
MSC (hyperacute)					
Av.±SE	40.42±0.922	45.62±0.922	51.32±0.922	56.14±1.010	62.65±1.010
Median	40.00	45.00	50.00	55.00	65.00
Min-Max	40.00-45.00	45.00-50.00	50.00-55.00	55.00-60.00	60.00-65.00
MSC acute					
Av.±SE	40.00±2.182	43.28±1.700	47.28±2.020	53.28±2.020	57.28±2.020
Median	40.00	45.00	50.00	55.00	60.00
Min-Max	30.00-50.00	35.00-50.00	40.00-55.00	45.00-60.00	50.00-65.00

DISCUSSION

Traumatic spinal cord injury is an event with serious consequences and there is no definite medical treatment yet. Surgical decompression and instrumentation have little impact in neurologic recovery and in most of the cases he aim of surgical intervention is early mobilization and rehabilitation.

Stem cells have been tried in the treatment of many central nervous system diseases like amyotrophic lateral sclerosis, Parkinson's disease, Huntington's disease, stroke and multiple sclerosis.

More specifically MSCs have been transplanted in human subjects with multiple sclerosis [7,8,37] and Parkinson's disease [4]. There are many researches on effects of MSCs in animal model of Parkinson's disease [28,31].

Human adipose-derived stem cells have been noted in a wide variety of central nervous system disorders including spinal cord injury [5]. The recent studies on the mechanisms of cellular damage following SCI has emphasized the reliability of Allen's original description [1] of two phases of injury in 1911. The primary phase is the insult immediately after trauma and includes compression, contusion and/or laceration of the spinal cord. This is associated with the impact of the trauma. Damage to neurons, glial cells, and demyelination of the spinal tracts lead to anatomical discontinuity [35]. In practice, there is no definitive treatment for the first stage of insult and only preventive measures can be taken to minimize the damages of spinal trauma. No mode of therapy has succeeded in neuronal regeneration or marked clinical improvement of injured spinal cord tissue so far [2,11,14-18,22,32-34].

The attention has been focused on cellular therapy. This includes MSCs, pluripotent stem cells, embryonic stem cells, Schwann cells, olfactory cells, inhibitory molecules and gene therapies [13,23,30].

MSCs are multipotent adult progenitor cells which can differentiate into different types of mesodermal tissues including bone, cartilage, muscle and blood vessels. Bone marrow and umbilical cord blood are the richest sources of MSCs, however they can also be found in adipose tissue, skeletal muscle, trabecular bone and teeth [9]. It is generally believed that MSCs can be induced to secrete neurotrophic factors which may play a role in promoting axon growth, angiogenesis and anti-inflammatory actions [24]. MSCs have the disadvantage of causing increased incidence of hematological and other malignancies and tumor metastases [36].

Adult bone marrow MSC and neural crest stem cells have been found capable of inducing motor recovery in mice after SCI. They also may modify the inflammatory reaction in the lesion site. MSCs were able to secrete chemokines and attract macrophages in vitro. The authors concluded that both cell types have beneficial effects in experimental SCI [25].

Kim and associates have conducted a research regarding the effects of early IV injection of adipose-derived MSC in acute spinal cord injury in dogs. Their results revealed that adipose-derived MSC after acute SCI may prevent further damage through enhancement of antioxidative and anti-inflammatory

mechanisms and the authors have suggested that this treatment could be used as an alternative IV treatment modality for acute SCI [19]. 188

Bone-marrow derived MSCs were injected via intratechal route in a patient with a chronic (54 months) incomplete spinal cord injury in the form of atlanto-axial subluxation. The patient was followed by magnetic resonance (MR). Immediate MR after transplantation showed hypointense signal of paramagnetic substance tagged stem cells in the lumbar subarachnoid space. The same finding was observed at the surface around the cervical spinal cord at 48 hours, but it faded after two weeks and disappeared after one month. There was no neurologic improvement. There were some procedure related complications [6].

A phase III trial was performed in 16 patients with chronic ASIA B level who had experienced cervical trauma more than one year ago and showed no neurologic improvement during the last 3 months in spite of intense rehabilitation. Autologous MSCs were injected into the intramedullary compartment at the injured segment and MSCs were also injected into the subdural space. Outcome was evaluated at 6 months with neurologic examination, magnetic resonance imaging, diffusion tensor imaging MR (DTI-MR), and with electrophysiological analyses. Two patients showed neurologic improvement. The DTI -MR scans of these patients have revealed an appearance of continuity in the spinal cord tract. No complications were observed associated with MSCs injection. The author's remark was that the single MSCs application to intramedullary and intradural space is safe with very weak therapeutic effect compared to multiple MSCs injections [26]. Although the results of MSC therapy in experimental animal models of SCI are encouraging, clinical trials with MSC are few and the neurologic improvement especially in chronic SCI patients is not so satisfactory [3,20,27,37-38].

Cellular therapy for SCI may be successful by decreasing cell death, stimulating axonal growth or myelinated existing axons and replacing injured cells. Induced pluripotent stem cells may be help achieving this goal. It has been shown that mature adult cells can be reprogrammed to become immature stem cells [30]. More clinical studies with better outcome are needed to pave the way for effective MSC treatment in SCI.

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Volume: 28, Issue: 2, April 2017 pp: 91-98 ORIGINAL ARTICLE / ORJINAL MAKALE

COMPARISON OF TITANIUM SCREW WITH POLYESTER BAND WITH CLAMP (LOTUS) AND RIGID TITANIUM TRANSVERSE BINDER SYSTEM USING THE FINITE ELEMENT ANALYSIS

SONLU ELEMENT ANALİZİ KULLANILARAK TİTANYUM VİDA POLYESTER BAND KELEPÇE YÖNTEMİ (LOTUS) VE RİJİD TİTANYUM TRANSVERS BAĞLAYICI SİSTEMİN KARŞILAŞTIRILMASI

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SUMMARY:

Objective: There are many studies in the literature for posterior spinal instrumentations. In this study, we compared a titanium screw with a polyester band with a clamp (LOTUS) and a rigid titanium transverse binder system, which are used in the lower lumbar region and to examine the strength and superiority of the systems against each other with the finite element (FE) analysis.

Material and Methods: A Ti6Al4V grade 5 titanium biocompatible alloy support for a pedicle-based posterior stabilization system and a polyethylene band support for a pedicle-based posterior stabilization system were compared as testing material.

Results: Range of motion was decreased by 95.8 % when a pedicle-based stabilization system was used at L4–L5. Range of motion was decreased further, about 1%, when the polymer band was used in conjunction with a posterior stabilization system in axial rotation.

Conclusion: Similar results were observed when a titanium transverse connector was used. In light of the results of all finite element analyses, neither the titanium screws with a polyester band with a clamp (LOTUS) nor the rigid titanium transverse binder system has a significant superiority over the other. Equivalent results in the limitation of movement and rigidity allow the use of these systems in short-segment posterior spinal instrumentation with the same indications.

Key words: Finite element analysis, spinal biomechanics, pedicular screw

Level of evidence: Retrospective clinical study, Level III

ÖZET:

Amaç: Literatürde posterior spinal enstrümantasyon için pek çok çalışma vardır. Biz bu çalışmada lomber bölgede, sonlu eleman (FE) analiziyle, polyester bant sıkılaştırıcı ve rijit titanyum transvers bağlayıcı sistemleriyle bağlanmış titanyum vidanın, birbirlerine üstünlüklerini ve güçlerini değerlendirdik.

Materyal – Metot: Test materyali olarak, Ti6Al4V grade 5 biyolojik uyumlu alaşıma sahip pedikül temelli posterior stabilizasyon sistemi ve polietilen bantla desteklenmiş pedikül posterior stabilizasyon sistemi karşılaştırıldı.

Bulgular: Sonuç olarak, pedikül temelli stabilizasyon sistemi L4-5'de kullanıldığı zaman hareket oranı % 95.8 azaldı. Posterior stabilizasyon sisteminin bağlantısında polimer bant kullanıldığında, posterior stabilizasyon sistemi aksiyel rotasyonunun hareket oranı yaklaşık % 1 azaldı.

Sonuç: Titanyum transvers bağlantı kullanıldığında benzer sonuçlar gözlendi. Tüm sonlu eleman sonuçlarının ışığında ne polyester bant kullanılan titanyum vidalarda ne de rijit titanyum transvers bağlantı sistemi kullanılan sistemde diğerine önemli bir üstünlük gözlenmemiştir. Aynı endikasyon ile rijit alaşımların kullanıldığı kısa segment posterior spinal enstrümantasyon sisteminin hareketin sınırlandırılmasındaki sonuçları eşit bulunmuştur.

Anahtar Sözcükler: Sonlu eleman analizi, omurga biyomekaniği, pediküler vida

Kanıt Düzeyi: Retrospektif klinik çalışma, Level III

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INTRODUCTION

Rigid stabilizations with pedicle screw and rod-plate systems in patients with degenerative lumbar stenosis are the most widely accepted and applied fusion systems in the literature [1-2,6].

It has been reported that the transverse binders increased the mechanical strength of the system in the system stabilizations. The systems, which were connected with clamps to two rods made of titanium, are used widely as transverse binders. The idea of allowing minimal movement in the system has emerged with the development of science and technology. It is believed that the polyester band system, which is seen among new systems, may allow the minimal amount of movement. These systems are now used for instability due to spinal trauma, infection, tumor, deformity and degenerative disease [1-10].

In the study, a titanium screw with a polyester band with a clamp (LOTUS) and a rigid titanium transverse binder system were compared at flexion, extension and rotation in the systems where the transpedicular screw system is placed at the L4 and L5 levels. Besides the new system's ease of use, the superiority against the rigid titanium transverse binder system and the disadvantages are not exactly known [1].

MATERIAL AND METHODS

Intact FE model

A three-dimensional (3D) FE model of L1 to sacrum segments of the lumbar spine was developed. The geometry of the vertebrae was obtained from the CT scan data of a healthy 35-year-old male. The CT data were processed in MIMCS software (Mimics® Version 14.1; Materialise, Inc., Leuven, Belgium). The segmentation process was utilized to obtain the three-dimensional surface representation of each vertebra in STL format. The lordosis curvature was measured to be 25°. The multi-block approach introduced in the IA-FEMESH software (University of Iowa, IA) by Kallemeyn et al. was used to generate mesh [7]. The STL model of each vertebrae and disc was separately imported into the IA-FEMESH software in a three-dimensional surface. The blocks helped create the volumetric hexahedral mesh of the disks and vertebrae [4]. Three-dimensional gap contact 31 elements (GAPUNI) were used to simulate the facet joints between the vertebrae. ABAQUS software (ABAQUS®, Version 6.10-2; Abaqus, Inc., Providence, RI, USA) was used for all the simulations.

The circular mesh pattern on the disc helped to model the concentric rings of the annulus ground substance [3]. The rebar option of ABAQUS, oriented ±30° to the horizontal plane, was used to model the fibers in the annulus. The "no compression" option of the ABAQUS software was used to restrict the fibers only under tension loading. The Neo-Hookean hyperelastic model was used to simulate the behavior of the annulus. Further, the fluid behavior of the nucleus was simulated using a hexahedral element, which was assigned a very low stiffness (1 MPa) and near-incompressibility (Poisson's ratio ʊ = 0.4999).

The ligaments were simulated using 3D truss elements, which were constrained to act nonlinearly only in tension. All seven major ligaments, i.e., the anterior longitudinal ligament (ALL), posterior longitudinal ligament (PLL), ligamentum flavum (LF), intertransverse ligament (ITL), interspinous ligament (ISL), supraspinous ligament (SSL) and capsular ligament (CL), were represented. The complete model consisted of 72,193 nodes and 55,650 elements that represented the entire structure of the lumbar spine **(Figure-1,2).**

The material properties of various components of the lumbar model (Table-1) were obtained from the literature [3] **(Table-2,3).**

Instrumented FE models

The effect of the two different support systems used for the pedicle-based rigid posterior stabilization system was studied on the biomechanics of the lumbar spine. The Ti6Al4V grade titanium biocompatible alloy support for the pedicle-based posterior stabilization system and the polyethylene band support for the pedicle-based posterior stabilization system were compared as testing material. The range of motion (ROM) of the intact model; the intact model with the posterior stabilization system, including titanium alloy support; and the intact model polyethylene band support was compared.

The ROM of the index and adjacent levels after implantation of the posterior stabilization system, including **a)** titanium alloy support and **b)** polyethylene band supports, was compared to the intact model. Two different support systems that can be used with the pedicle-based posterior stabilization system have been shown **(Figure-3).**

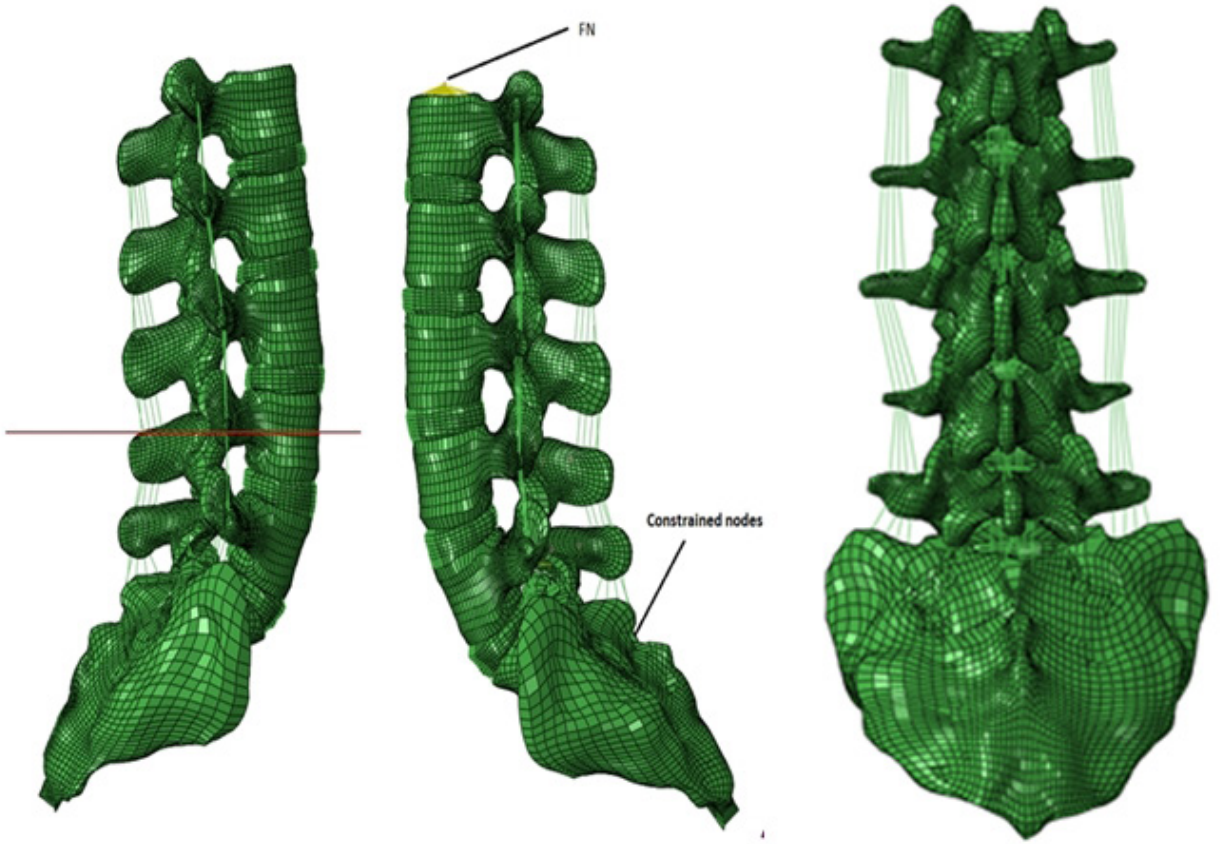

Figure-1. FE model of the intact lumbar spine

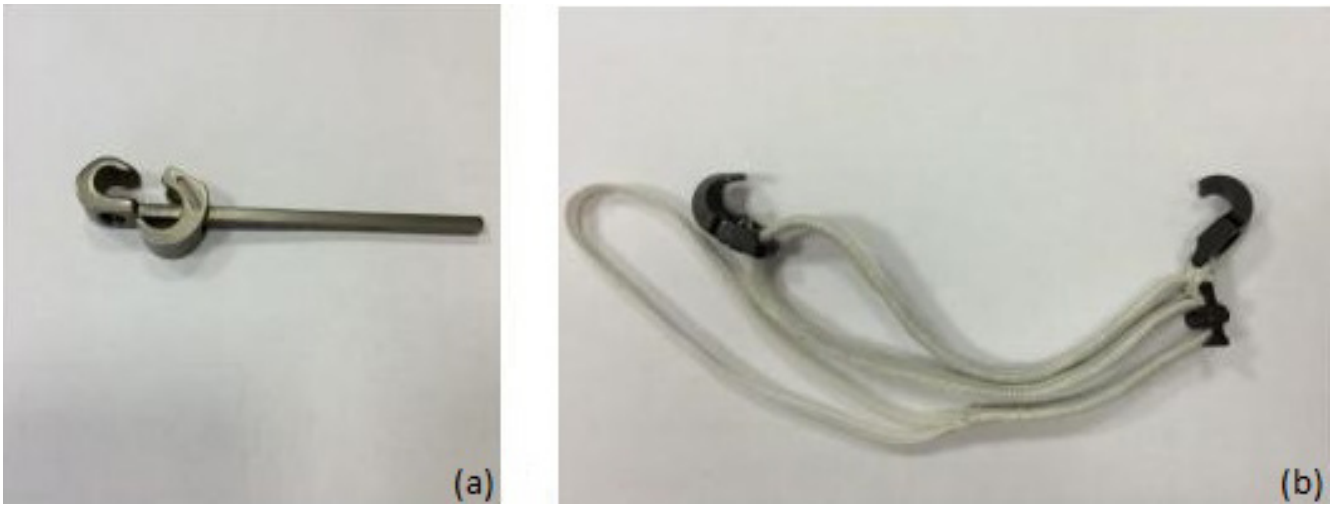

Figure-2. A support system for posterior stabilization constructs: **a)** Titanium alloy support **b)** Polyethylene support.

Table-1. Mechanical properties and element types of the different parts of the lumbar spine model.

Component	Element Formulation	Modulus (MPa)	Poisson's Ratio
Vertebral Cancellous Bone	Isotropic, elastic hex elements	450	0.25
Vertebral Cortical Bone	Isotropic, elastic hex elements	12000	0.3
Posterior Bone	Isotropic, elastic hex elements	3500	0.25
Nucleus Pulposus	Isotropic, elastic hex elements	9	0.4999
Annulus (Ground)	Hyperelastic, Neo Hooke	C10=0.3448, D10=0.3	
Annulus (Fiber)	Rebar	357-550	0.3
Ligaments			
Anterior Longitudinal	Truss elements	7.8 (<12%), 20.0 (>12%)	0.3
Posterior Longitudinal	Truss elements	10.0 (<11%), 20.0 (>11%)	0.3
LigamentumFlavum	Truss elements	15.0 (<6.2%), 19.5 (>6.2%)	0.3
Intertransverse	Truss elements	10.0 (<18%), 58.7 (>18%)	0.3
Interspinous	Truss elements	10.0 (<14%), 11.6 (>14%)	0.3
Supraspinous	Truss elements	8.0 (<20%), 15.0 (>20%)	
Capsular	Truss elements	7.5 (<25%), 32.9(25%)	0.3
Apophyseal Joints	GAPUNI		

Table-2. Range of motion for intact and intact with instrumented FE lumbar spine

Axial rotation				
	Intact	**Rod-fusion**	**Titanium-support**	**Polyethylene Band support**
L1-2	34.064	34.535	34.597	34.534
L2-3	3.354	3.372	33.717	33.782
L3-4	37.829	37.418	37.419	3.742
L4-5	39.243	0.161	0.1544	0.1544
L5-S1	46.391	46.354	46.354	46.353

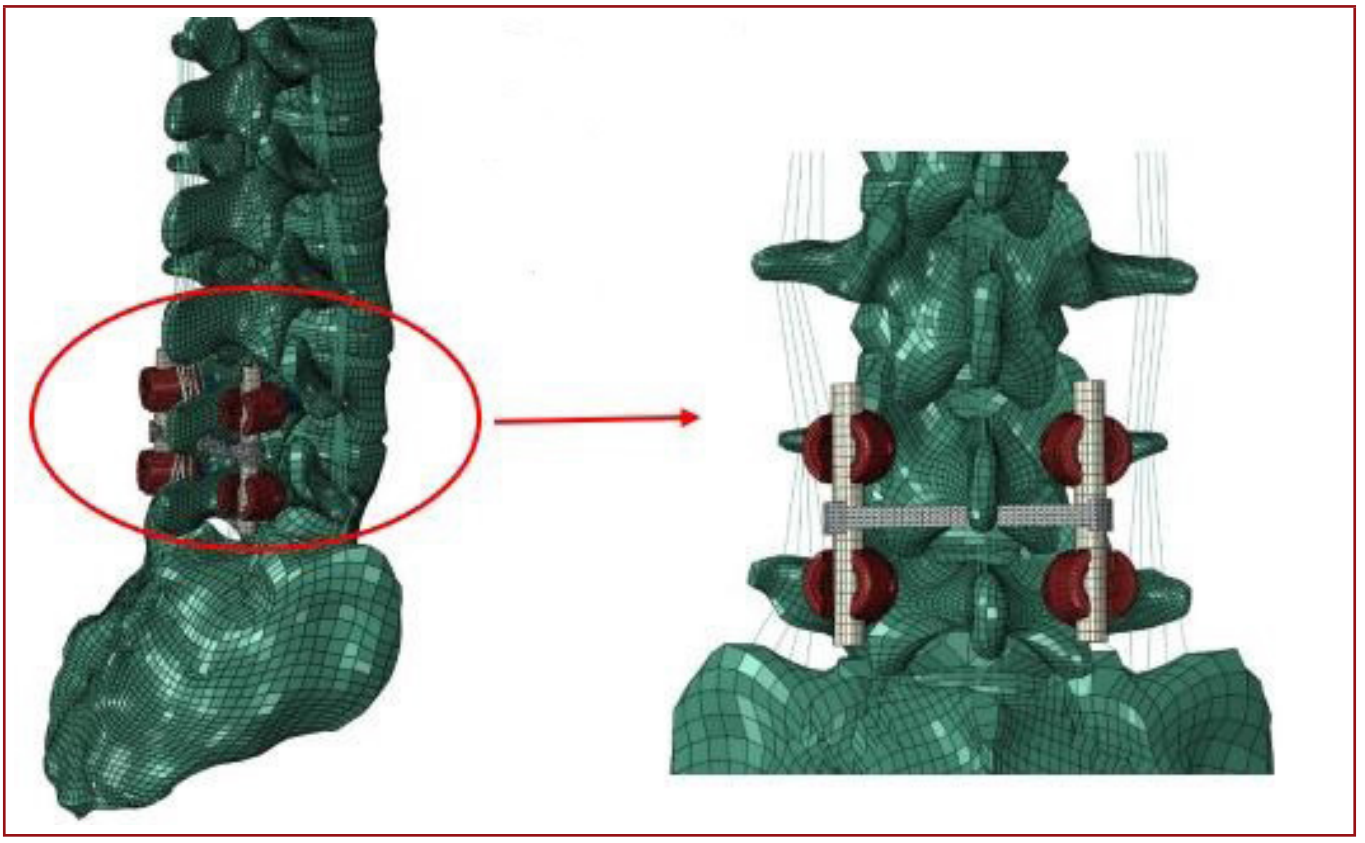

Figure-3. FE model of the lumbar spine with pedicle based posterior stabilization system with Titanium alloy support

Table-3. Range of motion of intact with instrumented FE model in % of intact

	Axial rotation		
	Rod-fusion	**Titanium-support**	**Polyethylene Band support**
L1-2	1.4	1.6	1.4
L2-3	0.5	0.5	0.7
L3-4	1.1	1.1	1.1
L4-5	95.9	96.1	96.1
L5-S1	0.1	0.1	0.1

Boundary and loading conditions

In all directions, the nodes lying on the upper endplate of L1 were coupled to a flying node (FN) higher than the surface of the L1 endplate; then, a pure moment was applied to the FN (Figure-1). The follower load was applied on each side of all segments such that the unwanted segmental rotation was less than 0.2° 19. The follower load was simulated using the connector elements between each set of adjacent vertebrae. The nodes lying at the outer surface of the sacrum were constrained in all directions (Figure-2).

A 10 Nm bending moment was applied to the superior surface of the L1 vertebra in the intact spine, and the segmental and overall ROM was obtained in flexion (Flex), extension (Ext), lateral bending (LB) and axial rotation (AR). The follower load concept was used to apply 400 N as the body weight in each segment.

RESULTS

Range of motion was decreased by 95.8 % when the pedicle-based stabilization system was used at L4–L5. Range of motion was decreased further about 1 % when the polymer band was used in conjunction with the posterior stabilization system in axial rotation. Similar results were observed when the titanium transverse connector was used.

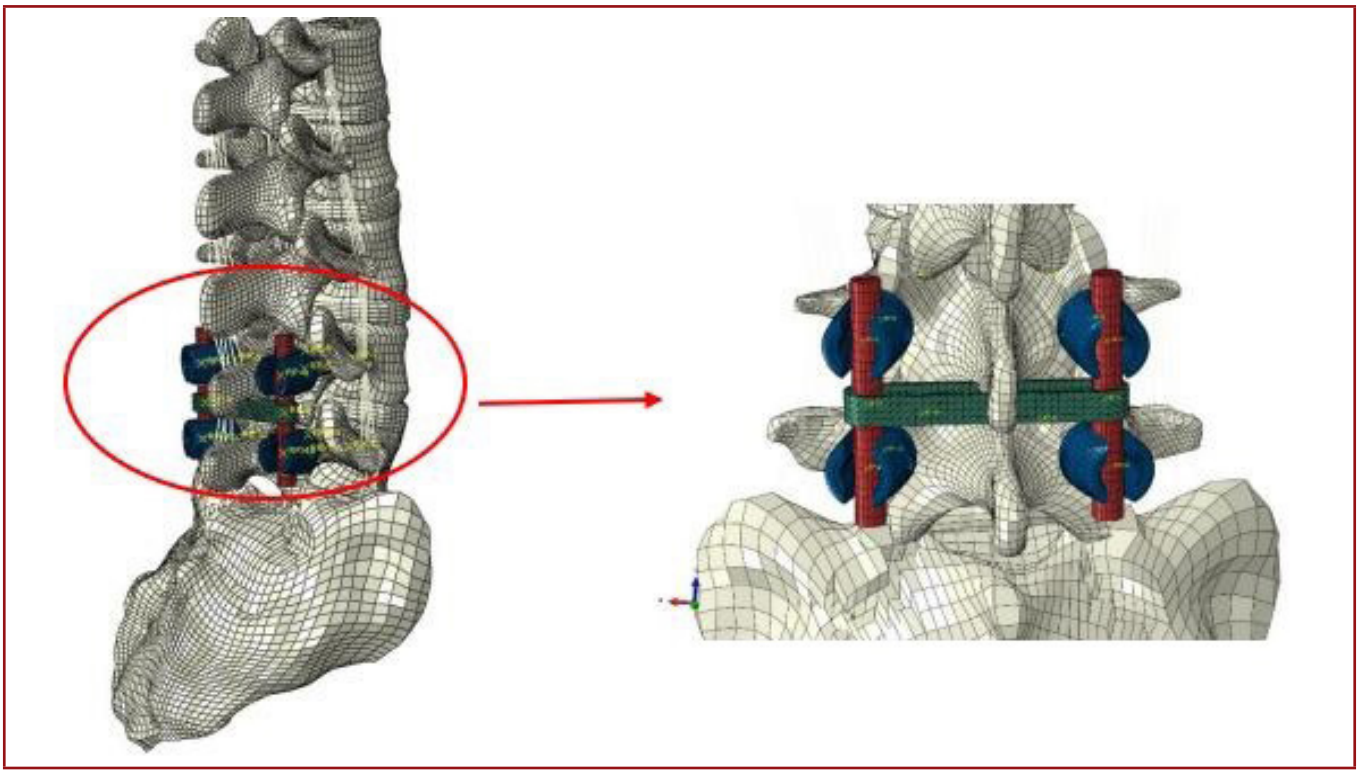

Figure-4. FE model of the lumbar spine with pedicle based posterior stabilization system with Polyethylene support.

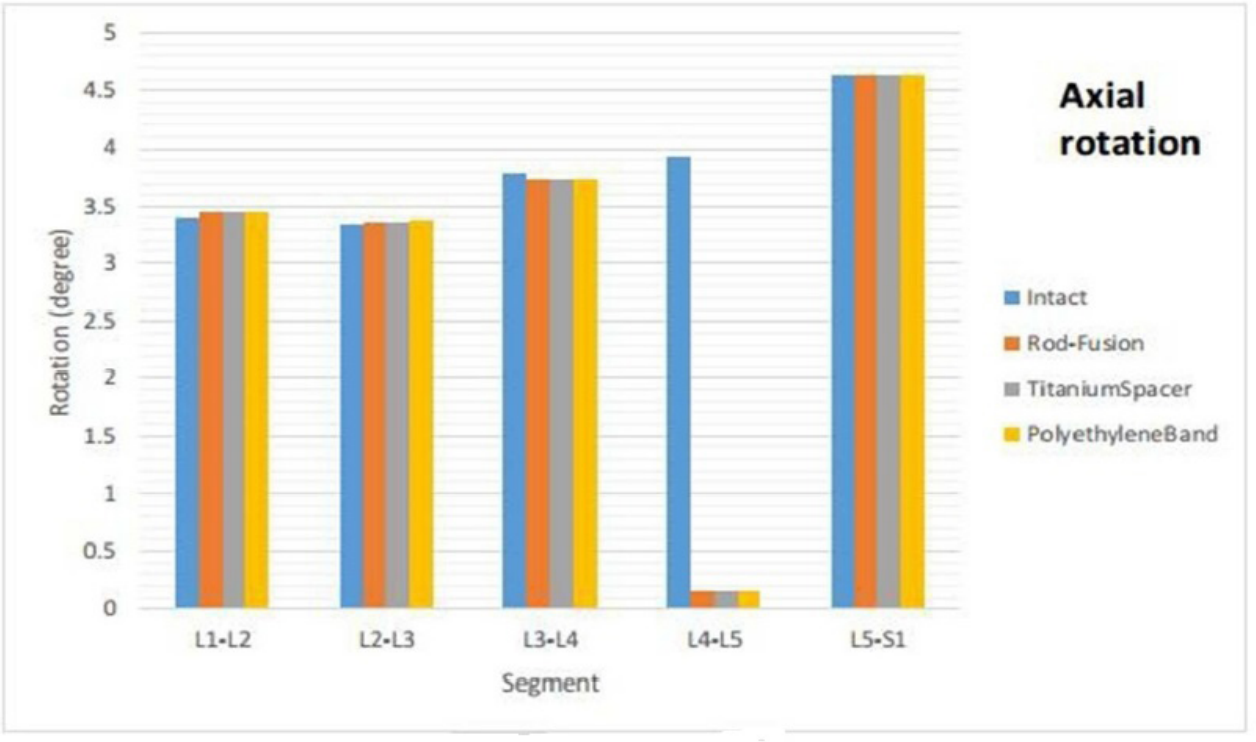

Figure-5. ROM of intact and intact with instrumented FE models in axial rotation

DISCUSSION

Surgery is the gold standard for lumbar degenerative disc disease. However, like many reports, inevitable side effects of fusion such as chronic back pain and adjacent segment degeneration have been documented [1-2,5]. The standard surgery is decompression through extensive laminectomy. The success rate of this procedure ranges from 62 % to 70 %. At the same time, failures caused by other reasons such as inadequate decompression in patients, who were selected incorrectly, are usually associated with iatrogenic postoperative spinal instability [6,8].

Iatrogenic instability is associated with incorrect detection and fusion. Motion preservation technologies are introduced as rigid stabilization and posterior dynamic stabilization systems to overcome these adverse effects [9-10]. Posterior dynamic stabilization systems have recently gained popularity. Abnormal load transmission along a degenerated spine motion segment leads to abnormal segmental motion. Dynamic systems were not effective in balancing this abnormal load distribution. The early clinical results of these systems have shown that they were effective in patients with degenerative spondylolisthesis and spinal stenosis [1,8,13].

Clinical results in the moving systems are still controversial despite the theoretical advantages over rigid fusion. One reason for the discrepancy between the two systems is caused by incorrect design. The ideal systems are ones that are normal kinematics, are capable of sharing the load with normal load transfer and may mimic a normal functioning spinal unit [11,12]. Ideal systems should have a stability and rigidity that will provide a fusion biomechanically and will not require external support. Technically, the application should be easy, tissue-compatible and easily found [2].

There are two types of lumbar spine displacement in all three action plans, including separately translation and angulation. Thus, the spinal column, and any part of it, can do six different movement [13]. The growth of the vertebra in the spine by going towards the distal, showing the physiological curvature for 4 times and anatomical features of the bone and soft tissue structures in accordance with the curvature are important in terms of spinal movements and the transport of the load over the spine. The rotational movement of the lumbar region is lumbar 5° [1-2,5].

The characteristics of an ideal instrument are as follows. It should provide an anatomic reduction and anatomic contour of the spine, an indirect decompression with distraction and a correction of the neural canal. It should have a stability and rigidity that will provide a fusion biomechanically and will not require external support. Technically, the application should be easy, it should be tissue-compatible and easily found [2].

Spinal instrumentations are among the medical supplies that are most discussed and developed in the last century [10,12]. Authors have always worked on something better. Except for a few issues, which have gained certainty, many techniques and application materials are controversial. The effects of the transverse binder systems' binding of the transpedicular screw rod system on the movements of the lumbar spinal region has not been fully studied.

Rigid transverse binders also minimize the rotational movements of lumbar spinal regions whose movements are largely lost. Newly developed polyester bands affect the rotational movement less.

In our study, both systems provided the rigidity needed in areas where they were applied for fusion. Significant superiority was not observed in the values, which is due to the application.

The most important short-term advantage of polyester band usage is the easy merging with the transpedicular screw and rod system in the perioperative period, which reduces the operation time and the amount and time of anesthesia received. The first priority in this process is patient comfort and bringing his/her everyday life as close to normal as possible. Other factors are the comfort of the surgeon, the amount of bleeding, surgical areas, time of the anesthesia and cost.

In light of all FE analysis results, neither of the systems applied had a significant superiority over the other. There are not enough studies in the literature on the use of transverse binder systems in spinal transpedicular screw systems. We believe that the advantages of the use of the polyester band in axial rotation will assure superiority over rigid systems.

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Volume: 28, Issue: 2, April 2017 pp: 99-102 ORIGINAL ARTICLE / ORJİNAL MAKALE

THE EFFECT OF CONVEX ROD DEROTATION ON LUMBAR LORDOSIS IN LENKE TYPE-5 ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS WHO UNDERGONE SELECTIVE POSTERIOR SURGERY

SELEKTİF POSTERİOR CERRAHİ YAPILAN LENKE TİP 5 ADOLESAN İDİOPATİK SKOLYOZ HASTALARINDA KONVEKS ROD DEROTASYONUNUN LOMBER LORDOZA ETKİSİ

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SUMMARY:

Objective: To evaluate the effect of convex rod derotation on lumbar lordosis in Lenke type-5 AIS patients who undergone selective fusion

Methods: Twenty-five Lenke Type-5 AIS patients, operated by selective fusion and convex rod derotation, evaluated retrospectively. Thoracolumbar/lumbar Cobb angles and lumbar lordosis angles were measured on preoperative and last follow-up standing full-length anteroposterior and lateral radiographs. Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

Results: There were 24 female and 1 male patients. Mean age was 16 years, mean follow-up was 40 months. Preoperative and last follow-up thoracolumbar/lumbar Cobb angle was 40° and 9.72°, respectively. Mean preoperative lumbar lordosis was 52.66° and last follow-up was 50.29°. Thoracolumbar/lumbar Cobb angle difference was statistically significant, however, lumbar lordosis change was not.

Conclusion: Convex rod derotation is an effective correction maneuver on lumbar lordosis in Lenke Type-5 AIS patients who undergone selective posterior surgery.

Key words: Adolescent idiopathic scoliosis, Lenke Type-V, Surgical treatment, selective fusion.

Level of evidence: Retrospective clinical study, Level III.

ÖZET

Amaç: Selektif füzyon yapılan Lenke tip 5 adölesan idiopatik skolyoz (AİS) hastalarında konveks rod derotasyonun lomber lordoza etkisini araştırmak

Metot: Selektif füzyon yapılan ve konveks rod derotasyon manevrası uygulanan 25 Lenke tip 5 AİS hastası geriye dönük olarak incelendi. Hastaların preoperatif ve son kontroldeki ayakta tüm omurgayı içeren anteroposterior ve lateral grafilerinde torakolomber/lomber Cobb açıları ve lomber lordoz açıları ölçüldü. Verilerin dağılımı için Kolmogorov-Smirnov testi kullanıldı. Ameliyat öncesi ve sonrası karşılaştırma için Wilcoxen Sum Rank testi kullanıldı. $p<0.05$ değeri istatistiksel anlamlı olarak kabul edildi.

Sonuçlar: Yirmi dört hasta kız, 1 hasta erkek idi. Ortalama yaş 16, ortalama takip süresi 40 aydı. Ameliyat öncesi TL/L Cobb açısı 40° iken son takipte 9.72° olarak ölçüldü. Ameliyat öncesi lomber lordoz 52.66° iken ameliyat sonrası 50.29° olarak ölçüldü. Ameliyat öncesi ve son takip karşılaştırmasında TL/L Cobb açısında istatistiksel anlamlı fark varken, lomber lordozda istatistiksel anlamlı fark görülmedi.

Çıkarımlar: Selektif füzyon yapılan Lenke tip 5 hastalarda konveks rod derotasyon manevrası lomber lordozun oluşturulmasında etkili bir korreksiyon manevrasıdır.

Anahtar kelimeler: adölesan idiopatik skolyoz, Lenke tip-5 eğrilik,, cerrahi tedavi, selektif füzyon

Kanıt Düzeyi: Retrospektif klinik çalışma, Düzey III.

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INTRODUCTION

Lenke Type-5 Adolescent Idiopathic Scoliosis (AIS) is a major thoracolumbar/lumbar curve with a non-structural thoracic curve. The surgical aim is to preserve maximal mobility of the spine while fusing minimal segments. Thus, recommended fusion is to fuse only the structural curves, which is the thoracolumbar/lumbar curves for Lenke Type-5 [8].

Traditionally, anterior approach was recommended for Lenke Type-5 AIS. It provides shorter fusion levels and better coronal correction [3]. Disadvantages of anterior approach are lumbar kyphosis effect, increased pseudo-arthrosis rates, increased risk of vascular injury, and cosmetic problems [9].

After introduction by Harrington in 1962 [5], posterior approach became the standard surgical approach for AIS. Regarding Lenke Type-5 AIS, posterior approach has better correction, lesser correction loss rates and lesser hospital stays[4].

Several correction maneuvers can be applied to correct the 3-dimentional deformity of AIS. Commonly used maneuvers are rod derotation, direct vertebral rotation and translation. The aim of this study is to evaluate the effect of convex rod derotation technique on lumbar lordosis in Lenke Type-5 AIS patients who undergone selective posterior surgery.

METHODS

Lenke 5 AIS patients treated at a single institution by a single surgeon was evaluated retrospectively. The surgeon prefers convex rod derotation maneuver for the thoracolumbar/lumbar curves to retain the lumbar lordosis. Inclusion criteria included: 1) a diagnosis of Lenke Type-5 AIS, 2) patients treated with selective posterior fusion, 3) no previous spine surgery 4) full sets of preoperative and last follow-up standing full-length radiographs.

Patients who were treated by non-selective fusion, had previous spinal surgery, anterior surgery and osteotomy were excluded. Those whose radiographs did not meet standards were also excluded in order to prevent measurement error.

Radiographs were measured by a surgeon who did not attend the surgeries. In the radiographs coronal TL/L Cobb angles and lumbar lordosis were measured. The Surgimap software (New York, NY, USA) was used to measure the Cobb angles.

A total of 25 patients were included in the study who met all the inclusion criteria.

Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

RESULTS:

There were 24 female and 1 male patients. Mean age was 16.64 (±2.3) years. Mean follow-up was 40.88±21.5 months. Mean preoperative TL/L Cobb was 40° (±8.89°), and last follow-up Cobb was 9.72° (±8.33°). Mean preoperative lumbar lordosis was 52.66° (±12.75°) and last follow-up lumbar lordosis was 50.29° (±9.97°) (Figure-1).

Preoperative and last follow-up TL/L Cobb angle comparison showed that there is a significant difference ($p<0.05$), however there is no difference in comparison preoperative and last follow-up lumbar lordosis ($p=0.337$)

DISCUSSION:

AIS involves a complex 3D deformity in coronal, sagittal and axial planes and the mail goal of AIS surgery is to obtain a balanced spine while correcting all 3 plane deformities, gain maximal function and maximal correction by preserving more mobile segments.

Several correction techniques were described for AIS surgery. Historically, Harrington instrumentation was introduced to apply a concave side distraction [5]. However, this technique was correcting only the coronal plane, and resulted in iatrogenic flat-back and decreased thoracic kyphosis [7].

Cotrel and Dubousset developed an instrumentation system, called CDI, in 1988 [2]. It uses pedicle screws and rods, and based on the 3D deformity of the scoliosis with simple rod derotation technique. This technique provides better coronal and sagittal correction, and significant vertebral derotation. After introduction of pedicle screws with CDI, pedicle screw instrumentation and fusion has been widely used with rod derotation, direct vertebral rotation and translation techniques because of its better deformity correction ability than transitional hook system [6].

For Lenke Type-5 AIS, both posterior and anterior selective or non-selective fusion options can be choosen [4,9-10]. However, anterior method may result in higher kyphosis, pseudo arthrosis and correction loss [3]. In contrast, posterior selective fusion has better curve correction, less correction loss rate, less blood loss during surgery and shorter hospital stay [4].

The surgeon in our study prefers standard posterior approach, instrumentation and convex rod derotation for Lenke Type-5 AIS patients. Placing first rod on the convex side and applying a 90-degree rod derotation maneuver creates the scoliotic curve into lumbar lordosis.

In a study by Zhang et al [11], they used the same correction maneuver for Lenke Type-5 AIS patients and achieved a slight increase in lumbar lordosis, from 53° preoperative to 56° postoperative, which was statistically significant.

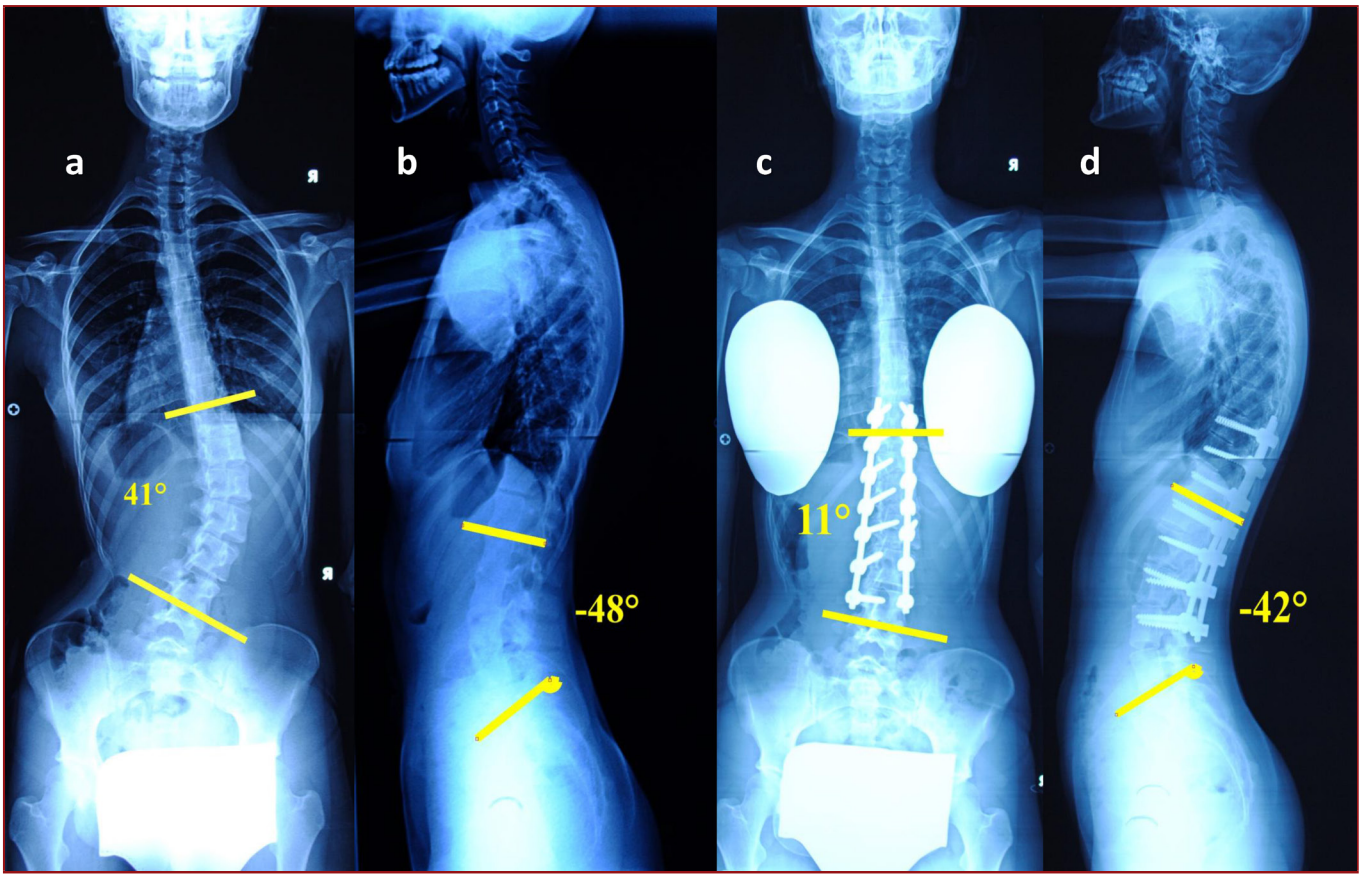

Figure-1. 16-year-old girl with Lenke Type-5 AIS. **a-b)** Preoperative and **c-d)** last follow-up Xrays after selective posterior fusion

Chang et al [1] analyzed their thoracolumbar and lumbar AIS patients treated by rod derotation and direct vertebral rotation. They found a slight increase in the lumbar lordosis, which was statistically not significant.

In our study, by convex rod derotation maneuver, lumbar lordosis of our patients was slightly decreased from 52° to 50°, which was statistically not significant, and maintained in normal range.

This study is not without limitations. First, this is a retrospective study and it lacks randomization and control group. The measurements were done by a computer-based software and there could be some measurement errors. Finally, we did not evaluate the patient reported outcome parameters, for the reason that they are out of the scope of our aim.

CONCLUSION:

Convex rod derotation technique is a safe and effective maneuver for treating Lenke Type-5 AIS patients. It creates a significant correction in coronal plane and helps to maintain normal lumbar lordosis.

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Volume: 28, Issue: 2, April 2017 pp: 103-108 ORIGINAL ARTICLE / ORJİNAL MAKALE

LATE RESULTS OF OPEN DOOR LAMINOPLASTY FOR CERVICAL OSSIFYING POSTERIOR LONGITUDINAL LIGAMENT

SERVİKAL LONGİTUDİNAL LİGAMAN OSSİFİKASYONU İÇİN AÇIK KAPI LAMİNOPLASTİNİN GEÇ SONUÇLARI

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SUMMARY:

Introduction: In this prospectively designed study, it was planned to present an Open Door Laminoplasty (ODL) series, to discuss effectiveness of this approach and to investigate correlation between preoperative cervical canal cross-sectional area and recovery rate of patients.

Patients and Method: A 47-patient group which had minimum 36 months follow-up was included in the study. All patients were performed a standard ODL. Preoperative and various postoperative times clinic and radiologic parameters were compared statistically, and recovery rates (RR) of patients were calculated.

Results: RR of patients was statistically significant by Friedman's test. It cannot be found any statistical relation between preoperative cross sectional area (CSA) and preoperative clinic by statistical significance tests. That RR decreases as preoperative symptom duration increases is remarkable.

Conclusions: ODL is an effective and safe way to reduce symptoms of degenerative cervical myelopathy due to OPLL.

Key words: Cervical spondylosis, Open door laminoplasty, Ossifying posterior longitudinal ligament, Surgical results

Level of evidence: Prospective clinical study, Level II

ÖZET:

Giriş: İleri dönük olarak planlanmış bu çalışmada, açık kapı laminoplasti (ODL) hasta dizisi sunularak, bu yaklaşımın etkinliği ve ameliyat öncesi kanal alanı ile hastaların belirti ve bulguları arasında ilişki olup olmadığının araştırılması amaçlanmıştır.

Hastalar ve yöntem: En az 36 ay takip edilmiş 47 hastalık bir topluluk çalışmaya alınmıştır. Tüm hastalara standart ODL yapılmıştır ODL. Ameliyat öncesi ve ameliyat sonrası çeşitli zamanlarda klinik ve radyolojik sonuçlar istatistiksel olarak karşılaştırılmışlardır. Hastaların iyileşme oranları hesaplanmıştır.

Sonuçlar: Hastaların iyileşme oranları Friedman testi ile istatistiksel olarak anlamlı bulundu. Ameliyat öncesi kanal alanı ile klinik arasında ilişki yoktu. Belirti ve bulgu süresi ile iyileşme oranı arasında ters ilişki olması dikkate değer bir durumdur.

Çıkarım: ODL, OPLL nedeni ile gelişen servikal dar kanalda belirti ve bulguların giderilmesi için etkin ve güvenli bir yaklaşımdır.

Anahtar kelimeler: Açık kapı laminoplasti, Cerrahi sonuçlar, Ossifiye posterior longitüdinal ligaman, Servikal spondiloz

Kanıt düzeyi: Prospektif klinik çalışma, Düzey II

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INTRODUCTION

Long-lasting compression of the cervical spinal cord leads to a clinical syndrome of cervical spondylotic myelopathy [10,13]. Posterior decompression for cervical spinal canal narrowing due to ossifying posterior longitudinal ligament (OPLL) is widely performed method although it cannot provide direct ossification excision [1]. But by this approach, it can be avoided that many complications of an anterior approach such as spinal cord injury, hemorrhage or anterior dural tears [6,9]. Besides, for cases with three or more vertebrae resections, implant failure and malunion risks will come into question [4]. Comparable clinical outcome and less risk of complications of posterior approaches have made these approaches more popular. Open door laminoplasty (ODL) is a kind of posterior approaches which can preserve range of motion [14]. ODL is performed widely since 1970s [8].

The primary goals of ODL are to decompress the spinal cord and maintain cervical spine stabilization. To minimize complications and provide long-term pain and disability control are the secondary aims of this approach. In this prospectively designed study, it was aimed to present an ODL series, to discuss efficacy of this approach and to investigate correlation between preoperative cervical canal cross-sectional area (CSA) and recovery rate (RR) of patients.

PATIENTS AND METHODS:

This study was conducted in Dışkapı Yıldırım Beyazıt Training and Research Hospital between July 2004 and August 2006. Study was started with 103 patients with cervical stenosis diagnosed by clinically and documented and approved by radiologically. A 47-patient group which had minimum 36 months' follow-up was included in the study. Two patients died because of amyotrophic lateral sclerosis (ALS) in a two-year period after operation and one patient have not come to hospital to control. So the study was conducted with 44 patients. Patients' ages were between 35 and 72 years with a mean of 56.61 ± 8.39 year. Thirty-two of patients were men and 12 of them were women (73 and 27 % respectively).

Including criteria: Men and women between 30 and 80 years old with cervical stenosis diagnosed by clinically and approved by radiologically; and patients followed-up minimum 36 months were included in the study. Each patient had minimum 2 levels of compression with accompanying signs and symptoms of myelopathy.

Excluding criteria: Patients with severe cardiac, metabolic, pulmonary or malignant diseases; patients had undergone spinal operations for any reason; patients had history of spinal trauma and patients with any accompanying spinal disorders such as spinal tumor, disc herniations, dislocations etc., were excluded from the study. Patient with ankylosing spondylitis and systemic infections were also excluded.

Preoperative work-up: A written informed consent was obtained from all patients. Clinic status of patients were assessed with mJOA scores preoperatively, postoperative 1. day, 3., 6., 12., 24., 36., 48., and 60. months. Preoperative radiological work-up included lateral, antero-posterior (AP) and oblique roentgenograms, cervical computed tomography (CT) and cervical magnetic resonance imaging (MRI). CSA was measured on axial MRI sections. For this measurement, the narrowest region was used.

Recovery rate (RR) was calculated due to the formula of RR=100 X (postoperative mJOA-preoperative mJOA) / 18-preoperative mJOA [3].

Operation: All patients were performed a standard ODL between C3 and C7 according to the description of Hirabayashi [5]. Open side was decided due to patients' complaints. Autogenous bone grafts obtained from spinous processes of the cervical spine were used as expander in the open side of the laminoplasty.

Statistical analysis: Statistical package for the social sciences (SPSS) version 24.0 was used. Preoperative and follow-up RRs were compared by Friedman's test. Symptoms and RR correlations was investigated by Spierman's rho correlation test. CSA and preoperative clinical status was assessed by Pearson's correlation index.

Postoperative instructions: All patients discharged after a reasonable and uneventful period with a soft collar for using at least 3 weeks. Patients with neurologic complications were referred to physical therapy clinics to take under control and therapy.

RESULTS

Table-1 and 2 summarize mJOA scores and RR respectively (Table-1, 2).

Preoperative mean mJOA scores were 11.48 ± 2.79 (6-16). At all follow-up times, RR of patients were statistically significant by Friedman's test ($p<0.005$). It cannot be found any statistical relation between preoperative CSA and preoperative mJOA by statistical significance tests. The same situation is also true between postoperative CSAs and postoperative mJOA scores; and between RR and increasing CSA percent postoperatively ($p>0.05$). The narrowest CSA was 118.625 ± 45.88 mm^2 (56.50 ± 326.70 mm^2) preoperatively. After operation, the narrowest CSA was 10.77 ± 2.62 mm^2 (7.4-18.0 mm^2).

That RR decreases as preoperative symptom duration increases is remarkable (r= -0346 by Spierman's rho correlation test) **(Figure-1).**

Myelopathy symptoms were seen in 29 patients, where radiculopathy symptoms were found in 8 patients. Seven patients had both symptomatology of myelopathy and radiculopathy.

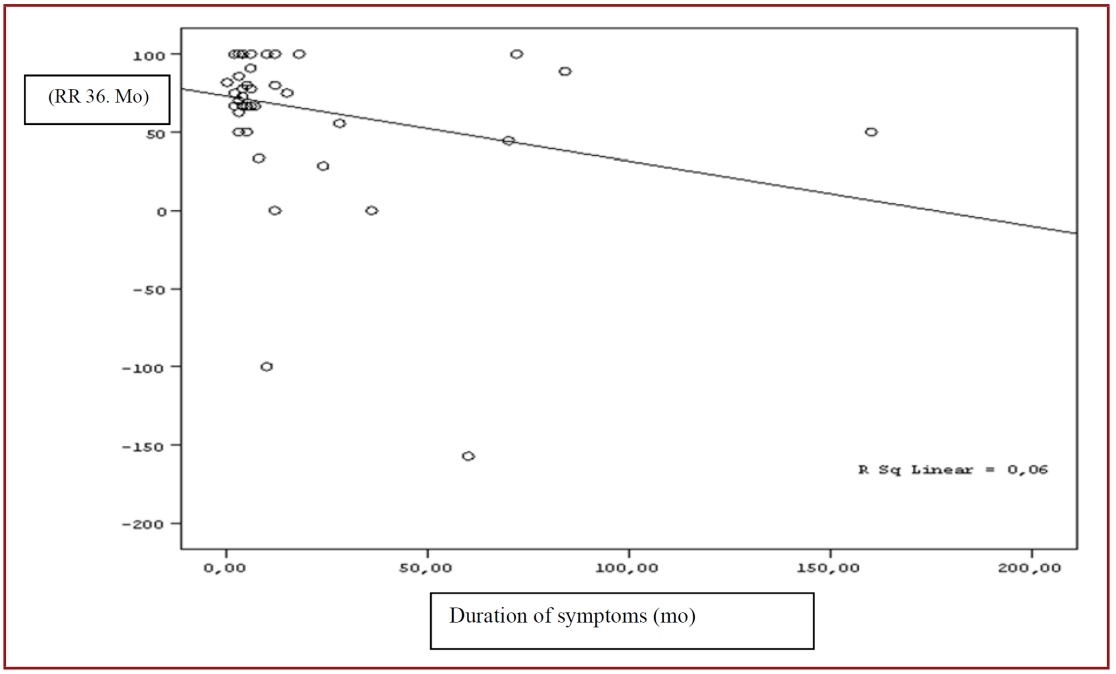

Figure-1. Relation of preoperative symptom duration and RR. 36. Month results were used for RR.

In 4 patients some surgical complications have developed (9.1 %). Shoulder drop due to C5 palsy was seen in 3 (6.8 %) and quadriparesis was seen in 1 (2.3 %) patient. Quadriparetic patient had undergone a second operation for widening decompression. After a rigorous physical therapy period, he has gained preoperative muscle strength.

Table-1. Preoperative and follow-up mJOA scores of patients.

	preop	1. day	3. mo	6. mo	12. mo	24. mo	36. mo	48. mo	60. mo
N	44	44	44	44	44	44	43	36	36
Mean	11,48	13,77	15,61	15,82	16,07	16,18	16,14	16,29	16,28
Median	11,00	14,00	16,00	16,00	17,00	17,00	17,00	17,00	17,00
SD	2,791	3,003	2,365	2,275	2,182	2,038	2,054	1,947	1,907
Range	10	15	9	8	8	8	8	8	8
Minimum	6	3	9	10	10	10	10	10	10
Maximum	16	18	18	18	18	18	18	18	18

Table 2. Postoperative RR of patients.

	Day 1	3. mo	6. mo	12. mo	24. mo	36. mo	48. mo	60. mo
N	44	44	44	44	44	44	36	36
Mean	32,61	62,85	65,66	69,36	71,66	66,05	68,75	72,9172
Median	43,65	69,05	77,78	80,91	80,00	77,78	81,67	78,8889
SD	60,014	46,463	46,165	41,738	37,392	50,555	40,644	37,7854
Range	333	200	200	200	200	257	150	200,00
Minimum	-233	-100	-100	-100	-100	-157	-50	-100,00
Maximum	100	100	100	100	100	100	100	100,00

Table 3. Pre and postop narrowest CSA of patients.

The narrowest CSA	preop	postop
N	44	44
Mean	8,19	10,770
Median	8,00	10,000
SD	1,611	2,6216
Range	7	10,4
Minimum	5	7,6
Maximum	13	18,0

Table 4. Preoperative CSA of patients.

N		44
Mean		118,6250
Median		114,2700
SD		45,88086
Range		270,20
Minimum		56,50
Maximum		326,70
Percentile	25	85,3350
	50	114,2700
	75	142,4000

(Measurements are mm^2)

DISCUSSION:

Degenerative narrowing of cervical spinal canal ordinarily happens in the natural course of aging [2]. Symptomatic myelopathy develops as a result of this process. OPLL is an important factor that causes narrowing of the cervical spinal canal; and presence of OPLL may change operative procedure for decompressing spinal cord. Existence of OPLL, especially non-segmental types, partly reduces cervical mobility and by restraining the ROM [11]. Anterior cervical decompression and fusion (ADF) can provide complete ossification resection and decompression for cases with cervical myelopathy due to OPLL [9]. But risk of spinal cord injury, dural tears, and extensive bleeding cannot be disregarded. Besides, an anterior decompression for OPLL sometimes requires vertebrectomy one or two levels. Enlarging the operation with vertebrectomy carries with some additional risks such as implant failure, malunion, screw malposition etc. [4]. Although it cannot allow resection of OPLL, posterior decompression provides a wider canal for spinal cord. Thus, posterior decompression techniques become popular approaches by having far less risks. Laminectomy procedures previously have been performed as decompression of the cervical canal from posterior sides for compressive myelopathy [7]. But, extensive invasion of scar tissue after laminectomy worked as a new cause of compression. Furthermore, postoperative instability triggered additional complaints. Idea of "laminoplasty" developed in 1972 by a group of Japan investigators first time, for avoiding complications of laminectomy, and also providing benefits of posterior approach [12]. Subsequently, many methods of cervical laminoplasty have been developed. "Open door" type laminoplasty techniques are constitutes one of two main types of laminoplasty due to the sites of osteotomy [5].

Results of this study, especially RR of patients at the postoperative period put forward effectiveness of ODL for treatment of cervical myelopathy due to OPLL. The main factor affecting positive postoperative result was duration of symptomatic period before operation. This negative correlation is one of the vital results of this study (r= -0346). Another significant result of this study is that the preoperative CSA is not so central to produce symptoms preoperatively. And also, postoperative widening rate is not correlate with RR of patients ($p>0.05$). This result might give rise to thought that effort for further widening the cervical canal by extension of laminoplasty beyond the standard borders or scale up the graft size has not provided more recovery at the same rate. However, extra widening the canal especially at the C5 root region may belong to avoiding C5 paresis. New, prospective clinical studies have needed to clarify this.

One limitation of this study is that the sample size was small. The other limitation is that comparing with other decompression techniques was a necessity for deciding effectiveness.

There is still debate about the proper surgical treatment of multilevel cervical degenerative disease involving three or more cervical segment. Although, an ADF is also a beneficial approach, ODL is an effective and safe way to reduce symptoms of degenerative cervical myelopathy due to OPLL.

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Volume: 28, Issue: 2, April 2017 pp: 109-112 ORIGINAL ARTICLE / ORJİNAL MAKALE

COMPARISON OF PREOPERATIVE AND POSTOPERATIVE CERVICAL SAGITTAL PARAMETERS IN PATIENTS WITH CERVICAL DEGENERATIVE DISEASE

SERVİKAL DEJENERATİF HASTALIĞI OLAN HASTALARDA SERVİKAL SAGİTTAL PARAMETRELERİN PRE-OPERATİF VE POST-OPERATİF KARŞILAŞTIRILMASI

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SUMMARY

In this article, cervical sagittal parameter values were measured in patients with cervical degenerative disease between the ages of years preoperatively and postoperatively and compared with each other. Sagittal equilibrium parameters measured for comparison are; C0 inclination angle (angle made with the horizontal line of the Frankfurt line), C0-C2 angle (angle between the McGregor line passing through the skull base and C2 lower end plane), T1 slope angle (angle between C7 lower end plate and T1 upper end plate), and cervical lordosis (angle between C2-C7).

Cervical sagittal parameters were not changed postoperatively with statistically ($p > 0.05$). In our study we found a slight decrease in Cobb angle of cervical lordosis postoperatively in patients with cervical spondylosis.

According to the results of our study, surgical treatment did not effect to the sagital parameters in the cervical region of the patients with degenerative spondylitis was found. It is still premature to make a correlation between cervical sagittal parameters and clinical outcomes pre and postoperatively. Prospective studies with larger patient groups needed before making general statements on this subject.

Keywords: Cervical Degenerative Disease, Cervical Sagittal Spine Parameters

Level of evidence: Retrospective Clinical Study, Level III

ÖZET

Bu makalede 41-79 yaş arası servikal dejeneratif hastalığı olan hastaların, servikal sagittal parametre ölçümleri pre-operatif ve post-operatif olarak karşılaştırılmıştır. Karşılaştırma için ölçülen servikal sagittal denge parametreleri; C0 inklinasyon açısı (Frankfurt hattının horizontal ile yaptığı açı), C0-C2 açısı (kafa tabanından geçen Mc Gregor hattı ile C2 alt son plağı arasındaki açı), T1 slope açısı (C7 alt son plağı ile T1 üst son plağı arasındaki açı), servikal lordoz (C2-C-7 arasındaki açı)'dır.

Dejeneratif servikal spondiloz nedeniyle opere edilen hastalarda servikal sagittal parametrelerde istatistiki olarak bir fark oluşmadığı belirlenmiştir ($p>0,05$). Servikal lorozda operasyon sonrası hafif azalma olduğu belirlenmiştir.

Dejeneratif servikal spondilozu olan hastalarda klinik sonuçların değerlendirilmesinde sagittal parametreler çok önemlidir. Ne var ki bu çalışmada opere edilen ve normal servikal lordozu düşük olan hastalarda cerrahinin bu parametrelere olumlu bir etkisi olmadığı görülmüştür. Kesin bilgiler elde etmek için daha geniş ve prospektif çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Servikal Dejeneratif Hastalık, Servikal Sagittal Vertebra Parametreleri

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INTRODUCTION:

Cervical spinal vertebral column has a complex structure and has higher mobility than the rest part of the vertebral column. Disorders affecting the cervical spine results in adverse outcomes on health quality of patients. Cervical spondylosis is the general term for degenerative disease seen in cervical spine and is the most common disorder of the cervical spine.

Sagittal balance of vertebral column is ensured by the harmony of cervical lordosis, thoracic kyphosis and lumbar lordosis. Cervical spine sagittal alignment and the normal cervical lordosis is critical for the normal function of the cervical spine. Malalignment results in kyphosis, decreased mobility, pain and neurologic compromise in advanced stages.

Several methods have been described to evaluate the sagital alignment of cervical spine and cervical lordosis. These are Cobb angle method, Harrison posterior tangent method and Jackson physiological stress line method. Clinically Cobb angle method is most widely used method although it is stated that while C0-C2 angles overestimate the cervical lordosis C2-C7 angles underestimate the cervical lordosis. Harrison's method is suggested as the best method for measuring cervical lordosis but Cobb method is easy and remains as the most commonly used method in clinical practice.

In this study, we aimed to measure the cervical sagital parameters of patients with cervical degenerative disease and make a comparison between preoperative and postoperative results in the Turkish population.

MATERIAL AND METHODS:

Cervical sagital parameters were analyzed in cervical lateral graphics of 40 (16 male, 24 female) patients in an age group of 41-79 C0 inclination angle (angle made with the horizontal line of the Frankfurt line), C0-C2 angle (angle between the Mc Gregor line passing through the skull base and C2 lower end plane), T1 slope angle (angle between C7 lower end plate and T1 upper end plate), and cervical lordosis (angle between C2-C7) were assessed. We compared the angle measurements pre and postoperatively with student t-test, probability range was taken as 0.05.

RESULTS:

Preoperative Cervical sagittal parameters were measured as; C0 inclination angle (30,0 ± 8,7), C0-C2 angle (35,1 ± 8,4), T1 slope angle (3,4± 2,1) and cervical lordosis (20,9 ± 9,2). Cervical sagittal parameters were not changed postoperatively with statistically ($p > 0.05$). C0 inclination angle were seen in the Table-1. The slight decreasing of cervical lordosis was determined.

Table-1. Pre- and postoperative cervical angles

Cervical Sagittal Parameters	PRE-OP.	POST-OP.	t	p
C0 inclination angle	30,00° ± 8,74°	27,19° ± 7,32°	0,76	> 0,05
C0-C2 angle	35,12° ± 8,40°	36,25° ± 8,50°	0,91	> 0,05
T1 slope angle	3,43° ± 2,18°	3,6° ± 1,79°	1,22	> 0,05
Cervical lordosis	20,91° ± 9,21°	15,94° ± 7,22°	0,56	> 0,05

DISCUSSION

In this retrospective study, we study the changes in cervical sagital alignment by measuring four different cervical sagittal values measured by lateral cervical radiography.

Cervical sagital alignment is important for normal function of the cervical spine. Preservation of this alignment is crucial for successful treatment of changes due to cervical degenerative diseases [1,5]. Due to this fact, assessment of cervical sagittal alignment measurements are valuable for preoperative planning and postoperative evaluation.

Cobb angle measurements of C0-C2 and C2-C7 for cervical lordosis is a widely used method by spinal surgeons. Although Harrison method of measurement of lordosis may provide better results, Cobb method is practical and has high intra and inter-observer reliability [6-7].

In our study, we found a slight decrease in Cobb angle of cervical lordosis postoperatively in patients with cervical spondylosis. There are few studies on correlation between cervical alignment parameters and clinical outcomes of patients postoperatively. Villavicencio et al showed that improvement of Cobb angles at C2-C7 level did not correlate significantly with clinical

results. They also showed that segmental improvement of lordosis angle has better correlations with clinical outcome [8]. Guerin et al and Jagannathan et al showed similar results in similar patient groups [3-4].

T1 slope is another important parameter used for assessment of cervical lordosis and have high correlation with C2-C7 angle. The higher T1 slope is that the higher cervical lordosis has to be in order to balance the horizontal gaze [2]. It has been shown that higher T1 slope values correlate with postoperative myelopathy in patients underwent surgery for cervical laminoplasty [2,9].

Cervical sagittal parameter measurements are important for preoperative and postoperative assessment of cervical spine lordosis. Cobb angles are the most widely used parameters among the spine surgeons. It is still premature to make a correlation between cervical sagittal parameters and clinical outcomes pre and postoperatively. Prospective studies with larger patient groups needed before making general statements on this subject.

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Volume: 28, Issue: 2, April 2017 pp: 113-118 ORIGINAL ARTICLE / ORJİNAL MAKALE

BALLOON KYPHOPLASTY IN OSTEOPOROTIC PATIENTS WITH SPONTANEOUS VERTEBRAL COMPRESSION FRACTURES

SPONTAN VERTEBRA KIRIĞI OLAN OSTEOPOROTİK HASTALARDA BALON KİFOPLASTİ

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SUMMARY

Objective: The purpose of this study is to assess the outcomes of our patients who underwent balloon kyphoplasty for spontaneous osteoporotic vertebral fractures regarding pain relief, correction of the vertebral body height, and complications such as adjacent segment vertebral fractures

Material and Methods: We retrospectively evaluated 63 consecutive patients (74 vertebral bodies) with vertebral body compression fracture who were treated by balloon kyphoplasty. Patients' body mass index (BMI), bone mineral density (BMD), level(s) of the fractured vertebrae, visual analog scale (VAS) for pain intensity were noted. Local kyphosis angle (KA), and the rate of vertebral height loss (VHL) were measured. Oswestry disability index (ODI) was used to assess the disability. All the patients had a minimum follow-up of 12 months

Results: KA and VHL as well as VAS and ODI scores significantly improved at the final follow-up ($p<0.05$, $p<0.001$ respectively). There were cement leakage in 5 procedures (6.7 %) and 11 (14.8 %) adjacent segment fractures (ASF) were detected during the follow-up.

Conclusion: Balloon kyphoplasty is an effective and safe procedure that can provide early pain relief, improve function and correct the deformity in spontaneous osteoporotic vertebral body fractures.

Keywords: Osteoporosis, osteoporotic spinal fractures, surgical treatment kyphoplasty

Level of evidence: Retrospective clinical study, Level III.

ÖZET

Giriş: Bu çalışmanın amacı balon kifoplasti yapılan spontan osteoporotik vertebra kırıklı hastaların; ağrının giderilmesi, vertebral gövde yüksekliğinin düzeltilmesi ve komşu segment kırıkları gibi komplikasyonlar açısından değerlendirilmesidir.

Materyal-Metot: Balon kifoplasti ile tedavi edilmiş vertebral gövde kompresyon kırıklı 63 hasta (74 vertebral seviye) geriye dönük olarak incelendi. Hastaların vücut kitle indeksi (BMI), kemik mineral yoğunluğu (BMD), kırık vertebraların seviyeleri kaydedildi. Lokal kifoz açısı (KA), ve vertebral gövde yükseklik kayıp oranı (VHL) ölçüldü. Klinik değerlendirmede ağrı için görsel analog çizelge (VAS) skorları ve Oswestry sakatlık skoru (ODI) kullanıldı. Tüm hastaların en az 12 aylık takipleri kaydedildi.

Sonuçlar: Hem KA ve VHL, hem de VAS ve ODI skorlarında son kontrolde anlamlı olarak düzelme görüldü ($p<0.05$, $p<0.001$). Takip süresince 5 (% 6.7) seviyede sement kaçağı ve 11 (% 14.8) komşu segment kırığı (ASF) tespit edildi.

Sonuç: Balon kifoplasti, osteoporotik vertebral gövde kırıklarında, erken ağrı kontrolü, fonksiyonun geri kazanımı ve deformiteyi düzeltmede etkili ve güvenli bir yöntemdir.

Anahtar kelimeler: Osteoporoz, osteoporotik omurga kırığı, cerrahi tedavi, kifoplasti

Kanıt düzeyi: Retrospektif klinik çalışma, Düzey III

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INTRODUCTION

Spontaneous vertebral body fractures are an increasing concern among senior population. These fractures can cause pain, a decrease in quality of life, kyphosis that may lead to respiratory insufficiency, and limitation of mobilization. Balloon kyphoplasty is a minimally invasive and effective technique for reducing pain and decreasing kyphotic deformity. It was introduced by Garfin et al. to restore vertebral height and correct kyphotic deformity and maintaining the correction by applying polymethylmethacrylate (PMMA) (5-6). The main goal in the treatment of osteoporotic vertebra fractures is to relieve pain, regain functions of daily living and halt the progression of osteoporosis. It can be performed in patients either with neoplastic, traumatic and osteoporotic fractures.

Conservative treatment of VCF usually consists of bed rest, analgesics and bracing.

Unfortunately, prolonged immobilization may exacerbate osteoporosis that may further predispose osteoporotic vertebral compression fractures (8,24-25). However, open surgery with implants pose higher risk, especially for the osteoporotic patients with associated co-morbidities (13).

The purpose of this study is to assess the outcomes of our patients who underwent balloon kyphoplasty for spontaneous osteoporotic vertebral fractures regarding pain relief, correction of the vertebral body height, and complications such as adjacent segment vertebral fractures. The patients were evaluated in terms of pain relief, correction of the deformity, and complications such as adjacent segment vertebral fractures.

Balloon kyphoplasty is a valuable tool for the patients with VCF when conservative treatment has failed. It provides sustainable improvement to the patients' pain and disability.

MATERIALS AND METHODS

We retrospectively evaluated 63 consecutive patients (74 vertebral bodies) with vertebral body compression fracture who were treated by balloon kyphoplasty between September 2014 and October 2016 (Table 1). Patients mean age was 78.5 ± 9.1 years. There were 15 male (23.8 %) patients and 48 (76.2 %) female patients in our study. Female: Male ratio was 3:1.

All of the patients had X rays and MRI scans of the involved area. Patients' body mass index (BMI), bone mineral density (BMD), level(s) of the fractured vertebrae, visual analog scale (VAS) for pain intensity were noted. Local kyphosis angle (KA), and the rate of vertebral height loss (VHL) were measured on the lateral plain radiographs. BMD was measured at the lumbar spine (L1–L4) by dual-energy radiograph absorptiometry (DEXA). An average BMD value was calculated for each subject by averaging values from L1 to L4, excluding those vertebrae where the augmentation procedure had been performed, and the T scores were noted. Oswestry disability index (ODI) was used to assess the disability (Table-1) (4).

All the patients had minimum 2 weeks of conventional treatment such as bed rest, NSAID, and bracing before the procedure. The indications for the procedure were severe pain due to acute (> 2 weeks) or sub-acute (2 – 8 weeks) osteoporotic vertebral body compression fracture and kyphotic deformity of more than 30°. The local kyphosis angle was measured by Cobb method (Figure 1). The rate of vertebral body height loss (VHL) was estimated by calculating mean anterior vertebral body height of the adjacent vertebrae and the ratio of the anterior vertebral height of the fractured vertebra to this average height. Bone edema indicating acute fracture was confirmed with short tau inversion recovery sequences (STIR) of the magnetic resonance imaging (Figure-2) (24).

Table-1. Presentation and clinical characteristics of the 63 patients (74 cases). KA: Kyphosis angle, VHL: Vertebral height loss, VAS: Visual analog scale for pain assessment, ODI: Ostrowski disability index.

T6	1 (1.4%)
T7	1 (1.4%)
T9	1 (1.4%)
T10	4 (5.4%)
T11	2 (2.7%)
T12	18 (24.3%)
L1	14 (18.9%)
L2	9 (12.2%)
L3	14 (18.9%)
L4	6 (8.1%)
L5	4 (%5.4)
BMI	26 ± 3.6
KA (degrees)	15.3 ± 11.4
VHL (%)	53.6 ± 13.4
T score:	-3.2 ± 1.26
VAS	8.1 ± 0.8
ODI	66.5 ± 7.1

The patients who had previous vertebroplasty, kyphoplasty, an osteoporotic vertebral collapse higher than 90%, or the patients with neurological deficit, bleeding disorders, unstable fractures due to posterior element involvement were excluded. Also the patients with a malignant disease, systemic or spinal infections were excluded.

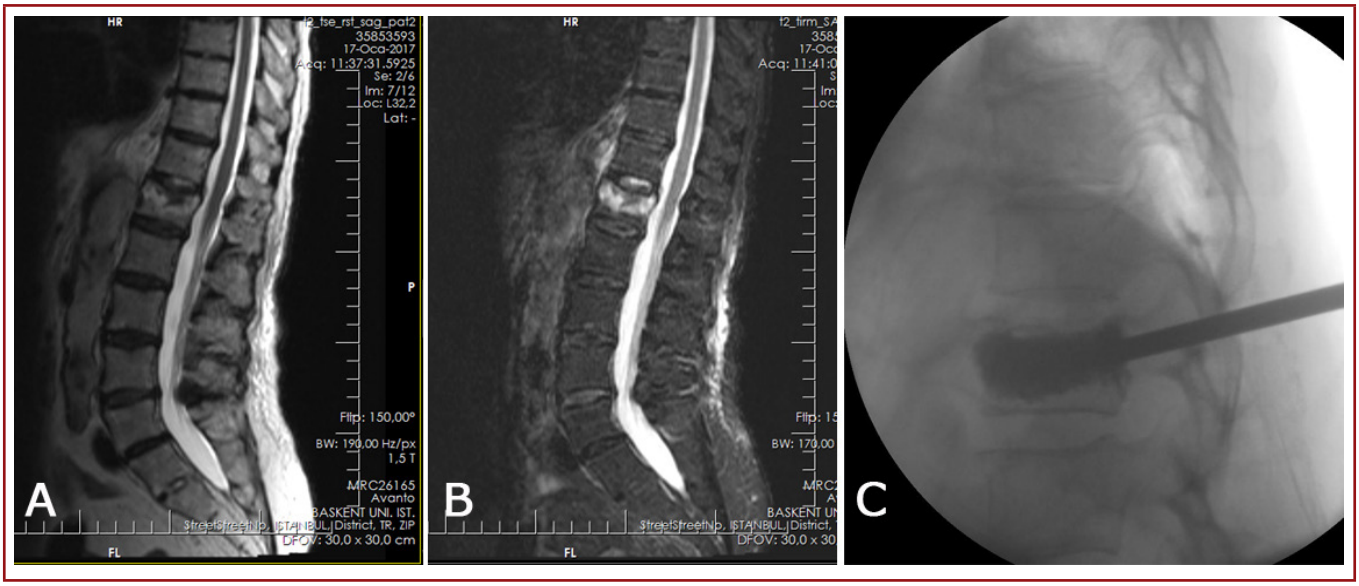

Figure-1. A) Preoperative T2A and **B)** STIR magnetic resonance images of a patient with L1 compression fracture, **C)** Lateral intraoperative C-arm image of the same patient.

Surgical technique

All the procedures were done with sedation and local anesthesia in prone position. Cephazoline sodium 1gr IV was used as prophylaxis. The fractured vertebra was centered on the AP and lateral C-arm projections. Two 11- gauge Jamshidi needles were inserted percutaneously into both pedicles of the fractured vertebra. Two guide pins were inserted through the Jamshidi needles into the two thirds of the vertebral body and then two inflatable bone tamps were advanced into the fractured vertebral body. The balloons were inflated simultaneously under C arm observation. A volume of 3-4 cm3 was created in the vertebral body while maintaining pressures below 200 pound/inch2 in the balloons. A matching volume of polymethylmethacrylate (PMMA) was injected through the pedicules. Postoperative anterior-posterior and lateral X- rays were ordered to check for complications and cement leakage.

Patients were asked to attend the follow-up visits on the 3rd, 6th and 12th months. BMD of the patients were obtained on the first follow-up visit. All follow up visits consisted of physical examinations, VAS assessments for pain, ODI and x-rays to assess the treated and adjacent vertebrae. The same investigator did all radiological measurements.

All the patients had a minimum follow-up of 12 months; the mean follow-up period was 23.4 ± 5.2 months.

Statistical Analysis

Statistical analyses were performed using SPSS software version 21 (Armonk, NY). The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov Simirnov / Shapiro-Wilk's) to determine whether they are normally distributed. Descriptive analyses were presented using medians and interquartile range (IQR) for the non-normally distributed and ordinal variables. Since the KA and VHL measurements were not normally distributed; nonparametric tests were conducted to compare these parameters, as well as to compare the ordinal variables. The Mann-Whitney U test was used to compare preoperative versus postoperative and follow up KA and VHL correction levels between the groups. A p-value of less than 0.005 was considered to indicate a statistically significant result.

RESULTS

A total of 63 patients underwent balloon kyphoplasty between September 2014 and October 2016. Nine patients had 2; one patient had 3 simultaneous VCFs, resulting in a total of 74 procedures.

Postoperative KA and VHL improved from 15.3 ± 11.4 degrees and 53.6 ± 13.4 % to 8.02 ± 2.9 degrees and 74.7 ± 11.3 % respectively ($p<0.05$). These values slightly deteriorated at the final follow-up, but it was not significant. The improvement was still significant at the final follow-up ($p<0.05$). The restoration of the vertebral height was 21.1 %. There were also immediate clinical improvement postoperatively; the VAS and ODI scores were improved from 8.1 ± 0.8 and 66.5 ± 7.1 to 2.2 ± 1.4 and 26.7 ± 5.3 respectively ($p<0.001$). Although, this early postoperative improvement was slightly lost at the final follow up, the improvements from the preoperative values were still significant (VAS: 2.7 ± 1.6; ODI: 27.1 ± 4.1. $p<0.001$) (Table-2).

Mean bone cement (PMMA) volume was 4.6 ± 1.3 ml. There were cement leakage in 5 procedures (6.7 %) and all of them were to the disc space, and 11 (14.8 %) adjacent segment fractures (ASF) were detected during the follow-up. ASF was above the fractured vertebra in 7 cases (63.6 %), it was below the fractured vertebra in 3 cases (27.3 %), and there were one ASF (9 %) between the two fractured vertebrae.

There was more than 5 % decrease in the mean vertebral height between the measurements taken before the procedure and at the final follow up with accompanying osteolysis in 9 (12.2 %) cases. There was no accompanying history of trauma. These were recognized as recollapses. There were no cases of cardiopulmonary adverse events associated with cement leakage and no neurological symptoms were observed.

Table-2. Clinical and radiological outcomes. KA: Kyphosis angle, in degrees, VHL: Vertebral height loss, VAS: Visual analog scale for pain, ODI: Oswestry disability index. * preoperative – postoperative value significance p< 0.001, † preoperative – final follow-up value significance p< 0.001).

	Preop	Postop	Final Follow-up
KA (Degrees)	15.3 ± 11.4	8.02 ± 2.9*	9.83 ± 2.7†
VHL (%)	53.6 ± 13.4	74.7 ± 11.3*	71.3 ± 11.7†
VAS	8.1 ± 0.8	2.2 ± 1.4*	2.7 ± 1.6†
ODI	66.5 ± 7.1	26.7 ± 5.3*	27.1 ± 4.1†

DISCUSSION

Primary goals of symptomatic vertebral compression fractures are pain relief, restoration of the vertebral height, restoring sagittal profile, early mobilization and thus improving general well-being of the patient. Balloon kyphoplasty is minimally invasive, effective and relatively safe procedure for achieving these goals when conservative treatment fails.

It has been reported that effective reduction of kyphotic wedge through balloon kyphoplasty is possible (7,20-21,33).

The initial VHL was 53.6 ± 13.4 % before the balloon kyphoplasty in our series; we successfully corrected the vertebral height by 21.1% to 74.7 ± 11.3 % (p<0.005). The local kyphosis angle was 15.3 ± 11.4 degrees and it was improved to 8.02 ± 2.9 degrees postoperatively (p<0.005). VHL restoration by balloon kyphoplasty was reported to be between 12.8 – 31.7 % (1,28,33). The correction in the kyphosis angle was reported between 3.9 - 16.5 degrees (1,27-28,33,35). The lowest correction was reported in a group of patients with rheumatoid arthritis (28).

Although there were several authors indicating minor deterioration of postoperative VAS and ODI scores, significant improvement persists over the follow up period as we had seen in our group (VAS: 2.7 ± 1.6; ODI: 27.1 ± 4.1; p<0.001) (17,28).

PMMA stabilizes fractured fragments and reduces pain, and it is keeps the fractured vertebra in corrected position. The immediate pain relief effect of balloon kyphoplasty and functional recovery were well established (1,10-11,18,28,33,36). Although, there were several studies showing diminishing pain relief and functional recovery throughout a follow up period of 12 months, they all indicated that the improvement from the preoperative state was still significant (3,17,28,34). Our results revealed significant pain relief and improvement of function in early postoperative period. Although this improvement diminished slightly at the final follow up, it was not significant. The significant improvement from the preoperative period was still maintained.

The volume of the cement (PMMA) to be injected had not been strictly defined, 2 – 6 ml of PMMA was usually suggested to repair a fractured vertebral body and up to 8 ml of PMMA was showed to remodel vertebral stiffness (14,20,23). However, no correlation could be shown between greater cement volume and pain relief (9,18).

It was pointed out that higher bone cement volumes were accompanied with higher risk of leakage and increased stresses in the adjacent vertebral bodies, in particular in the cranial vertebral body (2,15,31). The cement leak was reported in a wide range between 4 – 45 % (1,9,27,28). The average cement volume given in the 45 % leak was relatively high (6.4 ±1.8 ml) and all the patients had rheumatoid arthritis. Our average cement volume was 4.6 ± 1.3 ml, and we had relatively low rate of cement leak, only in 5 patients (6.7 %). We observed 11 (14.8 %) ASF, 7 (63.6 %) of them were in the cranial vertebra. ASF was reported to be between 9.6 – 21.7 %, and majority of the fractures were in the cranial segment (9,28–30,32).

Recollapse of the operated vertebra was reported to be between 12.5 – 22.5 % (17,28). This recollapse was attributed to stress shielding effect of PMMA, and/or osteonecrosis induced by PMMA by some authors (10,16). It was reported to be seen

higher in kyphoplasty patients rather than vertebroplasty. Interdigitation of PMMA with cancellous bone was proposed to prevent stress shielding. It was proposed that cyst like defect caused by osteonecrosis formed solid volume of PMMA in the vertebral body, and load transfer occurred through this lump of PMMA rather than interdigitated PMMA (10). We detected similar recollapse rate (12.2 %) in our patients.

Balloon kyphoplasty is an effective and safe procedure that can provide early pain relief, improve function and correct the deformity in spontaneous osteoporotic vertebral body fractures. Although complications such as cement leakage causing neurologic compromise or pulmonary embolus are low, fractures in the adjacent segments of recollapses in the fractured vertebra can be seen.

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Volume: 28, Issue: 2, April 2017 pp: 119-122 CASE REPORT / OLGU SUNUMU

PRIMARY FEMORAL NERVE ENTRAPMENT: A CASE REPORT

PRIMER FEMORAL TUZAK SENDROMU: OLGU SUNUMU

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SUMMARY

Entrapment neuropathies of the femoral nerve are uncommon clinical conditions. The symptoms of femoral mononeuropathy could manifest as acute or subacute severe pain in the inguinal region, weakness of the function of quadriceps femoris muscle and a decreased patellar reflex. We present a case with a 40-year-old woman suffering from pain, numbness and progressive weakness in her lower right limb due to an uncommon femoral nerve compression. The case were successfully treated with surgery. The femoral nerve was discovered to be trapped at the level of the inguinal ligament by a scar tissue. This scar tissue was incised and the femoral nerve was relieved. After the operation, her neurological deficits improved completely. Femoral nerve entrapment should be taken into consideration in such patients in order to prevent unnecessary surgical interventions.

Keywords: Femoral nerve, nerve entrapment syndrome, surgical decompression.

Level of evidence: Case report, Level IV.

ÖZET

Nervus femoralis'in tuzak nöropatisi, nadir rastlanan klinik bir durumdur. Femoral nöropati semptomları, inguinal bölgede akut veya subakut olarak oluşabilen ağrı, m. quadriceps femoris'te güç kaybı ve patellar reflekste zayıflamadır. Bu yazıda, femoral sinirin inguinal ligament seviyesinde sıkışması sonucu ortaya çıkan sağ alt ekstremitede ağrı, duyu kaybı ve progresif güçsüzlük şikayetleri ile kliniğimize başvuran, 40 yaşında kadın hasta sunuldu. Hastaya uygulanan cerrahi girişim sırasında, nervus femoralis'in, ligamentum inguinale seviyesinde, skar dokusu ile sıkışmış olduğu görüldü. Skar doku insize edildi ve nervus femoralis serbestleştirildi. Uygulanan cerrahi girişim sonrasında, hastanın nörolojik defisitleri tamamen düzeldi. Bu bölgede cerrahi girişim gerektiği durumlarda, postoperatif granülasyon dokusu ve fibrosise bağlı femoral sinir sıkışma olasılığı gözardı edilmemelidir.

Anahtar Kelimeler: Femoral sinir, tuzak sendromu, cerrahi gevşetme.

Kanıt Düzeyi: Olgu sunumu, Düzey IV.

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INTRODUCTION

The femoral nerve (FN) arises from the posterior divisions of the ventral rami of the second, third, and fourth lumbar nerves (L2-L4). It descends through the psoas major, emerging low on its lateral border and then passes between the psoas and iliacus, deep to the iliac fascia and behind the inguinal ligament [6,9,12]. The femoral nerve is most commonly injured within the retroperitoneal space or under the inguinal ligament. Damage to the femoral nerve can be the result of a direct injury, a tumor or other growth blocking or trapping part of the nerve and prolonged pressure on the nerve [5,7]. Additionally, pelvic fractures, therapeutic radiation in the pelvic region, hemorrhage in the retroperitoneal space and catheters placed during certain surgical procedures into the femoral artery have also been known to cause femoral nerve damage [6,10]. Iatrogenic injury during intra-abdominal and pelvic surgical procedures such as gynecological and urological operations still remains the most frequent cause of femoral neuropathy [3,8].

Our report describes a patient, who underwent an unnecessary right hip arthroscopy, harboring a primary right femoral nerve entrapment that remained undiagnosed for four years.

CASE REPORT

A 40-year-old woman suffering from pain, numbness and progressive weakness in her lower right limb for four years was admitted to our clinic. The patient also complained about difficulty walking and running. During the four years, she had been followed up for lumbar disc herniation in another clinic; however, her complaints had worsened in the last eight months. Last year, an orthopedic surgeon due to her pain had also performed a right hip arthroscopy but nothing could be identified.

Upon detailed questioning, she reported that 20 years ago, she received a steroid injection due to right groin pain she suffered while she was running. Although her pain subsided after the injection, she still feels the same pain intermittently.

Neurologic examination of the patient revealed motor weakness during right hip flexion (3+/5) and adduction and extension of the right knee (4/5), numbness of L2 and L3 dermatomes, and a hypoactive right patellar reflex. Tinnel's sign was positive. Also, there was atrophy in the right quadriceps femoris (4 cm circumferential difference was 4 cm between right and left side).

Magnetic resonance imaging of the lumbosacral and pelvic regions was normal except for the bulging at L4-L5 intervertebral disc level.

Electrophysiological evaluation of the right lower extremity revealed significant decrease of the compound muscle action potential of the right femoral nerve when compared with the left side and the findings were consistent with the entrapment of the right femoral nerve at the level of the inguinal region.

Based on the clinical, radiologic and laboratory findings, she was offered surgery under neuromonitorization, to release the nerve trapped in the inguinal region. Following informed consent from the patient, she was operated under general anesthesia in the supine position. The incision was made in the inguinal region just lateral to the femoral artery, extending vertically from the inguinal ligament level to the junction of upper and middle thigh. As the incision deepened, femoral artery and femoral vein became apparent. The femoral nerve was trapped at the level of the inguinal ligament by scar tissue. This tissue was incised to expose the distal part of the intrapelvic portion of the nerve. After relaxation of the femoral nerve the motor unit potential was obtainable. Following the operation, her neurological deficits fully improved **(Figure-1,2).**

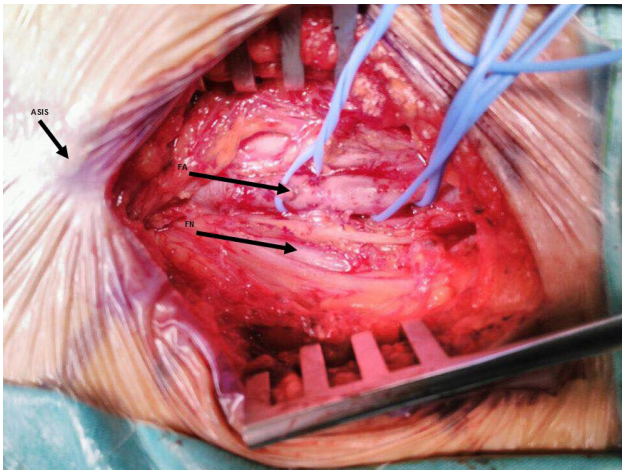

Figure-1. The photograph shows the ASIS, FA and the FN which belong to the right side of the patient. **(**ASIS: Anterior Superior Iliac Spine, FA: Femoral Artery, FN: Femoral Nerve)

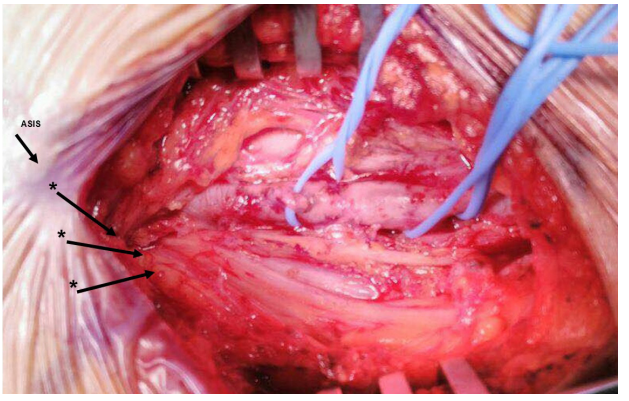

Figure-2. The photograph shows the ASIS, and the remnant of fibrosis tissue in surgical area. **(**ASIS: Anterior Superior Iliac Spine**,** *: Scar tissue remnant)

During the follow-up period her pain completely disappeared and she regained her full motor strength. Her electrophysiological evaluation of the right femoral nerve performed one month later after the operation revealed improvement which was also supported by the clinical findings **(Figure-3).**

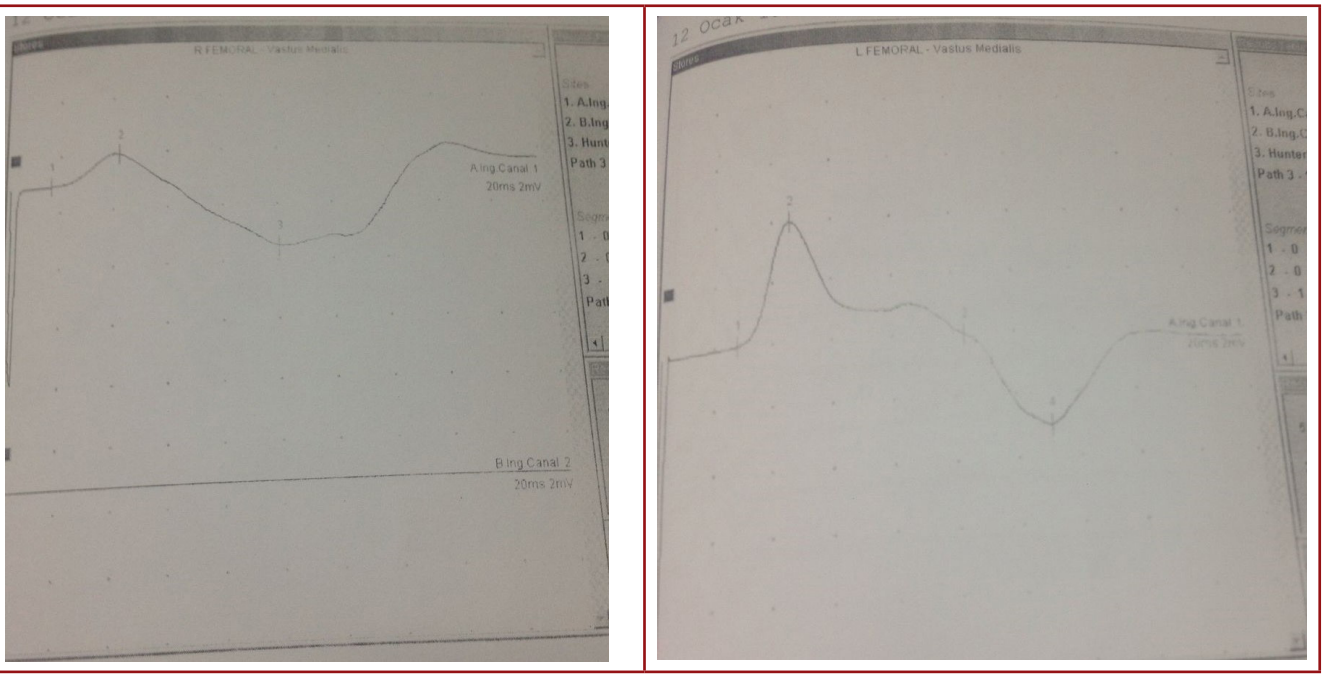

Figure-3. a) Electrophysiological evaluation of the right lower extremity performed before and **b)** one month after the operation revealed normal compound muscle action potential of the right femoral nerve.

DISCUSSION

Femoral nerve compression is an uncommon form of mononeuropathy [5]. There are many reasons for this type of nerve compression such as mechanical, pathological, traumatic, iatrogenic or metabolic issues [2,5].

Pneumatic tourniquet applied during the surgical procedures for lower extremities, psoas hematoma and abscess, diabetic amyotrophy, hip or pelvic fractures, thigh lacerations (these are often partial lesions, affecting nerve supply to the quadriceps), hip arthroplasty, abdominopelvic operations (particularly compression or stretching during these procedures) and coronary angiography are some examples to the reasons behind femoral nerve injury [3-6]. Besides this compressive femoral nerve neuropathy from a fibroid tissue is unusual presentation.

The symptoms of femoral mononeuropathy could manifest as acute or subacute severe pain in the inguinal region and tenderness in the iliac fossa [1,5]. The main symptoms of FN compression are weakness of the function of quadriceps femoris muscle and a decreased patellar reflex [4,12].

Weakness of the quadriceps femoris and sartorius muscle can cause reduced hip flexion and external rotation forces as well as diminished knee extension force [5, 7]. All this pathology may present as difficulty in ambulation [5]. In addition to these motor symptoms, paresthesia of the anteromedial aspect of the thigh, extending to saphenous nerve distribution down to the hallux, may also exist in patients [5,8]. In the chronic type, denervation of quadriceps femoris may result in wasting or atrophy of the muscle [11]. Furthermore, Tinnel's sign, pain created by percussion over the area of the femoral nerve, may be positive over the inguinal ligament and it is this symptom that confirms the femoral nerve involvement [1,10].

Muscle denervation can be detected using electromyography which detects waves and fibrillation potentials in a muscle at rest. Nerve conduction velocity studies can also be used to evaluate nerve integrity [5-6,11].

Nerve conduction studies (NCS) of the femoral nerve can be obtained by stimulating the femoral nerve at the inguinal ligament and recording over the quadriceps femoris. Comparison should be made with the clinically normal opposite side. Obtaining a compound action potential of at least 50% of the other side suggests good prognosis for recovery within 1 year. The needle examination should include both the quadriceps femoris and iliopsoas muscle [5,11].

Our patient's clinical findings (weakness of the quadriceps femoris, a decreased patellar reflex, and positive Tinnel's sign) were in accordance with right femoral nerve entrapment. The

possible mechanism of entrapment by fibrosis could have been the injection performed in the inguinal region and additional micro trauma that occurred during sports activities.

However, she was misdiagnosed with a hip pathology and had to experience an unnecessary hip arthroscopy. Atrophy of the quadriceps femoris points to a chronic pathology but her young age would help her improve quickly [5,7].

Femoral nerve entrapment mononeuropathies are uncommon conditions. Our case is a rare example showing that fibrosis can occur by injection performed in the inguinal region, additional microtrauma by sports activity and induce associated pressure neuropathy. However, to prevent unnecessary surgical interventions such as hip arthroscopy, we should be aware of their existence, especially in the presence of positive Tinnel's sign at the inguinal region and weakness of the hip flexion and knee adduction, which may be misdiagnosed as L2-4 radiculopathy.

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PULMONARY FUNCTIONS IN PATIENTS WITH IDOPATHIC SCOLIOSIS

İDYOPATİK SKOLYOZ TANILI HASTALARDA SOLUNUM FONKSİYONLARI

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SUMMARY

Idiopathic scoliosis is most common during periods of rapid somativ growth. It is caused by the lateral displacement and rotation of vertebral bodies and has many effects on respiratory function. Scoliosis results in a restrictive lung disease with a multifactorial decrease in lung volumes, displaces the intrathoracic organs, impedes on the movement of ribs and affects the mechanics of the respiratory muscles. Scoliosis decreases the chest wall as well as the lung compliance and results in increased work of breathing at rest, during exercise and sleep. Pulmonary hypertension and respiratory failure may develop in severe disease. In this review the epidemiological and anatomical aspects of idiopathic scoliosis are noted, the pathophysiology and effects of idiopathic scoliosis on respiratory function are described, the pulmonary function testing including lung volumes, respiratory flow rates and airway resistance, chest wall movements, regional ventilation and perfusion studies are presented. Preoperative pulmonary function testing required, as well as the effects of various surgical approaches on respiratory function are also discussed.

Key words: Pulmonary function, spirometry, idiopathic scoliosis

Level of Evidence: Review article, Level V

ÖZET

İdyopatik skolyoz, omurların yana doğru eğilmesi ve kendi etrafında rotasyonundan kaynaklanır. En yaygın olarak büyüme çağında görülmekte olup solunum fonksiyonları üzerinde birçok etkiye sahiptir. Skolyoz intratorasik organların yerini değiştiren, kaburga hareketini engelleyen ve solunum kaslarının mekanik etkilerini etkileyen, kısıtlayıcı-restriktif akciğer hastalığına neden olur. Skolyoz, göğüs duvarını ve akciğer kompliyansını azaltırak dinlenme egzersiz ve uyku esnasında solunum yükünün artması ile sonuçlanır. İlerlemiş hastalıkta pulmoner hipertansiyon ve solunum yetmezliği gelişebilir. Bu derlemede idiyopatik skolyozun solunum fonksiyonları üzerindeki patofizyolojisi ve etkileri tanımlanarak, akciğer volümleri, hava yolu akım ve direnç oranları; göğüs duvarı hareketleri, ventilasyon ve perfüzyon çalışmaları sunulmaktadır. Ameliyat öncesi pulmoner fonksiyon testleri ve çeşitli cerrahi yaklaşımların solunum fonksiyonları üzerindeki etkileri de tartışılmıştır.

Anahtar Kelimeler: Solunum fonksiyonları, spirometry, idiopatik skolyoz

Kanıt Düzeyi: Derleme, Düzey V

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INTRODUCTION

Scoliosis is the most common deformation abnormality of the spine with direct effects on the thoracic cage. Depending on which region of the spine is being affected by the displacement of the vertebrae, the scoliosis is classified as 'thoracic', 'lumbar' or 'thoracolumbar'. Involvement of the thoracic spine (alone or in combination with the lumbar spine) is primary responsible for the respiratory and cardiovascular complications of scoliosis. The prevalence of scoliosis in the general population varying significantly from 0.3 % to 15.3 % [9,13,18-19].

Idiopathic scoliosis is scoliosis for which there is no definite etiology unlike neuromuscular, congenital, or syndromic types and accounts for approximately 85 % of cases. Its diagnosis can be made after exclusion of a primary etiology such as vertebral anomaly, neuromuscular disorder, Marfan syndrome or other disorder.

The effects of scoliosis in the anatomy of the chest are quite complex. Scoliosis can affect pulmonary function in many ways. At an early stage it is usually asymptomatic. Most investigators who have studied the impairment of pulmonary function in scoliosis generally agree that [10] a Cobb angle greater than 90 degrees greatly predisposes to cardiorespiratory failure [16], lung function abnormalities are detectable when a Cobb angle is greater than 50 to 60 degrees [13], lung function abnormalities are mainly of the restrictive type and [9] the duration of scoliosis correlates with the patients degree of disability [15]. Its natural history is associated with curve progression, cardiopulmonary impairment, back pain, cosmetic deformity and neurologic compromise. A great variety on the degree of these manifestations exists, depending on age of onset, genetic background and curve pattern [15].

PATHOPHYSOLOGY AND EFECTS OF IDIOPATHIC SCOLIOSIS ON RESPIRATORY FUNCTION

In the absence of other underlying disorders, mild to moderate scoliosis (Cobb angle less than 70°) actually produces very few respiratory signs and symptoms. Scoliosis has generally been associated with the development of restrictive lung defect, manifested by a decrease in total lung capacity (TLC) on pulmonary function testing. The decrease in lung volume is multifactorial, being determined primarily by the angle of scoliosis (>70), the number of vertebrae involved (seven or more), the cephaladlocation of the curve and the loss of the normal thoracickyphosis [8].

In a recent clinical study, impairment of pulmonary function was seen in more severe cases of spinal deformity, proximally-located curvature and older patients [7].

The decrease in TLC may reflect different pathophysiology depending on the age of the patient at the onset of scoliosis and the chronicity of the problem. Thus, infantile (and possibly juvenile) scoliosis is more likely to be associated with true lung hypoplasia because the thoracic deformity is present during the period of very rapid lung growth and development [3]. In adolescent scoliosis the development, and to a large extent the growth, of the lungs has been completed before the onset of the scoliosis. Thus, the decrease in TLC is more likely to reflect the impaired chest wall mechanics that prevent the normal inflation of the lungs.

True lung hypoplasia due to thoracic deformity during the period of very rapid lung growth and development may be a factor in infantile and possibly juvenile scoliosis [17].

Airway obstruction may occur but is uncommon. Rotation of the chest can produce displacement/rotation of the intrathoracic and/or mainstem bronchi, or compression of a mainstem bronchus against vertebra and mediastinal structures, produce mechanical airway obstruction and reduce expiratory flows and increase airway resistance [5].

PULMONARY FUNCTION TESTING IN IDIOPATHIC SCOLIOSIS

Lung volumes

Restrictive lung disease manifested by a reduction in the TLC is characteristic of severe scoliosis. In such cases simple spirometry may provide a good estimate of the restrictive lung defect because the decrease in the forced vital capacity (FVC) is proportional to the decrease in TLC unless the patient has a mixed restrictive and obstructive defect. Spirometry is much easier to perform in outpatient care settings and is more useful in monitoring the changes in lung function over time, than as the sole means of diagnosing restrictive respiratory disease [1,21]. In patients with moderate to severe scoliosis a negative linear correlation has been established between the magnitude of the curve and FVC.

Patients with increasing coronal and sagittal plane deformities with a high thoracic scoliosis apex are at the highest risk for reduced FVC [4].

A reduction of lung volumes has also been reported in some adolescents with mild scoliosis (e.g. Cobb angle less than 35°), without a clear correlation between the magnitude of the curve and lung volumes. The FVC decreases in proportion to TLC unless there is air-trapping in which case the FVC decreases disproportionately.

Thoracic-dominant scoliosis has an impact on the thoracic cage, there were significant negative correlations between Cobb angle and FVC, and Cobb angle and forced expiratory volume in 1 second (FEV1) values in scoliotic patients [6].

Residual volume (RV) remains generally within the predicted values. Due to the relative decrease in TLC, RV/TLC ratio is

increased. Similarly, the functional residual capacity (FRC) is also normal or slightly diminished and the FRC/TLC ratio is increased. If scoliosis progresses to a severe degree, RV declines slightly. The absolute values of anatomic and alveolar dead space are believed to remain normal. If there is atelectasis and/or hypoinflation of the lung the alveolar dead space will be decreased as well. However, the ratio of dead space to tidal volume (V_D/V_T) is increased. This plays a major role in the development of alveolar hypoventilation.

Maximum inspiratory pressure (MIP) has been reported to be decreased. A crude but significant correlation between the decrease in MIP and the fall in FVC has been reported [13-14]. The decrease in MIP is of major importance in the pre-operative evaluation of the patient because a MIP less than 30 cmH_2O increases significantly the possibility of postoperative respiratory failure due to inability to get extubated. Maximum expiratory pressure (MEP) is normal or may be low, probably due to the chest wall deformity that prevents the muscles from contracting effectively and thus they can not generate the maximal pressure.

In general, the effects on lung volumes in idiopathic scoliosis are the result of reduction of chest wall compliance, impaired lung growth and impaired respiratory muscle strength which work at a mechanical disadvantage.

EFFECTS OF SCOLIOSIS ON THE AIRWAY FUNCTION

Airway function in patients with mild-to-moderate scoliosis tends to be normal. In more severe cases, the maximal expiratory flow volume curve assumes a very characteristic tall and narrow pattern with maximal expiratory flow rates that are elevated disproportionately to the lung volume (reflecting the rapid emptying of the lungs). In addition, the inspiratory flow volume curves, instead of having the semi-circular shape seen in a healthy individual, are virtually a mirror image of the expiratory ones (Fig. 1 and Fig. 2).

As the condition worsens, patients may also develop evidence of lower airway obstruction with concavity in the expiratory limb of the flow–volume curve (Fig. 3). The lower airway obstruction is often reversible with bronchodilators, indicating presence of airway hyperresponsiveness. The latter may be the result of chronic airway inflammation secondary to the poor clearance of secretions [2].

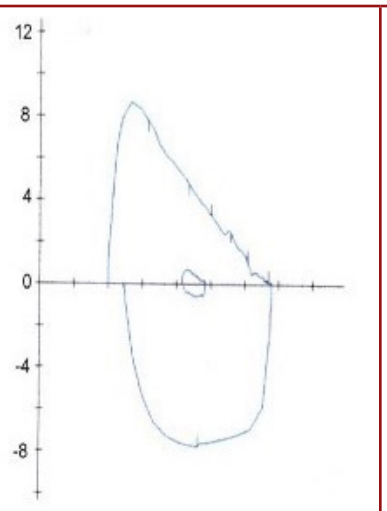

Figure-1. Maximal flow–volume curve (MFVC) in a healthy individual. The expiratory flow–volume curve (above the x-axis) has the typical triangular shape, whereas the inspiratory flow–volume curve (below the x-axis) has a semicircular configuration. Note the size of the tidal flow-volume curve (in the middle) relative to the MFVC. The ratio of tidal volume in relation to the forced vital capacity (VT/FVC) is less than 15%.

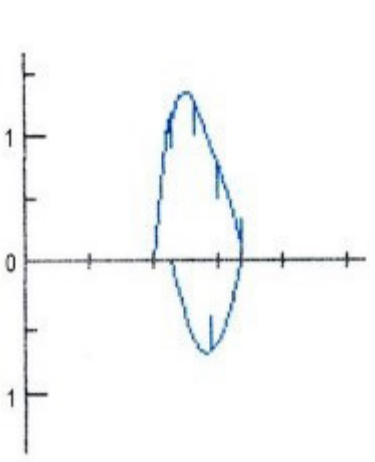

Figure-2. MFVC in a patient scoliosis. The inspiratory curve is a 'mirror' image of the expiratory one, and they both differ in configuration from the normal MFVC. (Forced vital capacity 49% of the predicted normal value; HbSaO2 97 % on room air).

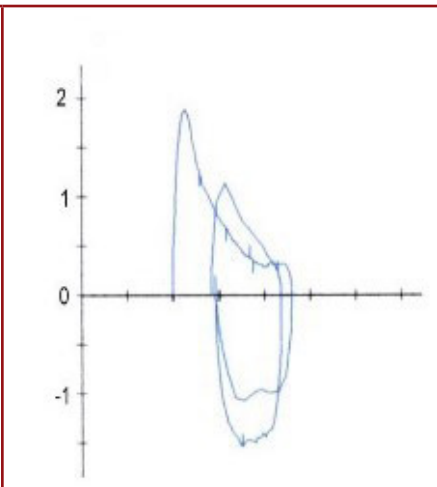

Figure-3. MFVC of a patient with scoliosis showing combined restrictive and obstructive defect. V_T/FVC >60%.

PREOPERATIVE AND POSTOPERATIVE PULMONARY FUNCTION IN IDIOPATHIC SCOLIOSIS

Pulmonary complications are the principal cause of morbidity and mortality in the immediate period following surgery for scoliosis. Preoperative assessment of pulmonary function including TLC and an overnight oximetry should be performed as a guide to prevent postoperative complications.

An FVC less than 40 % of the predicted normal and maximal inspiratory and expiratory pressures of less than 30 cm H2O significantly increase the risk that the patient may not be able to be extubated [(20)].

The presence of preoperative restrictive pulmonary function could be a useful predictor of postoperative pulmonary complications. Moreover, as the FVC ratio worsens, the incidence of postoperative pulmonary complications increases [(11)].

Corrective surgery is used primarily to prevent further progression of the deformity, and secondarily to increase the space available for lung expansion. Indications for scoliosis correction surgery are generally based on severity of curve magnitude and risk of curve progression. In a recent cohort study, scoliosis correction in adolescents was found to increase thoracic volume and is strongly correlated with improved TLC in cases with severe restrictive pulmonary function [(12)].

In summary, idiopathic scoliosis is a common debilitating deformity of the thoracic cage with potentially severe and irreversible effects on lung function. Because the pulmonary manifestations may not become clinically evident until significant or irreversible changes in lung function have already occurred, early recognition of the problem and regular evaluation with pulmonary function testing are advisable.

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THE MANAGEMENT OF THE BLOOD TRANSFUSION IN SPINAL SURGERY

OMURGA CERRAHİSİNDE KAN TRANSFÜZYONU YÖNETİMİ

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ABSTRACT:

Significant blood loss occurs in spine surgery even in routine situations. There are multiple reasons of blood loss and most of them are unpreventable. Blood transfusion to correct blood loss may cause complications and may increase mortality and morbidity. Unfortunately, perioperative unnecessary blood transfusion frequently occurs in clinical practices. In order to decrease blood transfusion there are several techniques which are restrictive blood transfusion strategy, correct patient position, use of antifibrinolytic agents, controlled hypotension, acute normovolemic hemodilution, preoperative autologous blood donation and cell-saver usage. In this article, all these techniques described briefly. The aim of this article is preventing hidden and neglected complications related to blood transfusion.

Key words: Spinal surgery, blood transfusion, autotranfusion

Level of evidence: Review article, Level V

ÖZET:

Spinal cerrahide, rutin uygulamalarda dahi önemli miktarda kan kaybı görülmektedir. Kan kaybının bu girişimlerde engellenemeyen bir çok nedeni vardır.Kan kaybı nedeniyle uygulanan kan transfüzyonunun bir çok komplikasyonları vardır. Bu komplikasyonlar postoperatif mortalite ve morbiditeyi artırabilir. Ne yazık ki perioperatif gereksiz kan transfüzyonu sıklıkla klinik uygulamalarda ortaya çıkar. Kan transfüzyonunu azaltmak için, kısıtlayıcı kan transfüzyon stratejisi, doğru hasta pozisyonu, antifibrinolitik ajanların kullanımı, kontrollü hipotansiyon, akut normovolemik hemodinüsyon, ameliyat öncesi otolog kan bağışı ve hücre koruyucu kullanım olmak üzere birçok teknik bulunmaktadır. Bu yazıda bu teknikler kısaca anlatılmıştır. Bu makalenin amacı, kan nakli ile ilgili gizli ve ihmal edilmiş komplikasyonları önlemektir.

Anahtar Kelimeler: Omurga cerrahisi, kan tranfüzyonu, ototransfüüzyon

Kanıt Düzeyi: Derleme, Düzey V

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INTRODUCTION:

The scope of spinal surgery is quite extensive in terms of age groups. Both adult and pediatric patients undergo emergency or elective spinal surgery. Due to the long duration of surgical intervention and the causes arising from the operation site, there can be excessive amounts of surgical blood loss. There can be significant surgical bleeding in spinal surgery, even in routine situations [6].

In spinal surgeries, bleeding occurs from both the muscle surface and the bone surface. Elderly patients have more bleeding due to having a thinner periosteum and the osteoporotic bone which has more vascular canals. In pediatric patients with neuromuscular scoliosis and adults with osteoporotic bones, the amount of bleeding is greater [7].

Laminectomy applied during decompression also causes epidural hemorrhage. The commonness of arthritic facet joints in adult patients leads to more osteotomies being performed and therefore to more blood loss from bone tissue. In deformity surgeries performed on adults, surgical blood losses during operations increase due to the deformed structure of many vertebrae.

Patients who are going to undergo spinal surgery often use nonsteroidal anti-inflammatory drugs (NSAIDs). This leads to an increase in blood loss in the perioperative period due to the adverse effects of NSAIDs on platelet functions [1]. In addition, the use of excess herbal extracts known to increase the bleeding by these patients is a factor that increases surgical blood loss.

In conclusion, even in routine cases, significant loss of blood may be seen in spinal surgeries and blood transfusion is often required.

BLOOD TRANSFUSION:

Blood transfusion brings many complications with it as well as being lifesaving (Table-1).

Therefore, techniques to prevent and reduce blood transfusions significantly reduce postoperative mortality and morbidity. Practices have been developed to reduce and prevent blood loss to avoid these negative effects of blood transfusion in major operations requiring blood transfusion, such as spinal surgery [10]. These applications vary from simple precautions to the use of a variety of equipment. The main techniques used to reduce and prevent blood loss and the need for blood transfusion are avoiding unnecessary blood transfusions, correct positioning of the patient, antifibrinolytic agents, controlled hypotension, and autologous blood transfusions. These techniques are as follows;

Although there is no scientific data on unnecessary blood transfusion, perioperative unnecessary blood transfusion frequently occurs in clinical practices. In order to avoid unnecessary blood transfusion, the patient's clinical condition and accompanying diseases should be taken into account and the correct indication should be determined. There is an indication for blood transfusion in cases where coagulopathy and hemorrhage are uncontrollable and in cases of active hemorrhages causing shock, if there are signs of tissue hypoxia such as lactic acidosis and increased base excess. In the last guideline published by the American Association of Blood Banks, approaches vary according to the Hemoglobin (Hb) level:

a. **Restrictive approach;** Blood transfusion should be considered when the Hb level is below 7-8 g/dL. In this approach, the threshold for blood transfusion in ASA I patients is Hb 7 g/dL. In postoperative patients, the threshold value is 8 gr/dL for chest pain, orthostatic hypotension, tachycardia not responding to fluid resuscitation, and congestive heart failure. A threshold value of 8 g/dL is similarly recommended for orthopedic surgical procedures, cardiovascular surgery and for patients with a previous cardiovascular disease. It does not apply to acute coronary syndrome, severe thrombocytopenia (patients at risk of bleeding who are treated for hematological or oncological reasons), and anemia due to chronic transfusion (not recommended due to inadequate evidence).

b. **In the liberal approach;** the threshold value for blood transfusion is 9-10 g/dL. But in restrictive red blood cell transfusion, meta-analyses have shown improved in-hospital mortality, reduced cardiac events, and reduced bacterial infections [2].

PATIENT POSITION:

The reduction and prevention of blood loss is most simply achieved by correct positioning of the patient. Patient position in spinal surgery can vary according to the level of operation and the nature of the operation. It is very important to keep the venous pressure low in the surgical field to reduce the bleeding. In the posterior approach in lumbar surgeries, the epidural venous pressure should be kept low. Freeing of the abdomen with support from a Wilson frame reduces bleeding. Freeing the abdomen in the same way in posterior approaches of the thoracic vertebra reduces venous pressure in the surgical field. When patients are in the prone and knee chest positions, care should be taken to reduce intra-abdominal pressure. Increased intra-abdominal pressure causes venous congestion in the lumbar region and increases surgical blood loss. The Relton-Hall frame, which allows the intra-abdominal organs to be freely suspended, reduces blood loss by reducing the pressure in the inferior vena cava by one-third. In another study, it was shown that correct positioning of the patient on

the Wilson frame could reduce blood loss at the vertebral level by 50 % [5].

Table-1. Complications of blood transfusion

Early
Haemolytic reactions
Immediate
Delayed
Non-haemolytic febrile reactions
Allergic reactions to proteins, IgA
Transfusion-related acute lung injury
Reactions secondary to bacterial contamination
Circulatory overload
Air embolism
Thrombophlebitis
Hyperkalaemia
Citrate toxicity
Hypothermia
Clotting abnormalities (after massive transfusion)
Late
Transmission of infection
Viral (hepatitis A, B, C, HIV, CMV)
Bacterial (*Treponeum pallidum, Salmonella*)
Parasites (malaria, toxoplasma)
Graft-*vs*-host disease
Iron overload (after chronic transfusions)
Immune sensitization (Rhesus D antigen)

ANTIFIBRINOLYTIC AGENTS:

Synthetic lysine analogues, tranexamic acid, aminocaproic acid, protease inhibitors, and aprotinin have been used in spinal surgery to reduce bleeding. Tranexamic acid and aprotinin has been shown to reduce intraoperative blood loss in a statistically significant manner [8]. Aprotinin is a protein derivative obtained from the bovine lung. It inhibits tissue plasmin and kallikrein. It also protects platelet functions. In 2006, the drug was withdrawn from the market due to acute renal failure, myocardial infarction, heart failure, encephalopathy, and cerebrovascular complications.

Desmopressin reduces bleeding time in platelet function disorders. But there is no evidence that it reduces blood loss due to spinal surgery.

CONTROLLED HYPOTENSION:

Controlled hypotension is defined as a reduction in systolic arterial pressure to 80-90 mmHg, a reduction in mean arterial pressure to 0-65 mmHg, or a 30 % reduction in mean arterial pressure from the basal value. Lowering of blood pressure results in a direct reduction of bleeding in arteries and arterioles, as well as a reduction in venous bleeding due to venous dilation and a reduction of bleeding from venous sinuses in bone structures. Controlled hypotension not only reduces the need for blood transfusion but also facilitates the imaging of the surgical field, allowing for a shorter operation time.

The concept of reducing surgical bleeding by creating hypotension was proposed by Harvey Cushing in 1917 for neurosurgical procedures. In 1946, the definition of a bloodless surgical field with the method of arteriotomy was made by Gardner. In 1948, Griffiths demonstrated that surgical blood loss could be reduced by inducing hypotension with high spinal anesthesia and in 1951 Gillies showed that the same was possible by inducing hypotension with high epidural anesthesia.

In the following years, ganglion blockers such as pentamethonium, hexamethonium, and trimethaphan were used to induce hypotension. In 1962, the use of short-acting sodium nitroprusside and halogenated anesthetic agents enabled controlled hypotension to be more easily achieved and safe.

Agents used successfully alone are inhalation anesthetics, sodium nitroprusside, nitroglycerin, trimethaphan camsylate, alprostadil (prostoglandin E1), adenosine, and remifentanil. Agents used alone or in combination are calcium channel antagonists (e.g., Nicardipine) and beta adrenoceptor antagonists (propranolol, esmelol) and fenoldopam. ACE inhibitors and clonidine are used as adjuvants.

Controlled hypotension is an easy and reliable method of reducing blood loss and the need for blood transfusion in spinal surgery procedures. It is fairly safe to reduce the mean arterial pressure to 50-65 mmHg or to reduce the basal mean arterial pressure by 30 % in patients with an American Society of Anesthesiologists risk classification of I (ASA I).

On the other hand, patients diagnosed with chronic hypertension cannot tolerate a 25 % reduction in the mean arterial pressure. Controlled hypotension should not be applied in patients with cerebrovascular, cardiac, hepatic, and renal disease, respiratory failure, severe systemic hypertension, anemia, hemoglobinopathies, and polycythemia.

Although controlled hypotension is safe, the patient has more risk of cardiac arrest when massive hemorrhage and surgical complications such as tension pneumothorax occur. Care should be taken when using controlled hypotension in spinal surgery that neurological deficits present or occurring at the surgical level or below may worsen.

Following the motor stimulated potentials of the anterior spinal cord and the sensorial stimulated potentials of the posterior spinal cord is a standardized method of monitorization in spinal surgery today. Controlled hypotension should be terminated promptly when a deterioration is detected at the basal level of electrical potential measurements during a surgical procedure.

When the controlled hypotension procedure is being performed, V5 derivation should especially be monitored along with ST segment analysis on ECG. Oxygen saturation should be monitored due to ventilation perfusion incompatibility and hypoxemia. Central venous pressure and invasive arterial pressure monitoring should be performed. Body heat should be watched closely. Monitoring of the motor and sensorial potentials of the medulla spinalis should be done.

In the postoperative period, attention should be paid to the continuity of the airway, oxygenation, analgesia, reactive bleeding, and fluid balance. An eye should be kept open for rebound hypertension after insufficient analgesia and the risk of postoperative bleeding related to this.

Clinical studies have shown that controlled hypotension reduces the need for blood transfusion in spinal surgery by 2-3% [4].

AUTOLOGOUS BLOOD TRANSFUSION:

Autologous blood transfusion is defined as the collection of the patient's own blood or blood products and their subsequent re-delivery. Autologous blood transfusion techniques are listed below;

a. Acute Normovolemic Hemodilution
b. Predeposit autologous transfusion
c. Cell saver use

a. ACUTE NORMOVOLEMIC HEMODILUTION:

It is described as the drawing of blood from the patient immediately before or at the beginning of the operation, and its transfusion to the patient again after the operation. Messer et al. first described the technique of preoperative hemodilution in surgical patients in 1974. They withdrew 1500-2000 ml of venous blood in the 20-30 minutes before surgery after anesthesia induction from patients with Hct levels above 35 % and replaced it with the same volume of 5 % Albumin solution. After surgery, the blood was returned to the patient. They showed that there was less red blood cell loss in hemodiluted patients during surgical procedure compared to normal hematocrit levels [3].

In this technique, between 1 and 3 units of blood is drawn according to the patient's basal hematocrit and Hb level. The estimated blood volume is 75 ml/kg for men and 70 ml/kg for women. The target Hb level is preferred as 9 g/dL. For each 1 ml of blood withdrawn, 2-4 ml of crystalloid/colloid volume should be replaced. Ringer's Lactate, 5 % Albumin, 6 % dextran 70, or 6 % hetastarch are used for the volume replacement.

Physiological changes:

Withdrawing blood from the patient and replacing it with an acellular fluid causes a decrease in arterial oxygen content. The acute decrease in the Hb level leads to hemodynamic changes through compensation mechanisms and causes the oxygen dissociation curve to shift to the right, resulting in an increase in the oxygen extraction of Hb. As a result, the oxygenation of peripheral tissues increases thanks to this. The hemodynamic changes are increased cardiac output, increased heart rate, increased stroke volume and contractility, decreased peripheral vascular resistance, and decreased blood viscosity [9].

Acute and marked reduction in hematocrit, which can lead to hemodynamic instability, can cause myocardial ischemia in susceptible patients. Complications arise from the physiological effects of acute hemodilution.

Indications:

Normovolemic hemodilution is used in operations with a high probability of blood transfusion, in patients with preoperative hemoglobin levels above 12 g/dL, in those without clinically significant coronary, pulmonary, hepatic, renal and liver disease, in persons without severe hypertension, and in patients with no infections or bacteremia.

Normovolemic hemodilution significantly reduces the need for blood transfusion in spinal surgery.

Monitoring:

Oxygen saturation, invasive arterial pressure monitoring, ST segment analysis and V5 derivation on ECG, CVP measurement (for adequate fluid resuscitation), and urine output and cardiac output measurements should be performed during acute normovolemic hemodilution.

b. PREOPERATIVE AUTOLOGOUS BLOOD DONATION:

Autologous blood donation is the collection, storing, and re-delivering in case of need of the patients own blood before elective surgery. Collecting blood begins 3-5 weeks prior to elective surgery. The last donation should be performed at least 48-72 hours before surgery to allow rebalancing of blood

volume. The blood is stored in citrated phosphate dextrose blood bags in traditional manner in a blood bank. In this way, 3-4 units of blood is collected depending on the need and is stored. Oral or intravenous iron supplementation may be required to maintain erythropoiesis [12].

It is possible to increase red blood cell production and increase the amount of blood collected preoperatively or to be withdrawn in normovolemic hemodilution by administering erythropoietin in the preoperative period. There are studies which have shown that the use of erythropoietin before surgery reduces the need for blood transfusion in orthopedic and spinal surgeries [13]. Erythropoietin is administered on the 1st, 4th, and 7th days preoperatively in the form of 300-600 IU/kg epoetin alfa and surgery is performed on the 13th day. Preoperative blood donation almost completely eliminates the risk of viral infections and immune-mediated fever, hemolysis, and allergic reactions. In addition, the immunomodulation that occurs after allogenic blood transfusion does not occur. This can reduce the risk of infection and cancer recurrence in the postoperative period.

Disadvantages: Blood collected in the preoperative period is not used at rates of approximately 50 %. Blood collected for autologous blood donation is rarely used in other patients. Therefore, it leads to higher costs per unit when compared to allogenic blood. In addition, complications such as hemolysis and bacterial contamination can also occur due to the collection, transportation, storage or transfusion technique.

Suitability:

The patient should be able to tolerate repeated phlebotomies and the hematologic and cardiovascular problems that occur after it. It is contraindicated in the case of anemia, cyanotic heart disease, ischemic heart disease, aortic stenosis, or severe hypertension. Children under 30-40 kg are not eligible for the technique.

Those with acute systemic infections should not donate, as well as patients with diarrheal disease in the period before donation or long-term diarrhea, as bacterial contamination may occur in these patients. Fainting and dizziness reactions are common during donation and this is rarely serious [11].

c. CELL SAVER USE:

The cell salvage technique consists of collecting blood lost from a surgical field in a reservoir, preventing the collected blood from clotting using citrate or heparin, filtering the collected blood in order to purify it from large particles, centrifuging it afterwards, washing it with 0.9 % NaCl, collecting it in a bag for reinfusion, and re-delivering it to the patient. It is used intraoperatively, postoperatively, or in both cases. Although cell saver is usually used in conjunction with normovolemic hemodilution, the benefit of using them together is disputable. Today cell salvage can be obtained by simple aspiration system (solotrans), semi-automatic system (Haemonetics, Cell Saver) and continuous auto-transfusion system (CATS).

Indications for the use of Cell Salvage: It is recommended for use when the estimated blood loss is 1000 mlt or more than 20% of the total blood, in surgical procedures requiring blood transfusions in more than 10% of patients, and in surgical procedures with an average blood requirement of more than 1 unit.

Factors related to the patient should also be considered when deciding on the use. These are the rejection of allogenic blood transfusion by the patient, difficulties in finding suitable blood, low hemoglobin in the patient, and increased risk of bleeding.

Cell Salvage can be used in all elective and emergency surgical procedures if there is no contraindication.

The main contraindications to Cell Salvage are that the surgical site is contaminated with intestinal content or infected material. When heparin is used as an anticoagulant, it is heparin induced thrombocytopenia. Citrate solution can be used as an anticoagulant in this case.

The points to be considered in intraoperative cell salvage use:

a. The use of iodine, cement, topical clotting agents, and antibiotics not suitable for intravenous use

b. Avoiding aspiration of infected areas

c. Not aspirating gastric and pancreatic secretions as this may cause hemolysis

d. Not aspirating the pleural effusion

e. There are concerns about its use in patients with sickle cell anemia. It should be taken into consideration that sickling may occur in these patients.

f. Amniotic fluid should not be aspirated because it will cause amniotic embolism

g. Intraoperative cell salvage is not recommended by the manufacturers in the presence of malignant conditions because the malignant cells can be reinfused in the patient and metastasize. However, there are publications in the literature suggesting that it can be used.

In conclusion, measures to reduce and prevent bleeding should be chosen according to the patient and the nature surgical procedure to be performed in those procedures where bleeding is unavoidable, such as spinal surgery. The methods to be applied can be used alone or in combination. Blood transfusions have negative effect on postoperative mortality and morbidity negatively. It is known to increase relapses due to immune modulation in cancer surgery. For this reason,

these methods should be considered in all surgical procedures where blood loss may be excessive.

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PROF. UFUK AYDINLI, M.D.

PROF. DR. UFUK AYDINLI

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SUMMARY

Prof. Dr. Ufuk Aydınlı was born in 1956 in Amasya. After graduation from Samsun 19 Mayıs University Medical School, he received his specialist training on Orthopedic Surgery and Traumatology at the same institution. He became interested in spinal surgery in this period and has opportunity of training by the most prominent names in spinal surgery, such as Dr. Robert Winter, Dr. Francis Denis, Dr. John Lonstein at Minnesota Spine Center in the US. A doyen on spinal tumors, Prof. Dr. Ufuk Aydınlı was also the editor of our book named "Diagnosis and Treatment of Spinal Cord and Spine Tumors" published by the Turkish Spine Association. Prof. Dr. Ufuk Aydınlı, who has publications in many international journals was the head of Turkish Spinal Surgery Association between the years 2006-2008. Prof. Ufuk Aydınlı is both a representative of Minnesota School in Turkey, and also a real friend and an elder brother. He is a genuine pioneer in Turkish Spinal surgery, with his works and research.

Key Words: Prof. Ufuk Aydınlı, M.D., Spinal Surgery, AOSpine Türkiye, Turkish Spine Association

Level of Evidence: Biography, Level V.

ÖZET

Prof. Dr. Ufuk Aydınlı 1956 yılında Amasya doğdu. Samsun 19 Mayıs Üniversitesi Tıp Fakültesini bitirdikten sonra aynı fakültede Ortopedi ve Travmatoloji uzmanlık eğitimini aldı. Bu dönemde cerrahisi ile ilgilenmeye başlayan Prof. Aydınlı, 1 yıla yakın bir süre Amerika Birleşik devletlerinde Minnesota'da Dr. Robert Winter, Dr. Francis Denis, Dr. John Lonstein gibi omurga cerrahisinin ileri gelenlerinden eğitim alma şansı buldu. Omurga tümörleri konusunda bir duayeni olan Prof. Dr. Ufuk Aydınlı, Türk Omurga Derneğinin çıkardığı "Omurga Ve Spinal Kord Tümörlerinin Tanı Ve Tedavisi" isimli kitabımızın da editörlüğünü yaptı. Birçok uluslararası dergide yayınları olan Prof. Dr. Ufuk Aydınlı, 2006-2008 yılları arasında Türk Omurga Cerrahisi Dernek Başkanlığını yürüttü. Minnesota ekolünün Türkiye'deki temsilcisi olan Sayın Prof. Ufuk Aydınlı aynı zamanda gerçek bir dost ve ağabeydir. Yaptıkları ve yayınları ile Türk Omurga cerrahisinin gerçek bir öncüsüdür.

Anahtar Kelimeler: Prof. Dr. Ufuk Aydınlı, Omurga Cerrahisi, AOSpine Türkiye, Türk Omurga Derneği.

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INTRODUCTION

Prof. Dr. Ufuk Aydınlı was born in Amasya in 1956, graduated from 19 Mayıs University and specialized in the Department of Orthopedic Surgery and Traumatology of this institution. Afterwards, he had started working at Bursa Uludağ University as Assistant Professor, and worked there till he had retired.

In the years when I first met Prof. Dr. Ufuk Aydınlı, I had imagined him to be a hard-tempered man, with his thick eyebrows and spiky hair, thick, black framed eyeglasses and cold attitudes. In the following years, I always appreciated his laboriousness strictly according to his rules, but as I came to know him better, I started to see him as a friend and brother, seeing how an honest, soft-hearted and friendly person he was. In my opinion, he is the only representative of Minnesota school in Turkey. He is a doyen surgeon and excellent educator in all areas of spinal surgery and especially spinal tumors **(Figure-1).**

Figure-1. Prof. Ufuk Aydınlı, M.D.

LIFE STORY

He was born on 9th of October, 1956 in Amasya. His mother Aliye Aydınlı is the daughter of Abdullah Altunay, who was one of the first teachers of Atatürk era, and his father was the son of Hüseyin Aydınlı, who was the gardener at Railroad plantation. Halil bey entered Military School after graduating from Samsun High School, and started his career in Koruköy, Gelibolu in 1950 at the rank of lieutenant and the adventure of the family in many cities of Turkey begun [4].

His older brother Atilla Aydınlı graduated from Marif High School of that time, educated at the Hacettepe University Department of Physics, worked as faculty at the US – Bilkent and is working as professor in Uludağ University. His sister Demet Aydınkarahaliloğlu graduated from Hacettepe School of Pharmacy, and is working as the head of Ministry of Health Turkey Institution of Drug and Medical Devices, Department of Pharmacovigilance and Controlled Substances, during which her doctorate on pharmaceutical toxicology.

When he started the first grade of primary school, his father was on duty in the US and so he had sent his son a letter. I will present this letter below for everybody to read. If you pay attention to the envelope, you will observe that he was addressed as an adult by his father, which is really very valuable **(Figure-2).**

Prof. Aydınlı continued his education in seven separate cities, and finally graduated from Ankara Atatürk Lisesi**.** He started his medical education at Hacettepe University Samsun Medical School in 1973 and graduated from 19 Mayıs University Medical School in 1980 as a medical doctor **(Figure-3,4).**

He worked at Virginia University Medical School twice in 1976 and 1979 as guest student, and was about to start working on internal medicine specialization at the same school, when he came back to 19 Mayıs University Medical School and started specialization on Orthopedic Surgery and Traumatology with Doç. Dr. Öner Gedikoğlu and Dr. Tarık Akyüz. Actually, he had met orthopedic surgery and ether anesthesia at the age of 8 twice with a broken fore-arm. He was on duty for 24 hours for 4,5 years with his closest friend Dr. Adem Türk, and completed his residency training. He did his military duty at Samsun Military Hospital.

He operated nearly 200 patients between the years 1986-1988 in Keşan State Hospital, without an anesthesiologist and an x-ray device. He applied spinal anesthesia himself in hip fractures and accomplished Richards intramedullary hip screwing in 20 patients without scope, by help of his knowledge of anatomy.

He created hospital's and his first thorax tube after diagnosis of pneumothorax by auscultation by using foley catheter and glass fluid bottle and biochemistry pipettes and thus treated the patient.

He was accepted at the University of Padua Department of Hand Surgery in 1987, after being successful at an examination for an educational scholarship, but he started to work at Uludağ University Medical School, Department of Orthopedic Surgery and Traumatology as assistant professor with an invitation from the former head of department, instead.

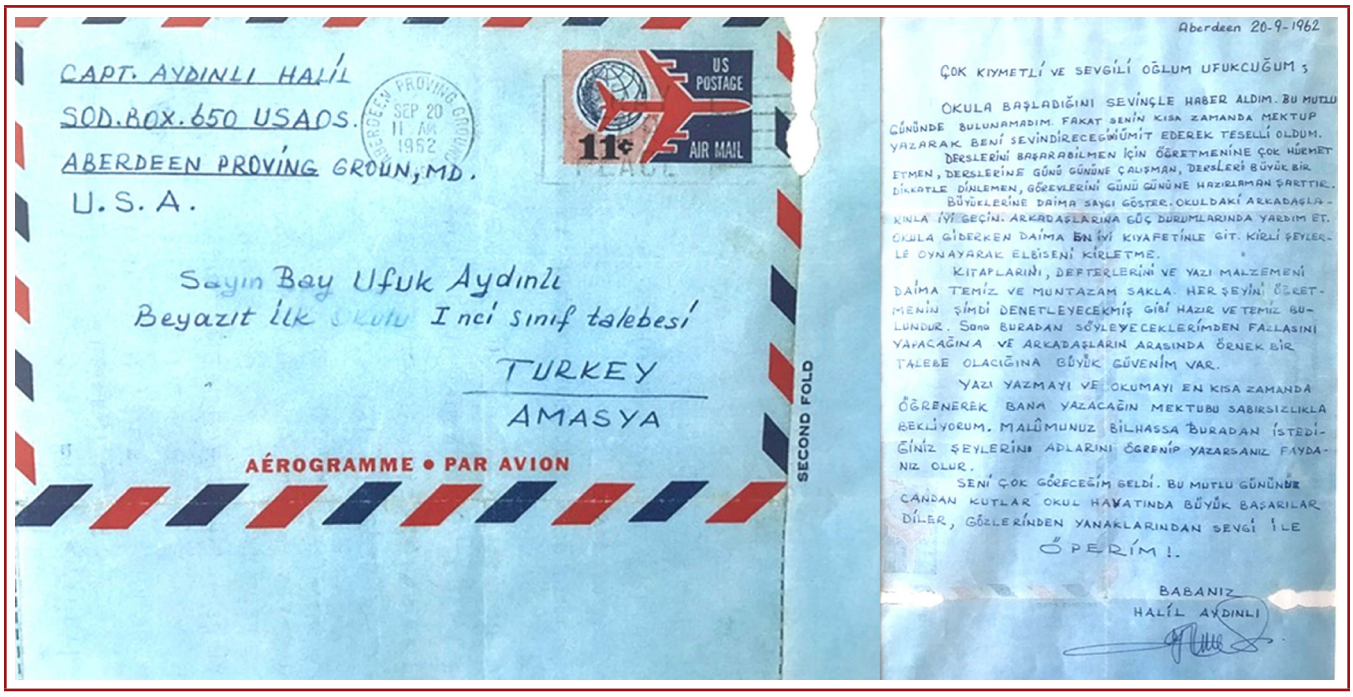

Figure-2. The letter of father of Prof. Aydınlı.

Figure-3. Biology Laboratory in Erzurum Deneme High School.

Figure-4. Prof. Aydınlı is seen with his friends in the garden of Hacettepe Medical School in 1976.

Figure-5. Prof. Aydınlı, his wife and his son in 1985.

In 1989, the departmental committee decided that he should specialize on spinal surgery, and he worked with many valuable faculty members at Ankara University Medical School Department of Orthopedic Surgery and Traumatology.

He worked as faculty at Uludağ University Department of Orthopedic Surgery and Traumatology between the years 1988-2010. During this period, he contributed to training of Prof. Dr. Alparslan Öztürk, Doç. Dr. Oğuz Karaeminoğlu, Doç. Dr. Çağatay Öztürk, Doç. Dr. Burak Akesen, Yrd. Doç. Dr. Kürşat Kara, Dr. Kenan Tişkaya, Dr. Serdar Çelebi, Dr. Rasim Şerifoğlu, Dr. Yavuz Yılmaz, and Dr. Müren Mutlu, who have come to high levels in spinal surgery. He also worked at administrative posts such as Uludağ University supervisor for operating theatre, Vice-Dean and Head of Purchasing Committee.

Prof. Aydınlı was married his classmate Dr. Jale Aydınlı in 1982. He has a son who was born in 1985 who is still working in Chicago in US as a computer engineer. He has twins daughters who were born in 1995. One of them is attending to the School of architecture and other is a student in department of international affairs the in a university **(Figure-5).**

According to him, the best thing in the recent years was the boat trip from Morocco to Miami with his friends **(Figure-6).**

Figure-6. Prof. Aydınlı , in the boat trip

His philosophy of work:

- Don't lie !
- Say once !
- Listen to the patient!
- Let the patient to decide himself for his treatment
- Don't call the patient more than ones when you offer operation
- Accept the complications, and stand by the side of the patient untill all problems are solved
- Determine your rules and follow them
- The main mission of the professor is education
- Keep walking, if you stop, you will die (As his friend Ensor Transfeldt said).

HIS CONTRIBUTIONS TO SPINAL SURGERY

He worked for 7 months at the Minnesota Spinal Surgery Clinics in the US in 1991 as an observer. He had the opportunity to be trained by most prominent names in spinal surgery in the world, such as Dr. Robert Winter, Dr. Francis Denis, and Dr. John Lonstein.

In addition to these valuable scientists, becoming acquainted with Dr. Ensor Transveldt at the Twin Cities Spine Center have contributed a lot to Aydınlı **(Figure-7).**

Figure-7. Prof. Aydınlı with Ensor Transveldt.

He continued his scientific activities in spinal surgery with first GICD, then SRS, and EuroSpine memberships. He succeeded to enter among 3 orthopedic surgeons who were elected for the fellowship program to visit 5 US cities in 2000.

He met the international CEO of AOSpine, Michael Piccerello in 2004. As it was much more widespread, active, democratic and transparent, he founded AOSpine Turkey after cancelling all of his other memberships. He was selected for membership of AOSpine European Board between the years 2010-2013. He worked as faculty at AOSpine International Educational Committee.

He published the spine curriculum with a group from AO for the first time in the world. He is currently an AOSpine Europe Education Advisor and AO International Board member. He gave talks in many scientific meetings, became moderator in meetings and worked as educational advisor in especially Europe, and also in the US, North Africa, Middle East, Russia, and China **(Figure-8,9,10).**

He was among the first that have done simultaneous anterior-posterior surgical intervention, total sacrectomy, en-bloc spondylectomy (3 and 4 segments) in Turkey. He has first

used a different stabilization technique after sacro-pelvic resection in the world. He modified the original technique of posterior vertebral column resection, thus obtaining a more reliable approach in which there is less bleeding [4].

Figure-8. Prof. Aydınlı with Dean of the Macedonia Medical Faculty.

In 2004, after nearly 14 years of active surgery on spine and tumors at the Uludağ University, a departmental committee decision was sent to Uludağ University Rectorate by faculty members of Uludağ University Department of Neurosurgery Prof. Dr. Ender Korfalı and Prof. Dr. Kaya Aksoy, declaring that he did not possess the training for and ability to perform spinal surgery, and thus should not perform such operations.

The rector of that time had initiated an inquary on this in order to monopolize the field issue, but did nothing for 19 months, after which had given Prof. Aydınlı administrative reprimand for other personal reasons, which was approved by the head of YÖK with the insistance of the rector. This issue was taken to administrative court, which cancelled the whole sentence and penalty.

This issue was also brought to the General Committee of Turkish Spinal Surgery Association, and after a historical speech by Prof. Dr. Azmi Hamzaoğlu, who was president of TOD at that time, asking for support for Dr. Ufuk Aydınlı, Ufuk AYDINLI was elected as president of TOD unanimously. Prof. Aydınlı related those days as: *"In all of my life I haven't interfered with anybody about to do or not do an action with the belief that everybody carries his/her own responsibilities for his/her deeds which is somewhat instilled me through my education process. For 20 years, I declared that spinal surgery must be an independent department and fought for it in various platforms. However what I see is decision makers act with the motivation of how the interests will be shared after the decision rather than what is the correct decision. And I perceive the accusations about me within this framework. Unanimous support of TOD for me with my election as president of TOD was very pleasing"*[4]

Figure-9. Prof. Aydınlı in the operation room of the spinal surgery in the Macedonia Medical Faculty.

Figure-10. Prof. Aydınlı is with Behrooz Akbarnia (President of SRS).

Prof. Aydınlı was the head of Turkish Spinal Surgery Association during the period 2006-2008. He brought on the agenda the writing a book on spinal surgery at this period.

One of the other tasks he worked on during this period was the organization of spinal surgery lists of TTB and SUT. TTB applied this change in 2009, but did not ask the opinion of our association. We prepared 10 books for publication during the period 2015-2017, thus realizing the dream of Prof. Aydınlı. Ufuk Aydınlı, who nearly wrote one or more sections in these books, was also the editor of our book "*Diagnosis and Treatment of Spine and Spinal Cord Tumors*" (ISBN.978-4711-01-7) [3] **(Figure-11).**

TTB-TOTBİD-TND-TOD coordination committee unified spinal surgery items of Orthopedic Surgery and Neurosurgery in the HUV list of TTB in 2015-2017 and a single list under the name of spinal surgery was accepted and published. We are happy that thus the second dream of Prof. Aydınlı became true.

Prof. Aydınlı, who continues working on both spinal surgery and tumor surgery reports it to be ironic that he was editors of both *Tumors of Musculoskeletal System* and *Diagnosis and Treatment of Spine and Spinal Cord Tumors*, while not being considered as a real tumor surgeon by Orthopedic Tumor Surgery Associations and surgeons **(Figure-12).**

Figure-11. The editor of ***"The Clinical Diagnosis and Treatment of The Tumors of Spine and Spinal Cord"*** which has been printed in 2015 is Prof. Aydınlı.

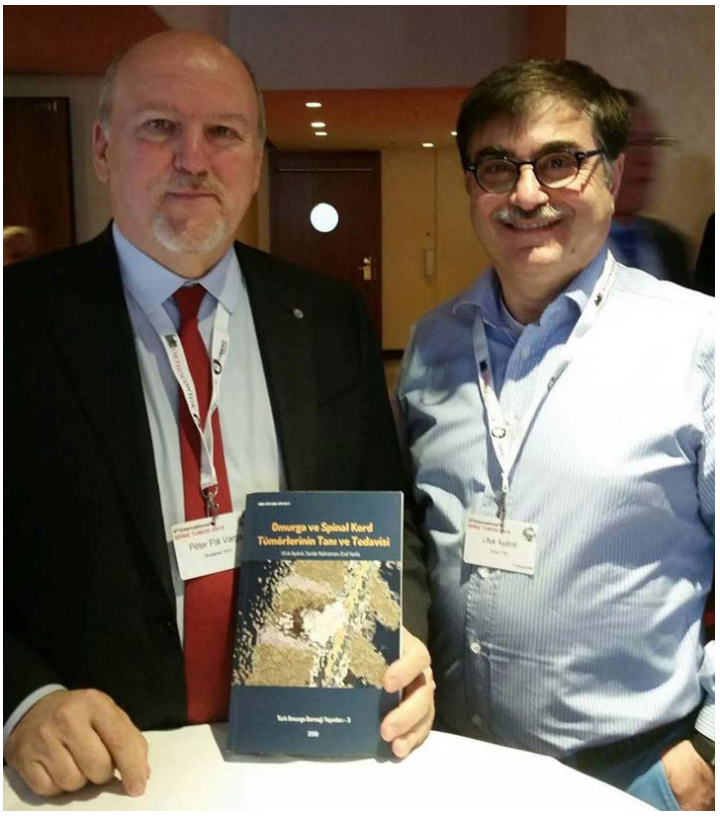

Figure-12. Prof. Aydınlı is with Prof. Peter Varga who is a famous surgeon of spinal tumors from Hungary.

In my opinion, the most important contribution of Prof. Aydınlı is his support to education. We observed this personally during 2015-2017 period, when he attended all meetings energetically that we had invited, and tried hard to transfer his knowledge to younger colleagues. He is working on creation of surgical training simulation programs with his firm, with the support of TÜBİTAK **(Figure-13).**

Between 2004 and 2006, his clinic was accepted as a training center of AOSpine, spinal surgeons from Kenya, Nigeria, Macendonia came to his clinic for the training of spinal surgery for 3 months **(Figure-14).**

He has many publications that are included in international indices [1-2,5-7]. Prof. Ufuk Aydınlı, who is the representative of Minnesota in Turkey is at the same time a real friend and an elder brother. He is a genuine pioneer in Turkish spinal surgery, with his accomplishments and publications.

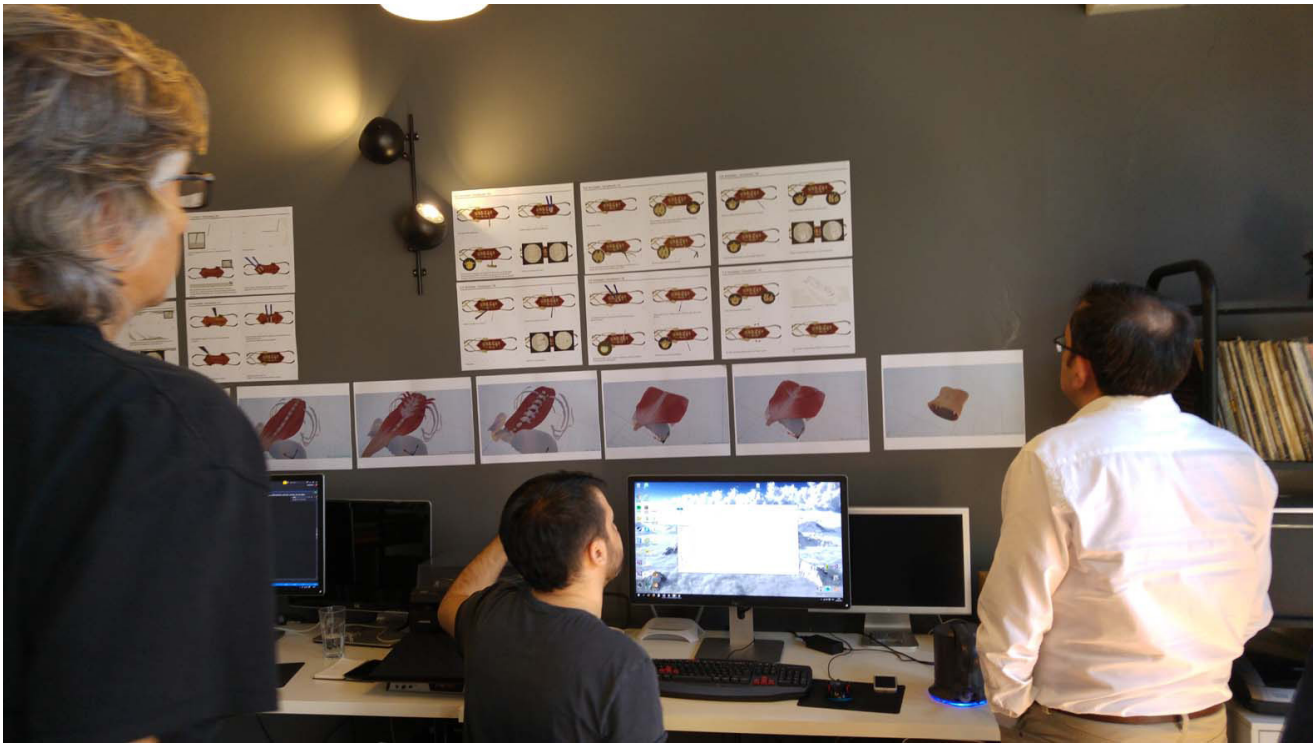

Figure-13. TUBITAK visit of his firm.

Figure-14. Prof. Aydınlı is making plates.

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CME QUESTIONS / *STE SORULARI*

1- Which subject of the below had been tested in the study of Sariyilmaz et al.
- **a)** Guina pigs
- **b)** Rabbits
- **c)** Rats
- **d)** Chickens
- **e)** Dogs

2- Which drug had been used for evaluating pathogenesis of idiopathic scoliosis in the study of Sariyilmaz et al?
- **a)** Steroids
- **b)** Melatonin
- **c)** Growth hormone
- **d)** Botulinum toxin-A
- **e)** Ergocalcipherol

3- Which experimental spinal cord injury area in the rats of the below had been made in the study of Cömert et al?
- **a)** Upper cervical region
- **b)** Lower cervical region
- **c)** Thoracic region
- **d)** Thoracolumbar region
- **e)** L-1 level

4- How many rats with the spinal cord injury had been evaluated in the study of Cömert et al?
- **a)** 30
- **b)** 40
- **c)** 50
- **d)** 60
- **e)** 70

5- Which Lenke type below had been evaluated with the idiopathic scoliosis treated with selective fusion according to the second study of Sariyilmaz *et al*?
- **a)** Type-I
- **b)** Type-II
- **c)** Type-III
- **d)** Type-IV
- **e)** Type-V

6- Which corrective maneuver had been evaluated for correction of the lumbar lordosis in the second study of Sariyilmaz *et al*?
- **a)** Translation
- **b)** Distraction
- **c)** Compression
- **d)** Convex rod derotation
- **e)** None of all

7- How many balloon kyphoplasty had been performed according to the study of Demircay *et al*?
- **a)** 23
- **b)** 33
- **c)** 43
- **d)** 53
- **e)** 63

8- Which sentence below was true according to the study of Demircay *et al*?
- **a)** ODI scores is not changed improved at the final follow-up.
- **b)** There were 15 female patients and 48 male patients.
- **c)** Mean bone cement (PMMA) volume was 4.6 ml.
- **d)** This study included 43 patients
- **e)** All of the sentence above

9- How many cases had been evaluated in the study of Akyol *et al*?
- **a)** 47
- **b)** 37
- **c)** 35
- **d)** 27
- **e)** 17

10- Which sentence below was true according to the study of Akyol *et al* ?
- **a)** Myelopathy symptoms were seen in 39 patients.
- **b)** Radiculopathy symptoms were found in 18 patients.
- **c)** ODL is an effective and safe way to reduce symptoms of degenerative cervical myelopathy due to OPLL
- **d)** Preoperative mean mJOA scores were 1.4
- **e)** None of all

JTSS 27(4) issue CORRECT ANSWERS OF CME QUESTIONS:

1. a	**6. d**
2. b	**7. e**
3. e	**8. a**
4. a	**9. e**
5. c	**10. d**