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Dear Colleagues,

We sincerely wish the new year of 2016 brings peace, happiness and health to all my colleagues and their families. We are happy to accomplish the first issue of 2016.

There are 8 research articles in this issue. The first article is the experimental biomechanics study analyzing for prevent failure of pedicle screws that is used for surgical treatment of osteoporotic spine diseases and to obtain a more stable fixation material by biomechanic comparing of two different screwing technique in corpuses of 15 sheep lomber spine. The next four study are about the morphometric anaysis of the spine. The MR evaluation of relation between Modic changes and occupational status in symptomatic young adults is discussing in sixth article. In the seven study, the results of interbody fusion at the level of conus are presented. The last article is about the the appropriateness and efficacy of vertebroplasty application in patients who developed osteoporotic vertebral compression fracture (OVCF) during their chronic obstructive pulmonary disease (COPD) treatment. We believe that all those studies will quietly interest the readers.

In this issue, in the "Frontiers of the Spinal Surgery" section, the biography was presented about the Prof. Nafiz Bilsel. The authors of the this article are Hüseyin Botanlıoğlu, M.D.

The "Marmara Spinal Group Meetings", which includes İstanbul and neighboring cities and which is conducted to increase the interests of especially assistants and new specialist on spinal surgery and to contribute to their trainings and to transfer the experiences of experienced colleagues and will be organized each month regularly by the regulatory board, and which Assoc. Prof. Dr. Mehmet Aydoğan will perform the headship this year and Yunus Atıcı performs the secretariat, will be continued. You can find the other meeting contents from the announcements section.

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: 27, Issue:1, January 2016 pp: 1-8 ORIGINAL ARTICLE / ORJİNAL MAKALE

COMPARISON OF SHEARING FORCES OF PEDICLE SCREWS THAT PLACED WITH KYPHOPLASTY AND VERTEBROPLASTY TECHNIQUES. A BIOMECHANICAL STUDY

KİFOPLASTİ VE VERTEBROPLASTİ TEKNİĞİ İLE YERLEŞTİRİLEN PEDİKÜL VİDALARININ SIYIRMA KUVVETLERİNİN KARŞILAŞTIRILMASI

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SUMMARY:

In this study, it was aimed to prevent failure of pedicle screws that is used for surgical treatment of osteoporotic spine diseases and to obtain a more stable fixation material by biomechanic comparing of two different screwing technique. In order to achieve that we created fracture in corpuses of 15 sheep lomber spine. Screwing were performed subsequent to injecting cement according to vertebroplasty and kyphoplasty techniques. Afterward, these screws were biomechanically tested. Mann Whitney-U test were used for statistical evaluation of the data.Alpha statistical significance value was accepted as $p<0.05$. It was determined that screwing with polymethyl methacrylate was superior to other techniques, especially in osteoporotic patients. According to these findings, screwing with kyphoplasty technique would be a convenient method for preventing possible screw failures in severe osteoporotic patients.

Key words: Biomechanics, kyphoplasty, poly(methyl methacrylate), vertebroplasty.

Level of Evidence: Biomechanical experimental study, Level II

ÖZET:

Bu araştırmada iki farklı vidalama tekniği biyomekanik olarak karşılaştırılarak, osteoporotik omurga hastalıklarının cerrahi tedavisinde kullanılan pedikül vidalarında yetmezliğin önlenebilmesi ve daha stabil bir fiksayon materyali elde edilebilmesi amaçlandı. Bunun için, 15 adet lomber koyun omuru korpusunda kırık oluşturuldu. Vertebroplasti ve kifoplasti teknikleri ile çimentolama sonrası vidalama yapıldı. Daha sonra, biyomekanik olarak bu vidalar test edildi. Bulguların istatistiksel olarak değerlendirilmesinde Mann Whitney-U testi kullanıldı. Alfa anlamlılık değeri $p<0.05$ istatistiksel olarak anlamlı kabul edildi. Özellikle osteoporotik hastalarda poli(metil metakrilat) ile vidalamanın diğer yöntemlere göre daha üstün olduğu tespit edildi. Bulgular doğrultusunda ileri derecede osteoporotik hastalarda, olası bir vida yetmezliğini önlemek amacıyla kifoplasti yöntemi ile vidalama tekniğinin kullanılması uygun bir seçenek olabilir.

Anahtar Sözcükler: Biyomekanik, kifoplasti, polimetil metakrilat, vertebroplasti.

Kanıt Düzeyi: Biyomekanik deneysel çalışma, Düzey II

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INTRODUCTION:

Percutaneous vertebroplasty is a minimal invasive treatment method used in the treatment of fractures due to osteoporosis, neoplastic diseases and metastatic diseases of vertebral column. Generally, poly(methyl methacrylate) (PMMA) is used as biomaterial, it is injected percutaneously into the fracture and it is stabilized. Thus, pain is relieved[5].

Recently, a similar method, called kyphoplasty, is used to treat vertebral fractures. It enables correcting kyphosis deformity, fracture stabilization, restoration of the height of vertebrae and correcting sagittal balance. In this method a balloon is inserted into the vertebrae. It is expanded in the vertebrae, which reduces the fracture, followed by removal of the balloon and injecting the biomaterial. Early results of this method are promising[21].

In addition to this it also enables people havig poor quality of life due to severe pain related to fracture, to return to their daily activities without pain[7].

It is known that pedicle screws are the most commonly used implants in the surgical treatment of spinal disorders[19]. However; they have some major and minor complications such as; neurological damage, screw breakage,screw pull-out. These complications may be reduced with experience and correct surgical technique[26].

The aim of this study was to prevent pedicle screw failure and to achieve more stable fixation in the surgical treatment of osteoporotic spinal diseases. For this reason we biomechanically compared the vertebroplasty and kyphoplasty techniques and screwing methods. We also compared our results with the current literature.

MATERIAL AND METHODS:

In this study we performed a fracture in the corpus of sheep vertebrae, followed by insertion of screws with vertebroplasty or kyphoplasty and these screws were biomechanically investigated.

Materials:

We used Instron 5569 Universal test machine to perform compression fracture. All the pedicle screws that we used are all universal brands. The vertebroplasty set was Kyphyx bone filler system. In order to perform screw pull-out test we used Instron 5569 Universal test machine.

Study design:

In this study we used 15 lumbar vertebrae of 3 healthy female 14-months old sheeps. We conducrted osteoporotic vertebral columns via expanding balloons in the body of the vertebrae. Vertebraes of each sheep were marked and considered as a group. Soft tissues were removed from vertebraes. We didn't detect any tumors or any other diseases in the vertebraes. Levels and sides of each vertebral segment were marked. Each vertebrae segment, vertebral disc and capsul of facet joint were removed. All the vertebraes to be prepared were kept at-20 ^{o}C.

We performed fractures in each vertebrae using a device with a pressure indicator. In order to standardize the fractures, we performed the pressure from the same point at 8 Bar. We inserted a steel and porous plate, which covers the 2/3 of vertebral body, to upper and lower end-plates

Vertebral bodies were fixed by holding from their spinous processes to prevent translation. The vertebral body was placed in to pressure site of compression device as covering the upper plate. Pressure was gradually increased during compression procedure. Height of the corpus was measured and 20-25% of collapse was created. Kyphoplasty group was established by adding L4 of third group to first group and vertebroplasty group was established by adding L5 of third group to second group.

Entry points of each vertebrae were determined separetely with the help of fluoroscopy. Cortex of entry point was pierced with awl. A thin probe were advanced to anterior cortex through pedicles parallel to upper endplate. Drilling with a 3.2 mm drill and tapping with 4.5 mm tap was performed in same axis with fluoroscopy control. Finally, 30 mm-long and 5.5mm-diameter pedicle screws (Evrenler) were placed and removed.

Appropriate positioning of the baloon that advanced from prepared entry points for kyphoplasty was confirmed with fluoroscopy. The baloon was inflated with equal pressure (10 atm) and equal space was created in each vertebrae. Same procedure was applied for contralateral pedicle. PMMA bone cement was prepared and filled into the cannulas by an injector.

Bone cement was injected in the prepared spaces in the vertebrae according to the technique. In kyphoplasty group, 1 cc bone cement was injected through a pedicle (total 2 cc for each vertebral body). Subsequently, 30 mm-long and 5.5mm-diameter pedicle screws were placed (until last thread of screw enters posterior cortex) (Figure-1).

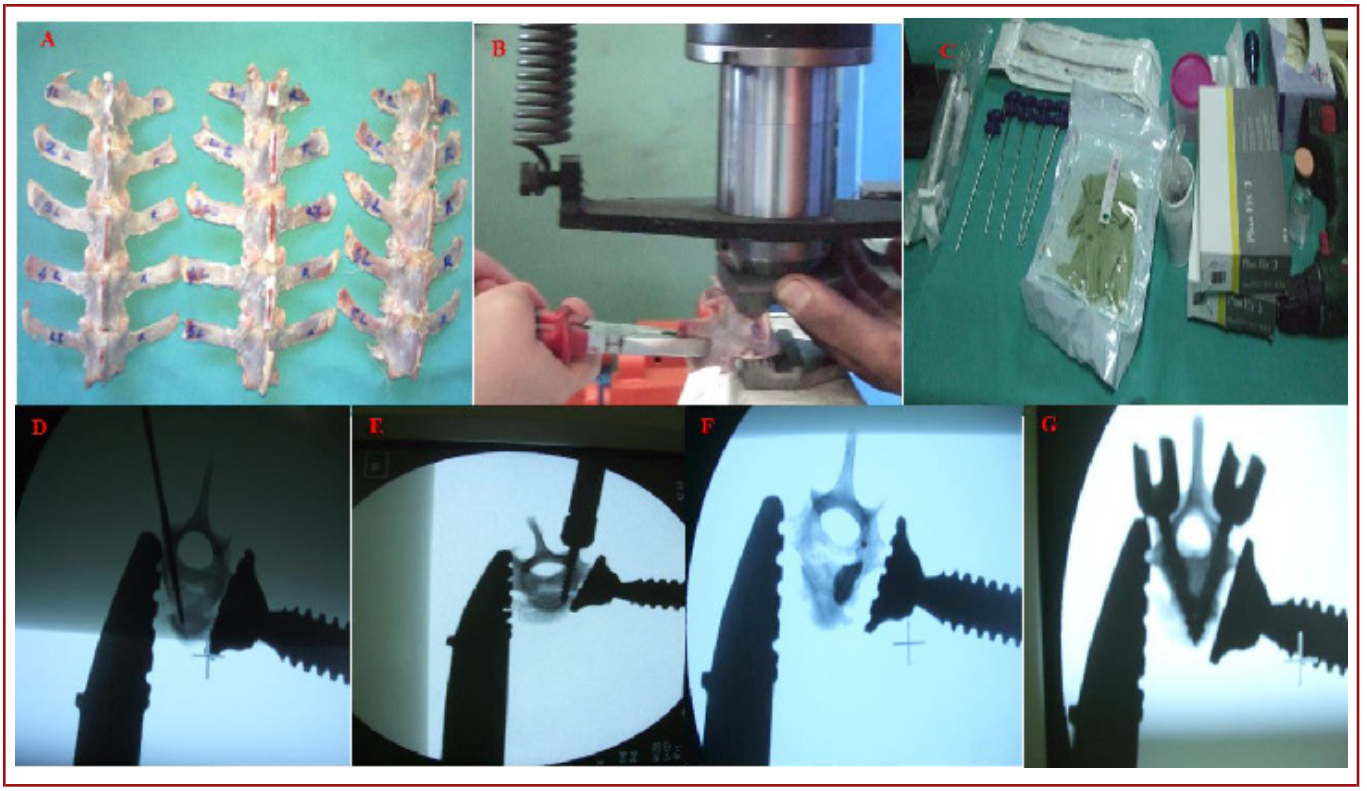

Figure-1. In kyphoplasty group, 1 cc bone cement was injected through a pedicle (total 2 cc for each vertebral body). Subsequently, 30 mm-long and 5.5mmdiameter pedicle screws were placed (until last thread of screw enters posterior cortex)

In the third group, 2 vertebral bodies (L1 and L2) were excluded due to non-standardized fracture duing compression and L3 was excluded due to inaccurate screwing (Figure-2).

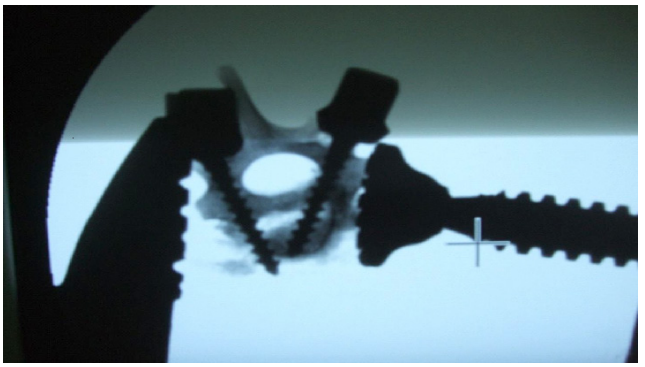

Figure-2. L3 was excluded due to inaccurate screwing

Remaining 12 vertebrae was divided into two groups (6 vertebrae for kyphoplasty -group I- and 6 vertebrae for vertebroplasty -group II).

A space was created in the vertebrae with a blunt tipped cement pushrod by moving forward and back for verteroplasty. Same procedure was applied from contralateral pedicle. PMMA bone cement was prepared and filled into the cannulas by an injector. Bone cement was injected in the prepared spaces in the vertebrae according to the technique.

In vertebroplasty group, 0.5 cc bone cement was injected through a pedicle (total 1 cc for each vertebral body).

Subsequently, 30 mm-long and 5.5mm-diameter pedicle screws were placed (until last thread of screw enters posterior cortex). Right pedicle of L5 that comes from the third group could not screwed due to early hardening of the cement. Only one side of this vertebrae was included in the study.

Cementing procedure for verteroplasty and kyphoplasty was undergone in 18 ºC. Vertebral bodies were kept in room temperature for 24 hours to provide appropriate maturity and hardness of the cement, subsequently was kept in -20 ºC until biomechanical study. Biomechanical test was performed after 12 hours of keeping the vertebraes in room temperature. Screw pullout test was applied to pedicle screws for biomechanical testing (Figure-3).

In all vertebral bodies in kyphoplasty and vertebroplasty groups, pullout test was started from right side. The vertebral bodies for kyphoplasty in group I were L1 (KFP1), L2 (KFP2), L3 (KFP3), L4 (KFP4), L5 (KFP5) of the first sheep and L4 (KFP6) of the third sheep. It was noted that L5 that added to the vertebroplasty group (group II) could not screwed due to early hardening of the cement.

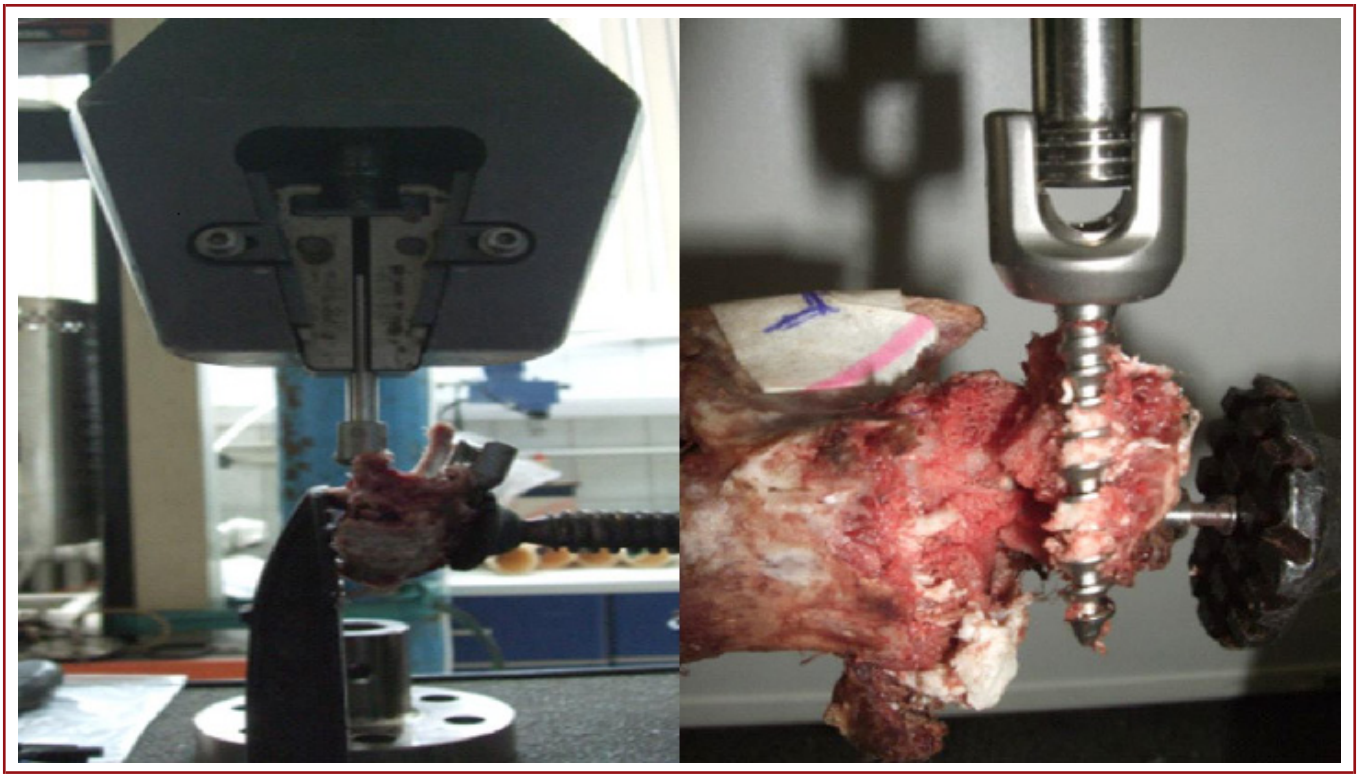

Figure-3. Biomechanical test was performed after 12 hours of keeping the vertebraes in room temperature. Screw pullout test was applied to pedicle screws for biomechanical testing.

The vertebral bodies for vertebroplasty in group II were L1 (VB1), L2 (VB2), L3 (VB3), L4 (VB4), L5 (VB5) of the second sheep and L5 (VB6) of the third sheep. Holdfast system that is used for holding the vertebral bodies was customized production. A small connection part was produced to provide linkage between head of pedicle screw and holder of instron device. Vertebral body was fixated with holdfast in a way that pedicle screw would be perpendicular to ground. Custommade connection part was adapted to screw head. Pulling force of 10 mm/min was applied with the instron device. Pulling force-migration curve was recorded in the computer.

Maximum pulling force that removing the screw from pedicle was determined for each pedicle.

Statistical Analysis

Non-parametric Mann Whitney-U test was used for analysis of the obtained statistical data. Results were showed as mean±standard deviation. A method that did not assume the data of the analysis is not compatible to any kind of statistical distribution was used.

For comparison of two independent groups, the T-tests was not preferred because the data was obtained in an intermittent and rational manner and also incompatible with normal distribution; score values were calculated in composite scale; sample-size in each group is less than 7 when calculation was applied with consecutie scale. Instead of this, Mann Whitney-U test that is non-parametric and alternative to t-test for dependent samples was used. Alpha significance value was determined if $p<0.05$ as statistically significant.

RESULTS:

In kyphoplasty group (group I); pullout forces of the first vertebrae was determined as 584 Newton (N) for right and 369 N for left pedice. Mean pullout forces of left pedicles in kyphoplasty group was calculated as 512,83±138,72 N, whereas mean pullout forces of left pedicles in vertebroplasty group was calculated as 316,33±67,79 N. No statistical significant difference was found between two groups for left side. Mean pullout forces of right pedicles in kyphoplasty group was calculated as 634,33±143,58 N, whereas mean pullout forces of right pedicles in vertebroplasty group was calculated as 347,80±188,99 N. The difference between two groups for right side was statistically significant.(Figure-1,Table-1)

Table-1. Taraflara uygulanan sıyırma kuvvetlerinin gruplar arası istatistiksel olarak karşılaştırılması.

Side	Group	n	Per order	Total order	U	z	P
Right+Left	Kyphoplasty	12	15.75	189.00	21	-2.77	0.006
	Vertebroplasty	11	7.91	87.00			
Left	Kyphoplasty	6	8.17	49.00	8	-1.601	0.109
	Vertebroplasty	6	4.83	29.00			
Right	Kyphoplasty	6	8.00	48.00	3	-2.191	0.028
	Vertebroplasty	5	3.60	18.00			

*: Mann Whitney-U test.

As a result of non-parametric Mann Whitney-U test that is used to determine whether maximum pullout force applied to sheep vertebrae differs according to screwing technique variable or not, it was determined that mean pullout force was 573,5±148,76 (N) for kyphoplasty group and mean pullout force was 330,63±169,17 (N) for vertebroplasty group, therefore statistically significant difference was found in favour of kyphoplasty group ($p<0.05$). Maximum pullout force of screwing method with kyphoplasty technique (median=15,75) is higher than screwing method with vertebroplasty technique (median=7,91).

DISCUSSION:

Spinal surgeries performed on elderly patients increase in number due to improvements in spinal surgery techniques and technology and increased number of elderly population due to increased average life span[13]. The most common materials used in these surgeries for spinal fusions are pedicle screws[11,24].

Human vertebra is the most suitable model for biomechanical testing of these screws in terms of anatomics, cinematics and morphology. Yet it is a challenge to obtain fresh material from younger populations. Besides, human vertebrae have various variations in mechanical and geometrical properties in terms of age, gender, bone quality and degenerative changes[8,16,25].

Because of these disadvantages of human vertebrae, animal models were increasingly used. Easy gain and use in in vitro and in vivo spinal experimental studies, similar geometrical and mechanical properties are some of the advantages why experimental animal models were choosed[9].

With the exception of thoracic vertebrae of sheeps, animal models have a similar pedicle width as of men. Human spinal canal width and depth in anteroposterior plane is greater in comparison to animal models. Human vertebral corpus width and depth is with the exception of deer thoracic vertebrae greater then animals'. However, height of human vertebrae is less then of animals'. Although anatomical and compositional structure of animal vertebrae have similarities with human vertebrae, less depth and width of vertebra corpus, greater vertebral corpus height, discrepancies in pedicle diameters and narrower spinal canals build significant differences. Therefore there is no ideal animal model for human spine. Named discrepancies should be remembered when working with animal models[17].

Although these comparative data exist, it is difficult to determine which animal model to use. Calves and pigs are not being preferred in in vivo studies, since they grow fast, hard to supply and expensive[17].

Wilke HJ et al. has compared biomechanical properties of sheep vertebra to human vertebra. They evaluated sheep vertebra by dividing it into cervical, thoracal and lomber segments and in flexion, extension, axial rotation and lateral bending manipulation, in terms of range of movement, neutral zone and stiffness. They concluded in favor of similarity of sheep and human vertebra[22].

Sanden B et al. compared pedicle screws with and without hydroxyapatite coat in their in vivo study done on sheeps with stripping test. They tested resistance of biomechanical stripping at the beginning and at the 6th and 12th weeks after placing pedicle screws. They didn't find any difference at the 6th week, yet at the beginning and at the 12th week hydroxyappatite coated screws had a greater strenght of stripping. They commented that the results from the first measurement was concluded so, because of roughness of surface. They interpreted the results from the 12th week depended on bone built around the hydroxyappatite coated screws. They preferred sheep vertebra because of its resemblence in anatomical and biomechanical terms in the light of literature data[14].

We preferred experimental animal models in our in vitro study, since obtaining human vertebra was difficult in our country

and also because of the discrepancies in terms of bone density in osteoporotic cadaver vertebra.

However, it is rare in literature that pedicle screws used in spinal fracture operations tested biomechanically in comparison to each other in human and animal models in terms of anatomical suitability. Therefore we believe that results of our study will contribute to literature.

There are several fracture models described in literature. Corpectomy models are established for burst fractures. By this way an unstabil fracture model is created, which has no anterior and middle colon support. As in our study, compression fractures are obtained in purpose of mimicking osteoporotic fractures.

George et al. have performed corpectomy on human vertebra to evaluate short segment posterior enstrumentation biomechanically in unstabil vertebra fractures. They performed corpectomy to T12 and short segment posterior enstrumentation to T11-L1 (20).

Furtado N et al. established fracture models to biomechanically evaluate prophylactic vertebroplasty on human cadaver vertebra. For this purpose, after they dissected vertebra between T12 and L2 from soft tissues, they compressed vertebra corpus between two layers of steel placed on superior and inferior parts of respective vertebra corpus. Following this, with a metal sphere they applied compression to the upper layer with a material test machine at the same point. They continued this compression till each vertebra has lost 25% of its anterior height[6].

Oakland RJ et al. made transverse saw cuts on one thirds of middle colons to demonstrate middle colon fractures. After that, they placed cranial and caudal parts of vertebra into PMMA bone cement and compressed them until they reached 50% of height loss[12].

One of our concerns in our study was whether one could make a hole in corpus with a baloon as being done in osteoporotic vertebra. Therefore we ought to choose a model either with a low body mass index in corpus or a corpus with degenerated trabecular structure and lost toughness. It is very hard to find animal models with low bone density. Therefore we created compression fractures by applying same power and at the same place on each vertebra as described in literature. Thus we destructed trabecular structure of corpus and ensured it could be inflated with a balloon. To apply restrained compression we changed pressure levels not instantly but gradually. We stopped compression when we reached 25 % of collapse.

There has been a lot of tests done in purpose of finding the most suitable screw size, depth of it's placement, direction and design. More to this, in osteoporotic vertebra, to strenghthen screw-bone attachment, PMMA, hydroxyapatite cement and calcium phosphate bone cement are used for augmentation[8,23].

Seemingly the best method for increasing screw coherence in osteoporotic vertebra is PMMA. For today, exothermic polimerization reactions are decreased so to decrease tissue necrosis and nerve injuries due bone cement leakage[2].

In several studies, it is shown that standart screws in osteoporotic vertebra are not very stable, have considerably less coherence and cause more then 12% of failure[2,10,23].

Among with that, PMMA augmentation is shown superior to any other alternative techniques. Moreover, it is favorable to cement adjacent segment for prophylactic purposes in case of future fracture risks. Therefore we used PMMA screws in our experiments in our study.

Studies show that screw diameter has a strong influence on coherence in healthy bones and screw diameter of 7 mm and more is related with significant strenght increase, but that wide screws cause failure after pedicle fracture in 20-40% of osteoporotic patients[3].

In our study we used conical screws. We didn't measure interstitial torque in kyphoplasty and vertebroplasty groups. In our study we measured screw deficiency strenght with stripping test. Although this seems like a limitation to our study, according to our theory contact area of screw with bone cement and increase of bone cement amount in vertebra corpus would increase stability.

Stephen DC et al. showed in their study, which was on augmentation with bone cement and expendable screws, that stripping strenght is increased by 250% in comparison to using only expendable screws[18].

We placed all screws in same axis in our study. Using screws with same groove depth, lenght and diameter we completed our analysis. We placed screws until last groove was buried in posterior cortex as decribed in literature[15].

Screws are placed perpendicular to floor in studies. Pulling speed is applied as 5 mm or 10 mm per minute in many studies[4].

We also placed screws perpendicular to floor and pulling speed was 10 mm per minute during stripping test.

Becker et al. compared three distinct cement techniques in human cadavre vertebra. They found standart screw method with vertebroplasty technique to be superior in comparison to other techniques[1].

As a conclusion, it was revealed that animal vertebra, although anatomical and dimensional differences exist, are good models. Sheep vertebra with created compression fractures may be a good model of osteoporotic human vertebra. Stripping test performed with an instron device in purpose of measuring screw adherence strenght is a good method. During strip test, vertebra must be fastened to device so, that screws are

perpendicular to floor. With kyphoplasty technique a large space is formed in vertebra corpus and this space can be filled with more bone cement than space volume itself with vertebroplasty technique.

After screw placement with kyphoplasty technique, due to increase in bone cement amount circumventing screws, stripping strenght increases significantly. It was concluded that cemented screw placement withkyphoplasty technique is superior to vertebroplasty technique.

Although created compression fracture caused softening of bone, as far as we are concerned, sheep vertebra mimics human vertebra better than other models.

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Volume: 27, Issue:1, January 2016 pp: 9-12 ORIGINAL ARTICLE / ORJİNAL MAKALE

MEASUREMENT OF SPINAL CURVATURE ANGLES ON ADULTS

ERİŞKİNLERDE SPİNAL KURVATUR AÇILARININ ÖLÇÜMÜ

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SUMMARY:

Objective: The aim of the study is to inspect the angles of cervical lordosis (CL), thoracal (TK) and lumbar lordosis (LL) in adults to collect data of the normal mean values for developing spinal deformity patient population.

Materials and Method: We inspected 135 thin-layered reconstructive computed tomography(CT) scans of whole spine that obtained in adult patients who were admitted to our hospital for emergency treatment retrospectively.

Results: 135 patients (60 females, 44.4%, and 75 males, 55.6%) were included in the study. Accordingly, mean age was 50.8±18.1 years, angles of CL was 28.5±6.4, TK 39.7±7.4 and LL was 31.7±6.2 degrees. When the measurements were compared between females and males, it was found that only LL was significantly different between genders (35.0±6.2 in females, and 29.1±5.0 in males, p=0.032), and females had greater values. Age (p=0.420), CL (p=0.083), and TK (p=0.903) were similar between females and males.

Conclusions: This work provided a useful tool for analyzing and understanding sagittal imbalance in patients with spinal disease or deformity and also a means of calculating corrections to be made with treatment, established from the linear regression equations which were elaborated by reconstructive computed tomography.

Key Words: Cervical lordosis, Thoracal kyphosis, Lumbar lordosis, Spinal curvature

Level of Evidence: Morphometric radiologic analysis, Level III

ÖZET:

Amaç: Çalışmanın amacı spinal deformite gelişebilecek hastalar için normal ortalama servikal lordoz (CL), torakal kifoz (TK) ve lomber lordoz (LL) açılarının verilerini toplamaktır.

Materyal ve Metod: Acil servise başvuran ve spinal patolojisi olmayan 135 hastanın ince-kesit bilgisayarlı tomografi görüntüleri retrospektif olarak incelendi.

Sonuçlar: Çalışmaya 135 hasta (60 kadın, % 44.4, and 75 erkek, % 55.6) dahil edildi. Ortalama yaş 50.8 ± 18.1, ortalama kurvatur değerleri CL 28.5 ± 6.4, TK 39.7 ± 7.4 ve LL 31.7 ± 6.2 derece olarak ölçüldü. Ölçümler cinsiyetler arasında karşılaştırıldığında, sadece LL anlamlı olarak gözlendi (kadınlarda 35.0 ± 6.2, ve erkeklerde 29.1 ± 5.0, p=0.032), kadınlarda daha yüksek bulundu. Yaş (p=0.420), CL (p=0.083) ve TK (p=0.903) cinsiyetler arasında benzer bulundu.

Çıkarım: Bu çalışma sagital dengeyi anlamada ve spinal hastalık ve deformitelerde ölçümlerin rekonstrüktif bilgisayarlı tomografi kullanarak daha rahat anlaşılmasına yardımcı olacağı düşünülerek yapılmıştır.

Anahtar kelimeler: Servikal lordoz, Torakal kifoz, Lomber lordoz, Spinal kurvatur

Kanıt Düzeyi: Morfometrik radyolojik analiz, Level III

INTRODUCTION:

Many literature reports suggested that up to 60% of elderly people demonstrated evidence of spinal deformity[11]. Main issues in treatment of patients with adult spinal deformity are disability and pain.

Landmarks on radiographies driving disability in patients with spinal deformity were pointed as sagittal vertical axis (SVA), regional Cobb angles, cervical lordosis (CL), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic tilt, sacral slope (SS), and pelvic incidence (PI) were generalized to assess patient outcomes[6]. The C7 plumb line usage and its relationship with the posterior aspect of the S1 superior endplate is a standardized assessment of global spinal balance; however, this omits the head position and craniocervical alignment[8]. True global sagittal balance should consider the head position in relation to the whole spine and pelvis[9].

Sagittal balance of the spine is a fundamental element necessary for understanding spinal disease and instituting proper treatment. The aim of study was to establish the physiological values of spinal curvature parameters of sagital balance of the spine.

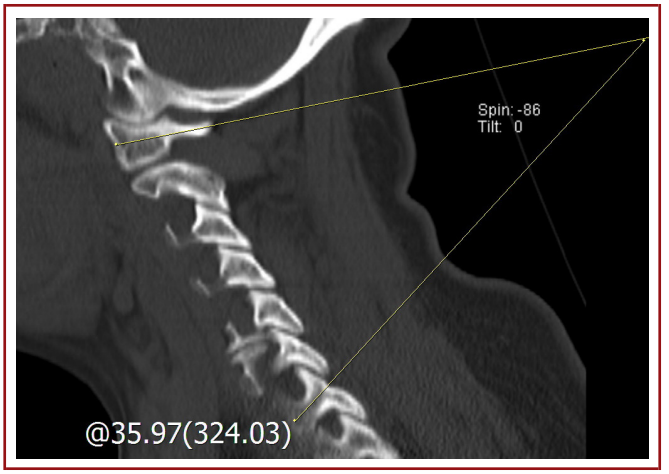
METHODS:

We inspected 135 thin-layered reconstructive computed tomography (CT) scans of whole spine that obtained in adult patients who were admitted to our hospital for emergency treatment retrospectively. Inclusion criterias for patients in the study are, patients had to be older than 17 years and have undergone a complete 3D-CT scan of the spine and had no pathological spinal trauma or disease. Patients were excluded if their radiological examinations were not sufficient for the proposed measurements or if they were known to have pathological conditions of the spine.

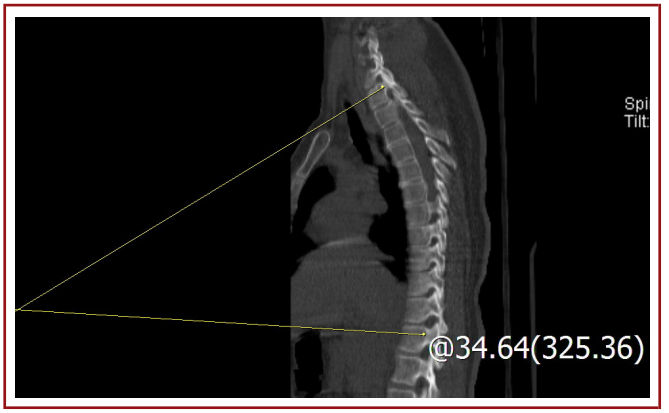
Measurements were made at cervical level from the midline of vertebra bodies C1-C7, Thoracic T1-T12and lumbar level L1-L5 with sagittal reconstructive 3D-CT. (Figure-1,2,3)

STATISTICAL ANALYSES:

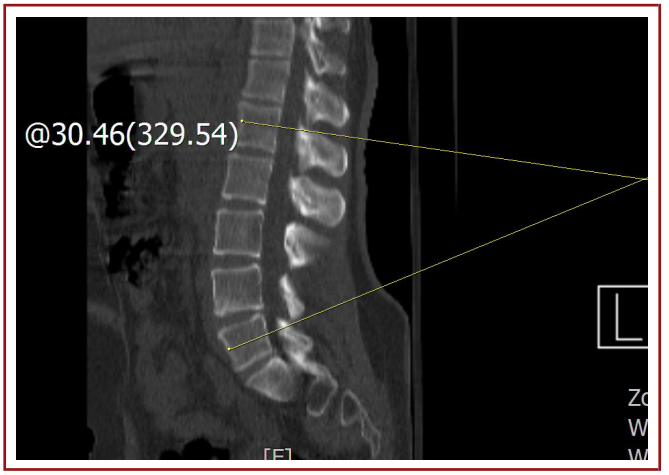
Descriptive data were presented as frequencies and percent for categorical variables, and as mean and standard deviation for numerical variables. Independent group comparisons between both genders were performed with Mann-Whitney U test. P values lower than 0.05 (Type I error level of 5%) was considered as statistically significant result. All analyses were performed by using IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.).



Şekil-1. Radiologic measurement of servical region



Şekil-2. Radiologic measurement of throcic region



Şekil-3. Radiologic measurement of throcic region

RESULTS:

135 patients (60 females, 44.4%, and 75 males, 55.6%) were included in the study. General characteristics of patients were presented in Table-1. Accordingly, mean age was 50.8±18.1 years, angles of CL was 28.5±6.4, TK 39.7±7.4 and LL was 31.7±6.2 degrees.

Table-1. General characteristics of patients and curvature angles

	n	%
Gender		
Female	12	44.4
Male	15	55.6
	Mean	**SD**
Age	50.8	18.1
Cervical Lordosis	28.5	6.4
Thoracic Kyphosis	39.7	7.4
Lumbar Lordosis	31.7	6.2

When the measurements were compared between females and males, it was found that only LL was significantly different between genders (35.0±6.2 in females, and 29.1±5.0 in males, p=0.032), and females had greater values. Age (p=0.420), CL (p=0.083), and TK (p=0.903) were similar between females and males. Comparisons between genders are presented in Table-2.

DISCUSSION:

The study of sagittal spinal alignment refers to the assessment of various local, regional, and/or global parameters of the spine. Global spinal balance refers to the overall alignment of the spine that generally using center of C7 vertebral body as a reference point with respect to another reference point on the sacrum or pelvis[7].

Assessment of global spinal balance provides information on existing relationships between parameters describing the sacropelvis, lumbar spine, thoracic spine, and cervical spine[1]. Clinically, global spinal balance is an important aspect of the evaluation of patients with spinal pathology and of surgical planning, to minimize complications such as adjacent segment disease, sagittal imbalance, pseudarthrosis, and progressive deformity[3,10].

Clinical importance of sagittal balance is important in the management of spinal degenerative pathologies[2]. Abnormal spinal sagittal alignment can cause persistent low back pain (LBP) and the association of acute LBP with hyperlordosis and the relationship of chronic LBP with hypolordosis have been demonstrated also[5].

Guigui et al reported from 250 patients, they have measured maximal lumbar lordosis 61 +/- 12.7 degrees, maximal thoracic kyphosis 41.4 +/- 9.2 degrees from plain radiographs[4].

Yukawa et al reported sagittal alignment and range of motion of the cervical spine in 1230 asymptomatic volunteer[s12]. They revealed that cervical lordosis in the neutral position increased with age, particularly in the sixth decade and to a greater degree in females[12]. Yoshida et al inspected TK increased with age more in females; therefore, females developed greater compensatory lordosis of the cervical spine with age[11].

In our study mean age was 50.8±18.1 years, angles of CL was 28.5±6.4, TK 39.7±7.4 and LL was 31.7±6.2 degrees. The similar age rated studies in the literature all support each other but all these studies are limited by the heterogeneity of the cohorts, radiographic protocols, positioning and measurement techniques.

This work provided a useful tool for analyzing and understanding sagittal imbalance in patients with spinal disease or deformity and also a means of calculating corrections to be made with treatment, established from the linear regression equations which were elaborated by reconstructive computed tomography.

Table-2. Comparisons of measurements between genders

	Female		Male		p
	Mean	**SD**	**Mean**	**SD**	
Age	54.3	19.9	48.0	16.6	0.420
Cervical Lordosis	30.4	4.7	27.1	7.4	0.083
Thoracic Kyphosis	39.9	7.4	39.5	7.7	0.903
Lumbar Lordosis	35.0	6.2	29.1	5.0	0.032

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Volume: 27, Issue:1, January 2016 pp: 13-17 ORIGINAL ARTICLE / ORJİNAL MAKALE

CRANIOVERTEBRAL JUNCTION MORPHOMETIC EVALUATION WITH RECONSTRUCTIVE COMPUTED TOMOGRAPHY

REKONSTRÜKTİF BİLGİSAYARLI TOMOGRAFİ İLE KRANİOVERTEBRAL BİLEŞKENİN MORFOMETRİK İNCELEMESİ

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SUMMARY:

Objective: The aim of the study is to evaluate information from reconstructive computed tomography parameters of the craniovertebral junction(CVJ) in asymptomatic individuals.

Materials and Method: We inspected 98 consecutive CVJ reconstructive computed tomography scans obtained in adult patients who were admitted to our hospital for emergency treatment of non-CVJ conditions retrospectively.

Results: 98 patients (46 females, 46.9 %, and 52 males, 53.1 %) were included in the study. Accordingly, mean age was 51.7 ± 18.7 years, mean Chamberline-Odontoid Distance was 2.5 ± 1.2 mm, mean Grabb-Oakes was 6.8 ± 1.4 mm, mean Atlantodental Interval was 1.4 ± 0.5 mm, mean Foramen Magnum AP was 34.3 ± 3.2 mm, and mean Foramen Magnum Lat-Lat, Coronal was 30.0 ± 2.7 mm. When the measurements were compared between females and males, it was found that only foramen magnum anterior-posterior(AP) distance was significantly different between genders (33.1 ± 2.6 mm in females, 35.4 ± 3.4 mm in males, p=0.011), and males had larges foramen magnum AP distance values. Age (p=0.960), Chamberline-Odontoid Distance (p=0.952), Grabb-Oakes (p=0.068), Atlantodental Interval (p=0.680), and Foramen Magnum Lat-Lat Coronal (p=0.741) were similar between females and males.

Conclusions: When evaluating CVJ malformations, surgeons should take into account the normal ranges based on computed tomography scan instead of those obtained from plain radiographs.

Key Words: Craniovertebral junction, reconstructive computed tomography, craniovertebral junction morphometry

Level of Evidence: Morphgometric analysis, Level III

ÖZET:

Amaç: Bu çalışmanın amacı asemptomatik erişkinlerde rekonstrüktif bilgisayarlı tomografi ile kraniovertebral bileşkenin değerlendirilmesidir.

Materyal ve Metod: Acil servise kraniovertebral bileşke patolojisi haricinde sebeplerle başvurmuş 98 hastanın rekonstrüktif bilgisayarlı tomografi görüntüleri retrospektif olarak incelenmiştir.

Sonuçlar: Çalışmaya 98 (46 kadın, % 46.9, ve 52 erkek, % 53.1) hasta dahil edildi. Ortalama yaş 51.7 ± 18.7, ortalama Chamberline-Odontoid mesafesi 2.5 ± 1.2 mm, ortalama Grabb-Oakes mesafesi 6.8 ± 1.4 mm, ortalama Atlantodental mesafe 1.4 ± 0.5 mm, ortalama Foramen Magnum AP mesafesi 34.3 ± 3.2 mm ve ortalama Foramen Magnum koronal yan mesafesi 30.0 ± 2.7 mm olarak bulundu. Ölçümler kadın ve erkekler arasındaki fark karşılaştırıldığında sadece foramen magnum çapı istatistiksel olarak anlamlı bulundu (kadın 33.1 ± 2.6, erkek 35.4 ± 3.4 mm, p=0.011). Yaş (p=0.960), Chamberline-Odontoid mesafesi (p=0.952), Grabb-Oakes mesafesi (p=0.068), Atlantodental aralık (p=0.680) ve Foramen Magnum yan koronal (p=0.741) erkek ve kadınlar arasında benzer olarak bulunmuştur.

Çıkarım: Kraniovertebral bileşke anomalilerini değerlendirirken, cerrahlar düz radyografiler yerine rekonstrüktif bilgisayarlı tomografi ölçümlerini tercih etmelidir.

Anahtar kelimeler: Kraniovertebral bileşke, rekonstrüktif bilgisayarlı tomografi, kraniovertebral bileşke morfometrisi.

Kanıt Düzeyi: Morfometrik analiz, Düzey III

INTRODUCTION:

The craniovertebral junction (CVJ) is the union of the occiput, atlas and axis. Morphological studies on the normal craniometry of the craniocervical junction can be helpful in improving the precision of such diagnosis criteria and improving the classification of CVJ anomalies[8,9].

Bone structures are superimposed on the plain radiographs so, for the evaluation of all CVJ anomalies and diseases we must use of modern diagnostic imaging methods such as CT scan with reconstruction or MRI[10]. CVJ could be well layed out with reconstructional 3-dimensional (3D) thin-layered computed tomography. This latter technique requires a large number of overlapping, thin-section axial images and an extremely cooperative patient. The craniometric parameters of the CVJ are of paramount importance to understand and propose adequate treatments for the different diseases that affect the region[12,13].

We performed a craniometrical evaluation of an asymptomatic population, with the purpose of gathering information on the normal reconstructional CT parameters of the CVJ in asymptomatic individuals.

MATERIALS AND METHODS:

We inspected 98 consecutive CVJ CT scans obtained in adult patients who were admitted to our hospital for emergency treatment of non-CVJ conditions retrospectively. Inclution criterias for patients in the study are, patients had to be older than 17 years and have undergone a complete 3D-CT scan of the CVJ for causes other than an investigation of a CVJ malformation or congenital anomaly. Patients were excluded if their radiological examinations were not sufficient for the proposed measurements, if they had undergone only a dynamic CT scan that would preclude some of the measurements, if they were undergoing mechanical ventilation at the time of the CT scan, or if they were known to have pathological conditions of the CVJ.

MEASUREMENTS:

1) The distance from the tip of the odontoid to the Chamberlain line was determined as follows. A line was drawn from the posterior hard palate to the tip of the opisthion (the Chamberlain line) on a sagittal CT image (Figure-1). A perpendicular line was then traced through the tip of the odontoid, and the length of this line was recorded as well as whether the odontoid tip was above or below the Chamberlain line.

2) The amount of ventral cervicomedullary encroachment by the odontoid the measurement proposed by Grabb-Oakes measured in a sagittal CT image as the distance to a line traced from the most posterior region of the dura mater covering the dens to the line that goes from the inferior surface of the basion to the posterior inferior aspect of the C-2 vertebral body (Figure-2).

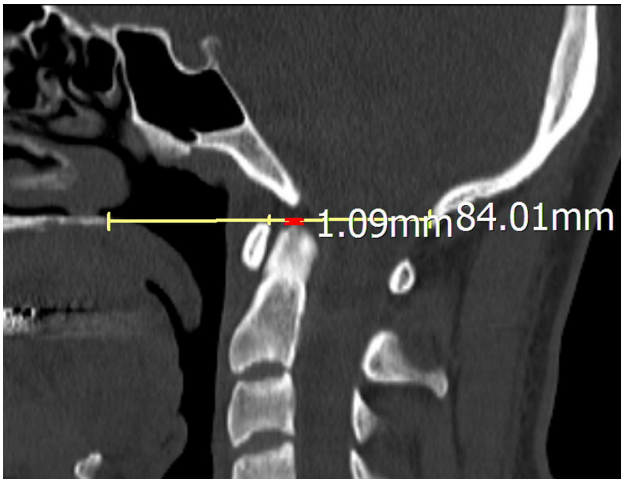

Figure-1. The distance from the tip of the odontoid to the Chamberlain line was determined as follows. A line was drawn from the posterior hard palate to the tip of the opisthion (the Chamberlain line) on a sagittal CT image.

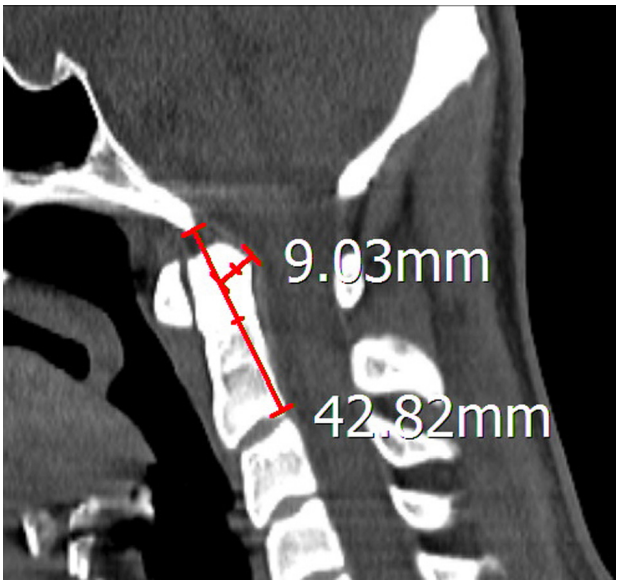

Figure-2. The amount of ventral cervicomedullary encroachment by the odontoid the measurement proposed by Grabb-Oakes measured in a sagittal CT image as the distance to a perpendicular line traced from the most posterior region of the dura mater covering the dens to the line that goes from the inferior surface of the basion to the posterior inferior aspect of the C-2 vertebral body.

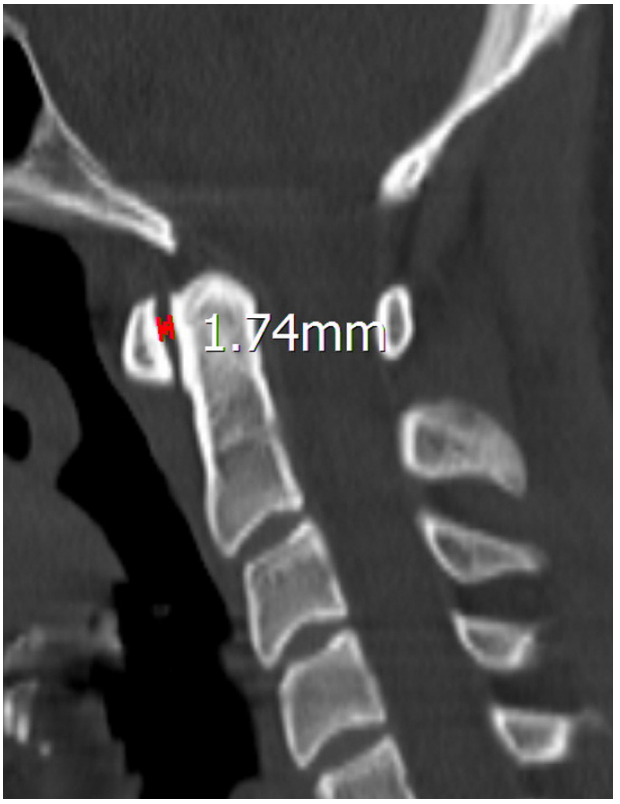

Figure-3. The atlantodental interval was measured as the distance between the posterior border of the anterior C-1 arch and the anterior margin of the odontoid process on a midline sagittal CT image.

3) The atlantodental interval was measured as the distance between the posterior border of the anterior C-1 arch and the anterior margin of the odontoid process on a midline sagittal CT image (Figure-3).

4) The anteroposterior and latero-lateral diameters of the foramen magnum were measured as the greatest distance between the anterior and posterior rims of the foramen magnum (Figure-4) and the greatest distance from its left lateral surface to its right lateral (Figure-5).

STATISTICAL ANALYSIS:

Descriptive data were presented as frequencies and percent for categorical variables, and as mean and standard deviation for numerical variables. Independent group comparisons between both genders were performed with Mann-Whitney U test. P values lower than 0.05 (Type I error level of 5%) was considered as statistically significant result. All analyses were performed by using IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.).

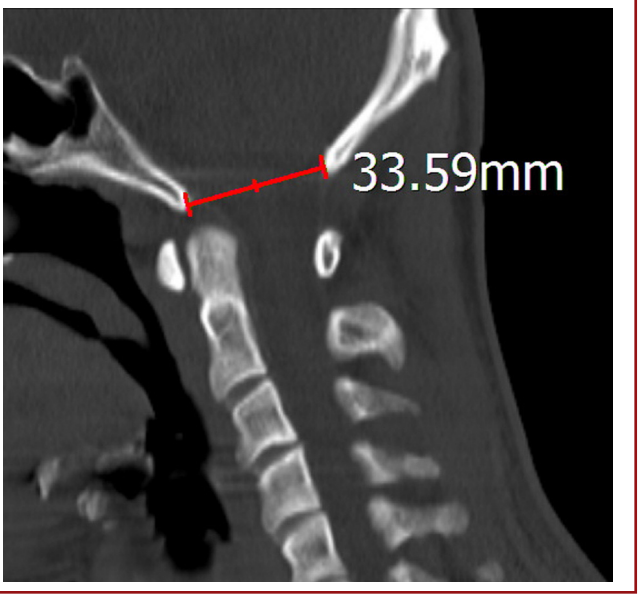

Figure-4. The anteroposterior and latero-lateral diameters of the foramen magnum were measured as the greatest distance between the anterior and posterior rims of the foramen magnum

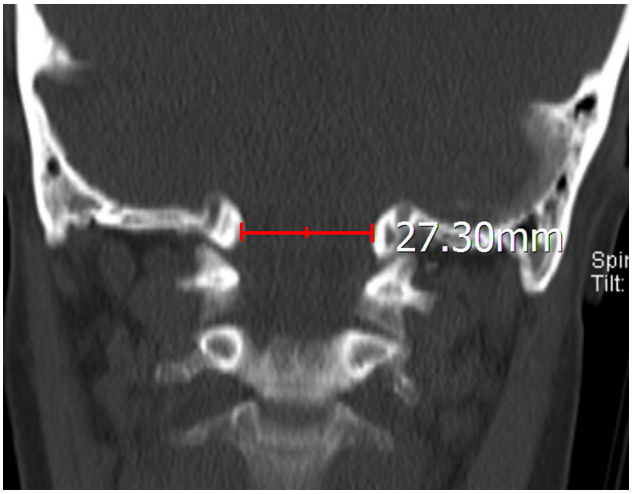

Figure-5. The greatest distance from its left lateral surface to its right lateral.

RESULTS:

98 patients (46 females, 46.9 %, and 52 males, 53.1 %) were included in the study. General characteristics of patients were presented in Table-1. Accordingly, mean age was 51.7 ± 18.7 years, mean Chamberline-Odontoid Distance was 2.5 ± 1.2 mm, mean Grabb-Oakes was 6.8 ± 1.4 mm, mean Atlantodental Interval was 1.4±0.5 mm, mean Foramen Magnum AP was 34.3 ± 3.2 mm, and mean Foramen Magnum Lat-Lat Coronal was 30.0 ± 2.7 mm.

Table-1. General characteristics of patients

	n	%
Gender		
Female	46	46.9%
Male	52	53.1%
	Mean (mm)	**SD (mm)**
Age	51.7	18.7
Chamberline-Odontoid Distance	2.5	1.2
Grabb-Oakes	6.8	1.4
Atlantodental Interval	1.4	0.5
For. Magnum AP	34.3	3.2
For. Magnum Lat-Lar Coronal	30.0	2.7

When the measurements were compared between females and males, it was found that only foramen magnum ap distance was significantly different between genders (33.1 ± 2.6 mm in females, 35.4 ± 3.4 mm in males, p=0.011), and males had larges foramen magnum AP distance values. Age (p=0.960), Chamberline-Odontoid Distance (p=0.952), Grabb-Oakes (p=0.068), Atlantodental Interval (p=0.680), and

Foramen Magnum Lat-Lat Coronal (p=0.741) were similar between females and males. Comparisons between genders are presented in Table-2.

DISCUSSION:

Understanding and evaluation of CVJ relationships can be simplified by identification of relatively few anatomic landmarks, basic knowledge of the development of structures constituting the CVJ (occiput, atlas, and axis), and application of some simple craniometnic measurements[3,5,6,7].

Rojas et al. assessed normal anatomical relationships of the CVJ on CT scans obtained in 200 patients who underwent imaging as part of a trauma protocol and were found to have no osseous or soft tissue abnormality (11). The values differed significantly from the classic values based on standard plain radiographs. The authors reported that 95 % of their patients had an ADI less than 2 mm, smaller than the historical value of 3 mm previously reported in studies from the 1960s as the normal upper limit[11].

Batista et al. reported that the mean distance from the tip of the odontoid process to the line proposed by Chamberlain was -1.55 mm (below the line)[1,2]. Of note, some patients had the tip of the odontoid 2 mm or even 5 mm above the Chamberlain line, both levels that have been proposed as diagnostic criteria for basilar invagination. Based on their findings they evaluated that due to anatomical variations, some asymptomatic individuals would have the diagnosis of basilar invagination. Based on a normal distribution, the normal accepted range of the distance of the tip of the odontoid process in their population was from 5.9 mm below to 2.9 mm above the Chamberlain line[1]. Patients with the tip of the odontoid extending more than 2.9 mm past the Chamberlain line would be considered abnormal in their study population[3]. When analyzing the amount of ventral cervicomedullary encroachment by the odontoid, a measurement proposed by Grabb et al., the mean distance from the most posterior region of the dura mater covering the tip of the odontoid process to the line that goes from the inferior surface of the basion to the inferior aspect of the C-2 body was 6.7 mm, and only 1 asymptomatic patient had a value above 9 mm for this measurement[4].

Table-2. Comparisons of measurements between genders

	Female		Male		p
	Mean (mm)	**SD (mm)**	**Mean (mm)**	**SD (mm)**	
Age	51.4	18.4	51.9	19.4	0.960
Chamberline-Odontoid Distance	2.5	0.9	2.5	1.5	0.952
Grabb-Oakes	6.5	1.4	7.2	1.4	0.068
Atlantodental Interval	1.4	0.4	1.5	0.6	0.680
For. Magnum AP	33.1	2.6	35.4	3.4	0.011
For. Magnum Lat-Lar Coronal	29.8	2.6	30.2	2.8	0.741

Our study is limited by the lack of intra- and inter-reliability assessment for the presented CVJ measurements. Further studies addressing the reliability of CT scan measurement of the normal CVJ craniometry are necessary. Additionally, CVJ craniometry may be influenced multifactors such as patient race height and among others. Our study did not address these issues, but they should be taken into account in future research in this field.

We reported our results on normal craniometrical values obtained from modern 3D reconstructions in 100 asymptomatic individuals. These studies can be useful for evaluating anomalies of the CVJ in comparison with normal parameters. We believe that the precise landmarks obtained with CT reconstructions should improve the reproducibility of CVJ craniometry compared with measurements obtained with simple plain radiographs. When evaluating CVJ malformations, surgeons should take into account the normal ranges based on CT scan instead of those obtained from plain radiographs.

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Volume: 27, Issue:1, January 2016 pp: 19-22 ORIGINAL ARTICLE / ORJİNAL MAKALE

LUMBAR INTERVERTEBRAL FORAMINAL MORPHOMETRY

LOMBER İNTERVERTEBRAL FORAMEN MORFOMETRİSİ

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SUMMARY:

Objective: The aim of the study is to collect data from all levels of lumbar intervertebral foramen on asymptomatic adults.

Materials and Method: We inspected 60 thin-layered reconstructive computed tomography scans of whole spine that obtained in adult patients who were admitted to our hospital for emergency treatment retrospectively.

Results: 60 patients (30 females, 50.0%, and 30 males, 50.0%) were included in the study. Accordingly, mean age was 47.8 ± 22.3 years. When the measurements were compared between females and males, none of the measurements were found to be different between females and males. Largest and smallest values for length were found to be at L2, and L5 level, respectively. And, largest and smallest values for width were found to be at L2, and L5 level, respectively.

Conclusions: The database should also enable both clinicians and researchers to better understand normal lumbar intervertebral foraminal morphometry.

Key Words: Lumbar intervertebral foramina, Reconstructive computed tomography, Intervertebral foramina morphometry.

Level of Evidence: Morphometric study, Level III

ÖZET:

Amaç: Asemptomatik erişkinlerin tüm lomber vertebral seviyelerinin foraminal verilerini toplamaktır.

Materyal ve Metod: Acil servise başvuran 60 hastanın ince kesit bilgisayarlı tomografi verileri retrospektif olarak incelendi.

Sonuçlar: Çalışmaya 60 hasta (30 kadın, %50.0, 30 erkek %50.0) dahil edildi. Ortalama hasta yaşı 47.8 ± 22.3 olarak bulundu. Sonuçlar kadın ve erkekler arasında karşılaştırıldığında fark bulunamadı. En geniş boy ve en oranı L2 seviyesinde, en dar ise L5 seviyesinde hesaplandı.

Çıkarım: Toplanan veritabanı hem klinisyenler hemde araştırmacıların normal lomber foraminal morfometriyi daha kolay anlamasını sağlayacaktır.

Anahtar kelimeler: Lomber vertebral foramen, Rekonstrüktif bilgisayarlı tomografi, Vertebral foraminal morfometri.

Kanıt Düzeyi: Morfometrik analiz, Düzey III

INTRODUCTION:

Diagnosing lumbar foraminal stenosis with conventional imaging can be challenging and requires a methodical assessment of the patient's history and baseline characteristics, as well as, imaging evaluation with direct measurement of the foramen, alignment and degenerative changes[3]. The dimensions of the foramen are much smaller on the symptomatic side in those with foraminal stenosis as compared to those with central stenosis[7].

However, numerous studies have noted the limitations of magnetic resonance imaging (MRI) at assessing foraminal stenosis, computed tomography (CT) is becoming the modality of choice to evaluate the foraminal area and facet degeneration in patients with radicular pain concerning for foraminal stenosis[8,11].

Our study was made to collect data from all levels of lumbar intervertebral foramen on asymptomatic adults to compare with the symptomatic ones'.

MATERIALS AND METHODS

We inspected 60 thin-layered reconstructive CT scans of whole spine that obtained in adult patients who were admitted to our hospital for emergency treatment retrospectively. Inclusion criterias for patients in the study are, patients had to be older than 17 years and have undergone a complete 3D-CT scan of the lumbar vertebra and had no pathological spinal trauma or disease. Sagittal reconstructive 3D-CT images used to measure all levels of lumbar level foraminal lenght and width (Figure-1). Patients were excluded if their radiological examinations were not sufficient for the proposed measurements or if they were known to have pathological conditions of the lumbar spine.

STATISTICAL ANALYSIS

Descriptive data were presented as frequencies and percent for categorical variables, and as mean and standard deviation for numerical variables. Independent group comparisons between both genders were performed with Mann-Whitney U test. P values lower than 0.05 (Type I error level of 5%) was considered as statistically significant result. All analyses were performed by using IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.).

RESULTS:

60 patients (30 females, 50.0%, and 30 males, 50.0%) were included in the study. General characteristics of patients were presented in Table-1. Accordingly, mean age was 47.8 ± 22.3 years.

Table-1. General characteristics of patients

	n	%
Gender		
Female	30	50.0%
Male	30	50.0%
	Mean	**SD**
Age	47.8	22.3

When the measurements were compared between females and males, none of the measurements were found to be different between females and males. Largest and smallest values for length were found to be at L2, and L5 level, respectively. And, largest and smallest values for width were found to be at L2, and L5 level, respectively Comparisons between genders are presented in Table-2.

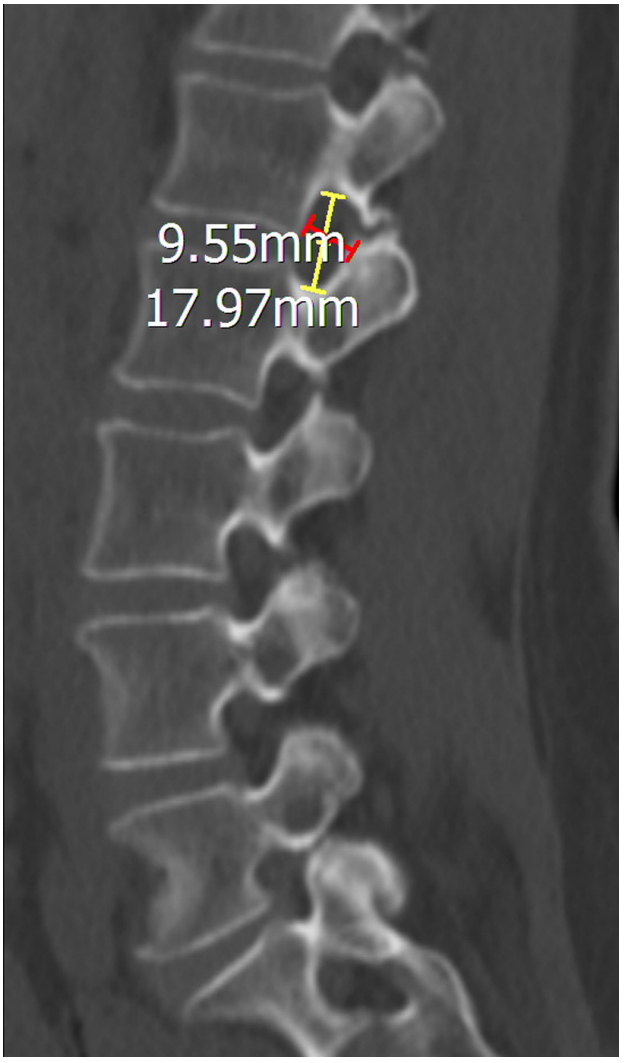

Figure-1. Sagittal reconstructive 3D-CT images used to measure all levels of lumbar level foraminal lenght and width.

Table 2. Comparisons of measurements between genders

	Female		Male		p
	Mean	SD	Mean	SD	
Age	50.6	21.7	45.0	23.7	0.571
L1_Length_L	17.0	2.5	18.4	3.3	0.199
L1_Length_R	17.1	2.8	18.5	3.4	0.199
L1_Width_L	8.6	1.6	9.7	1.0	0.112
L1_Width_R	8.6	1.6	9.8	1.2	0.096
L2_Length_L	19.0	2.4	19.5	3.0	0.596
L2_Length_R	18.7	2.8	19.2	3.0	0.570
L2_Width_L	8.8	1.1	9.3	0.9	0.272
L2_Width_R	8.7	1.1	9.4	0.9	0.150
L3_Length_L	17.9	2.4	19.1	2.5	0.162
L3_Length_R	17.9	2.2	19.0	2.6	0.290
L3_Width_L	8.3	1.5	9.2	1.2	0.325
L3_Width_R	8.2	1.6	9.1	1.2	0.272
L4_Length_L	17.2	1.4	17.4	1.9	0.384
L4_Length_R	17.5	1.6	17.4	2.2	0.970
L4_Width_L	7.8	1.4	8.1	1.3	0.597
L4_Width_R	7.7	1.4	8.2	1.4	0.450
L5_Length_L	15.5	1.6	17.2	2.2	0.082
L5_Length_R	15.5	1.6	16.6	2.2	0.160
L5_Width_L	7.8	1.5	8.6	1.5	0.120
L5_Width_R	7.7	1.5	8.6	1.6	0.212

DISCUSSION:

Radicular symptoms are due to compression of the dorsal root ganglion and root that cause of lumbar disk herniation and spinal stenosis. The most common cause of failed spine surgery is an inadequate decompression. This can be secondary to an inability to execute the surgical plan, but more commonly occurs from unrecognized stenosis[1]. Preoperative identification of lumbar spine foraminal stenosis is important given the surgical plan can differ greatly from that for lateral recess stenosis.

The diagnosis of lumbar foraminal stenosis is important because this clinical entity is often associated with failed back surgery syndrome. Although MRI is widely used and is considered by many as an appropriate tool for studying spine pathologies, there is limited data to suggest that MRI examinations are sufficiently sensitive or specific for the diagnosis of lumbar foraminal stenosis[2,6].

Torun et al reported from a cadaveric study that the widest diameter of lumbar intervertebral foramina was determined for the L4 nerve root with a mean of 3.9 mm, the narrowest for the L1 nerve root with a mean of 3.3 mm and no significant difference was observed between genders[10]. Foraminal pathologies at the L1-L2 and the L2-L3 distances are frequently asymptomatic. Stephens et al concluded that the cross sectional area and the height of the foramen do not change, although the foramen becomes auricular in the case of disk pathology of the upper two levels, which explains why

the foraminal pathologies at this level are usually silent[9]. There have been only a few anatomic studies aimed at determining mean foraminal heights. In one such study, Epstein et al measured it as 13 to 15 mm, whereas Magnusson determined it to be 11 to 17 mm[4,5].

There were significant differences between foraminal measurements carried out on MRI, CT and on the cadavers. This is duo to the facts like race, gender, age, osteoporosis degree, pathologies and observers measurement style. More studies should be made to get a true mean values of intervertebral foramina.

The database should also enable both clinicians and researchers to better understand normal lumbar intervertebral foraminal morphometry. The development of this normal database should further allow for more meaningful evaluation of the dimensions of intervertebral foraminal pathologic states, such as spinal stenosis, disc degeneration, disk protrusion or prolapse, facet arthropathy, and spondylosis.

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Volume: 27, Issue:1, January 2016 pp: 23-27 ORIGINAL ARTICLE / ORJİNAL MAKALE

LUMBAR SPINAL CANAL MORPHOMETRY

LOMBER SPİNAL KANAL MORFOMETRİSİ

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SUMMARY:

Objective: The aim of the study is to collect data of the mean morphometric values for spinal canal, dural sac and ligamentum flavum.

Materials and Method: We inspected 63 MRI scans of lumbar spine that obtained in adult patients who were admitted to our clinic for lumbar axial pain retrospectively.

Results: 63 patients (33 females, 52.4%, and 30 males, 47.6%) were included in the study. Accordingly, mean age was 37.7 ± 12.2 years. Mean values of measurements of spinal canal area, dural sac area, ligamentum flavum area, ligamentum flavum thickness were measured. When the measurements were compared between females and males, only L5 spinal canal was found to be different between females and males (p=0.041), and males had greater values.

Conclusions: Morphometry of the spinal canal and ligamentum flavum is important to be inspected by the researchers and spinal surgeons because LSS operations must be planned with these data; otherwise failed back surgery is the inevitable result.

Key Words: Spinal canal area, Dural sac area, Ligamentum flavum morphology.

Level of Evidence: Morphometric study, Level III

ÖZET:

Amaç: Çalışmamızın amacı spinal kanal, dural kese ve ligamantum flavumun ortalama morfometrik değerleri hakkında veri toplamaktır.

Materyal ve Metod: Kliniğimize aksiyel bel ağrısı nedeniyle başvuran 63 hastanın MRI görüntüleri retrospektif olarak incelendi.

Sonuçlar: Çalışmaya 63 hasta dahil edildi (33 kadın, %52.4, ve 30 erkek, %47.6). Ortalama hasta yaşı 37.7 ± 12.2 olarak bulndu. Lomber her seviye için spinal kanal alanı, dural kese alanı, ligamantum flavum alanı ve ligamantum flavum kalınlığı ortalama değerleri hesaplandı. Sonuçlar kadın ve erkekler arasında karşılaştırıldığında, sadece L5 spinal kanalında farklılık saptandı (p=0.041), ve erkeklerde daha büyük olarak bulundu.

Çıkarım: Spinal kanal, dural kese ve ligamantum flavum morfometresinin araştırmacılar ve spinal cerrahlar tarafından bilinmesi önemlidir çünkü lomber dar kanal cerrahisinin planlanması bu verilere göre yapılmalıdır aksi takdirde başarısız bel cerrahisi kaçınılmaz sondur.

Anahtar kelimeler: Spinal kanal alanı, Dural kese alanı, Ligamantum flavum morfolojisi.

Kanıt Düzeyi: Morfometrik analiz, Düzey III

INTRODUCTION:

Spinal stenosis can be defined as a which causes neurogenic intermittent, radicular pain, claudication and sensory and motor disturbances in the lower extremities diagnosed with narrowing of the spinal canal caused by mechanical compression of the spinal nerve roots[11]. The most common spinal disease have been diagnosed in elderly patients is lumbar spinal stenosis (LSS).

Magnetic resonance imaging (MRI) is considered to be an appropriate measurement tool for studying LSS with some limitations. MRI examination is imagined in supine position, but LSS symptoms are often provoked by standing postures so the results of MRI are not always compatible with the clinical symptoms[10].

MATERIALS AND METHODS:

We inspected 63 MRI scans of lumbar spine that obtained in adult patients who were admitted to our clinic for lumbar axial pain retrospectively. Inclusion criterias for patients in the study are, patients had to be older than 17 years ,had no pathological spinal trauma or disease and radiological report of MRI is normal. Patients were excluded if their radiological examinations were not sufficient for the proposed measurements or if they were known to have pathological conditions of the lumbar spine.

Axial T1-weighted MRI images were inspected at the facet joint level from each patient. We measured the spinal canal cross-sectional area (SCA) (Figure-1) and dural sac cross-sectional area (DSA) (Figure-2) at the facet joint level using a PACS system. The ligamentum flavum cross-sectional area (LFA) (Figure-3) and ligamentum flavum thickness (LFT) (Figure-4) at the same level on the MRI The LFT was measured at the thickest point.

STATISTICAL ANALYSIS:

Descriptive data were presented as frequencies and percent for categorical variables, and as mean and standard deviation for numerical variables. Independent group comparisons between both genders were performed with Mann-Whitney U test. P values lower than 0.05 (Type I error level of 5 %) was considered as statistically significant result. All analyses were performed by using IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.).

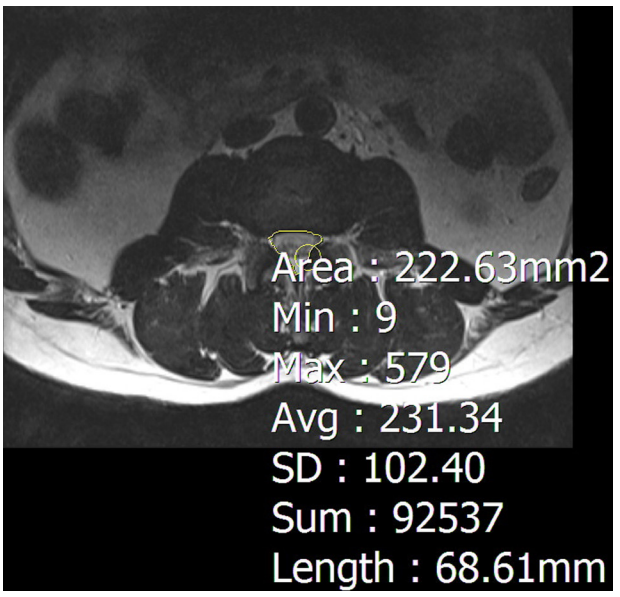

Figure-1. Axial T1-weighted MRI images were inspected at the facet joint level from each patient. We measured the spinal canal cross-sectional area (SCA) .

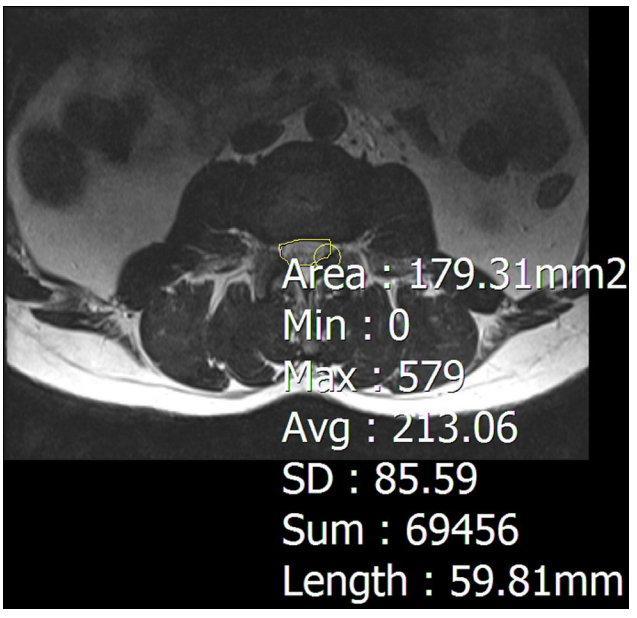

Figure-2. Dural sac cross-sectional area (DSA) at the facet joint level using a PACS system.

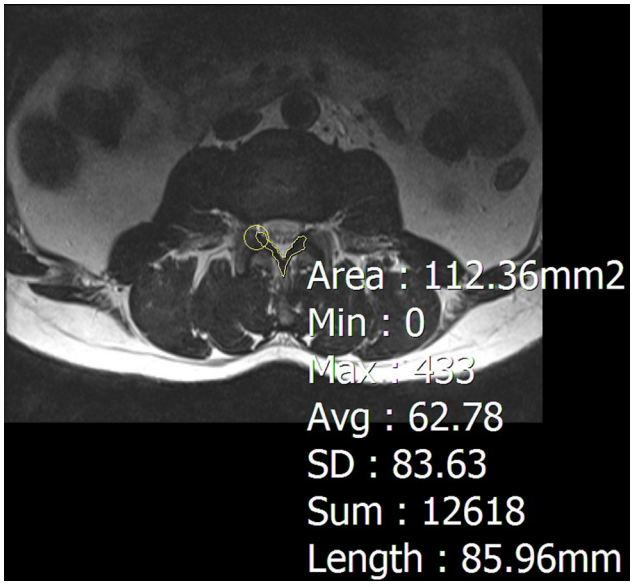

Figure-3. The ligamentum flavum cross-sectional area (LFA).

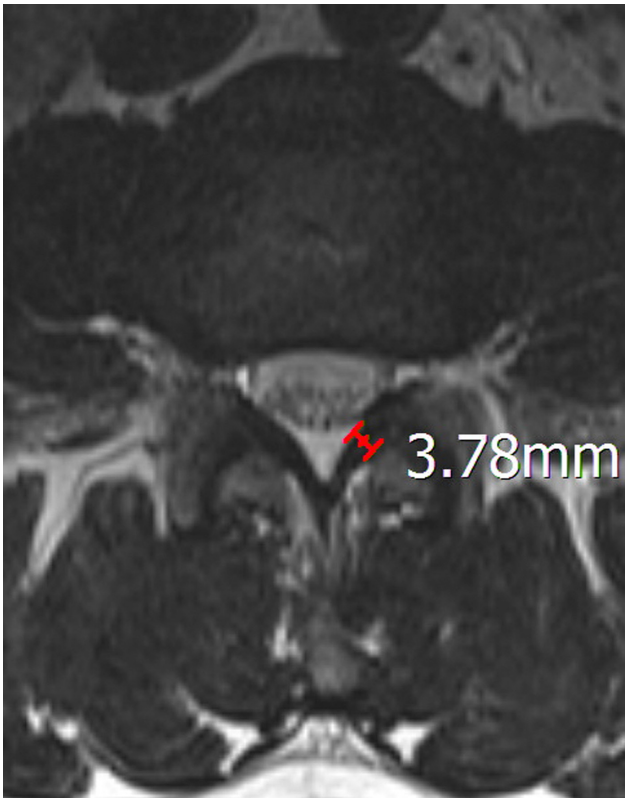

Figure-4. Ligamentum flavum thickness (LFT) at the same level on the MRI

Table-1. General characteristics of patients

	n	%
Gender		
Female	33	52.4
Male	30	47.6
	Mean	**SD**
Age	37.7	12.2

RESULTS:

63 patients (33 females, 52.4%, and 30 males, 47.6%) were included in the study. General characteristics of patients were presented in Table-1. Accordingly, mean age was 37.7 ± 12.2 years.

When the measurements were compared between females and males, only L5 spinal canal was found to be different between females and males (p=0.041), and males had greater values. Mean values of measurements of SCA, DSA, LFA, LFT and comparisons between genders are presented in Table-2.

Table-2. Comparisons of measurements between genders

	Female		Male		p
	Mean	SD	Mean	SD	
Age	37.3	14.6	38.0	10.3	0.916
L1 SP CAN	240.1	32.1	249.0	62.0	0.751
L1 DUR SAC	160.1	45.1	173.6	51.5	0.481
L1 FL AR	99.5	39.1	87.1	9.0	0.572
L1 FL TH	2.3	0.4	2.4	0.2	0.619
L2 SP CAN	239.6	51.2	227.2	66.4	0.778
L2 DUR SAC	158.3	42.1	147.0	56.6	0.481
L2 FL AR	102.6	32.4	114.2	17.3	0.090
L2 FL TH	2.2	0.4	2.3	0.3	0.180
L3 SP CAN	246.4	28.0	238.5	35.5	0.647
L3 DUR SAC	154.9	35.4	143.8	26.2	0.438
L3 FL AR	107.0	33.0	111.2	19.5	0.548
L3 FL TH	2.4	0.5	2.2	0.3	0.972
L4 SP CAN	231.3	50.2	247.3	31.8	0.360
L4 DUR SAC	155.0	49.4	152.2	36.4	0.916
L4 FL AR	127.1	30.6	124.8	32.8	0.724
L4 FL TH	2.5	0.5	2.4	0.7	0.360
L5 SP CAN	222.6	76.6	288.0	42.8	0.041
L5 DUR SAC	151.8	62.6	163.5	68.9	0.526
L5 FL AR	124.4	40.6	157.6	38.3	0.057
L5 FL TH	29.7	85.5	2.6	0.5	0.698

SP CAN: Spinal Canal Area, DUR SAC: Dural Sac Area, FL AR: Ligamantum Flavum Area, FL TH: Ligamantum Flavum Thickness

DISCUSSION:

Spinal stenosis represents a combination of pathogenic factors, including the the facet joints, ligamentum flavum (LF), intervertebral disk and crosssectional area of the cauda equina[4]. Many experimental studies have been performed to evaluate associations between the morphological parameters on MRI and the symptoms and signs in LSS[6].

The ligamentum flavum is a segmentally organized structure that connects the vertebral laminae[7]. The pathogenesis of LF thickening has been associated with the reductions in the elastin and collagen ratio or age-related fibrosis, and is a major cause of LSS[9].

Kim et al reviewed 117 patients who underwent MRI of the L-spine, diagnosed as LSS[3]. They measured DSA, SCA, LFA and LFT at the most stenotic intervertebral level on MRI. Clinical outcomes were investigated using the patient-assessed quantitative measurement of visual analog scale and subjective disability was assessed by the Oswestry Disability Index(ODI)[3]. Additionally, subjective walking distance (SWD) was also collected from electronic medical records. Larger LFA and LFT values are associated with higher ODI values. A larger DSA and SCA are associated with a longer SWD before claudication occurs[3].

Altinkaya measured 224 patients LF and concluded that thickening of the LF is correlated with disc degeneration, aging, body mass index, LSS, spinal level and disc herniation[1]. They also reported that thickening of the LF is due to buckling of the LF into the spinal canal secondary to disc degeneration more than to LF hypertrophy and sex and the degree of pain were not correlated with the thickness of the LF[1]. Sakamaki et al reported that thickening of LF at L4–5 had already started in patients in the 30–39 age bracket and that thickening of the LF was not the buckling of the LF into the spinal canal with disc degeneration; and the thickness of LF at L2–3 may serve as an indicator of LSCS at multiple levels[8].

Choi et al reported that axial loaded MRI may contribute to overcoming a limitation of MRI in decumbency, which can overlook dynamic spinal disorders such as dynamic lumbar spinal stenosis[2].

Ogikubo et al inspected 82 patient and reported that the mCSA was a strong predictor of the preoperative walking ability, leg and back pain, and was directly related to the quality of life of patients with central spinal stenosis[5].

Finally, we inspected 63 MRI scans of lumbar spine from axial T1-weighted MRI images at the facet joint level from each patient. Morphometry of the spinal canal and ligamentum flavum is important to be inspected by the researchers and spinal surgeons because LSS operations must be planned with these data; otherwise failed back surgery is the inevitable result.

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Volume: 27, Issue:1, January 2016 pp: 29-34 ORIGINAL ARTICLE / ORJİNAL MAKALE

THE RELATION BETWEEN MODIC CHANGES AND OCCUPATION TYPES IN SYMPTOMATIC YOUNG ADULTS

SEMPTOMATİK GENÇ ERİŞKİNLERDE MODIC DEĞİŞİKLİKLER VE MESLEK TÜRLERİ İLE İLİŞKİSİ

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SUMMARY:

Purpose: We aimed to study relation between Modic changes and occupational status in symptomatic young adults.

Materials and Method: T1 and T2 weighted lumbar MR images of 32 female and 76 male between the ages 20-40 were evaluated for disk degeneration and Modic changes. Average age was 30,99. Patients were divided into three groups according to physical workload; sedentary workers, standing workers and ones with a heavy workload.

Results: The prevalence of the Modic changes was 29.62%, while disk degeneration was 45.37%. Type 2 predominance was observed. 94.59% of the Modic changes were observed in the lower lumbar segments. Comparison between occupational groups showed no statistically significant difference.

Conclusions: Contribution of this study to literature was the relation between occupational groups and Modic changes, and no significant difference was determined. We concluded that occupation type has no effect on the emergence of Modic changes.

Key words: Modic changes, occupation type, young adults, degenerative disk disease.

Level of evidence: Cross-sectional clinical study, Level III.

ÖZET:

Amaç: Semptomatik genç erişkinlerde Modic değişikliklerin meslek tipi ile ilişkisi araştırıldı.

Materyal ve Metod: 20-40 yaş arası, 32 kadın ve 76 erkek hastanın T1 ve T2 ağırlıklı lomber MR görüntüleri disk dejenerasyonu ve Modic değişiklikleri açısından değerlendirildi. Ortalama yaş 30.99'du. Hastalar iş yüklerine göre 3 gruba ayrıldı; sedanter çalışan, ayakta çalışan ve ağır işlerde çalışanlar.

Sonuçlar: Disk dejenerasyonu %45.37 iken, Modic değişikliklerin prevelansı %29.62 bulundu. Tip 2 hakimiyeti gözlendi. Modic değişikliklerinin %94.59'u alt lomber segmentlerde gözlendi. Meslek grupları kendi aralarında karşılaştırıldığında istatistiksel olarak anlamlı fark saptanmadı.

Çıkarım: Bu çalışmanın literatüre katkısı,Modic değişiklikleri ile meslek tipleri arasındaki ilişkinin incelenmesidir ve anlamlı fark saptanmamıştır. Bu çalışma ile bizim çıkarımımız Modic değişikliklerinin gelişiminde meslek türlerinin herhangi bir etkisi olmadığıdır.

Anahtar kelimeler: Modic değişiklikleri, meslek tipi, genç erişkin, dejeneratif disk hastalığı.

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INTRODUCTION:

Non-specific low back pain is the most common cause of pain in young adult population and it's closely related to vertebral endplate changes[7,22,25].

Degenerative disk disease (DDD) related vertebral endplate and subchondral bone changes were defined by De Roos and Modic and Modic classification was made based on MR imaging[4,17,18]. According to that, hypointensity in T1 weighted sequences and hyperintensity in T2 weighted sequences are described as Modic Type 1 lesion and considered as an indicator of active inflammatory process. In Modic Type 2 lesion,hyperintensity in T1 and T2 weighted sequences signify fatty degeneration of bone marrow with a more chronical process. Type 3 lesion described later is characterized by hypointensity in both sequences that are due to subchondral bone sclerosis[18].

Degenerative disk disease and Modic changes might increase with age but it has also been reported in various rates for young adult patients[16,23,24].

In this study, degenerated disk disease and distribution of Modic changes has been investigated by MR imaging for young adult symptomatic patients between the ages 20-40.

MATERIALS AND METHOD:

In this cross-sectional study, Modic changes and disk degeneration presence (and their localization) for patients between the ages 20-40 with complaints of low back pain and sciatalgia was examined with the MRI and they were distributed in terms of age, gender and occupational groups (Table-1).

108 patients (76 male and 32 female between the ages 20-40; average 30,99) with back pain for more than three weeks, who has never had a surgical operation were included to the study. Patients who has a lumbar trauma story, scoliosis or spondylodiscitis were excluded.

In the study, 540 disk levels and adjacent endplates located in L1-S1 area were scanned by 1.5 T MRI with 4mm thick sections. T1 and T2 sagittal sequences and T2 axial sequences were examined. Radiological evaluation was made by an experienced orthopedist without the knowledge of clinical story. Disk degeneration was classified and recorded as; without signal change (grade-0), slight signal lose in nucleus in T2 sections (grade-1), hypointense nucleus with normal disk height (grade-2) and hypointense nucleus pulposus with decreased disk height (garde-3)[3]. Disk levels determined as grade 2 and 3 were added to calculation as degenerative disk. Same sections were also evaluated according to Modic classification and recorded as Type-1, Type-2 and Type-3 [17,18].

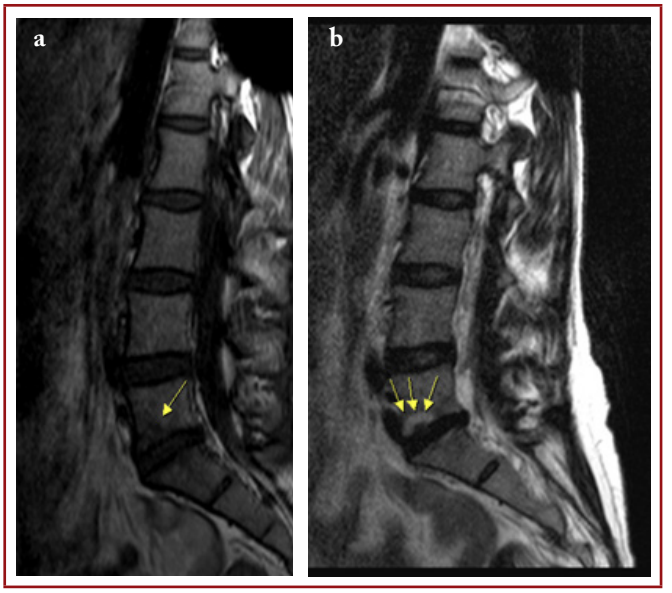

Figure-1. 33 years old female, **a)** T1WI shows hypointensity and **b)** T2WI shows hyperintensity in L5 vertebra

Figure-2. 32 years old male, **a)** T1 and **b)** T2 weighted images show hyperintensity adjacent to degenerated disc at L4-L5 segment.

Patients were divided into three groups according to physical workload, as sedentary workers, standing workers and ones with a heavy workload. First group included patients who work in desk jobs for more than 4 hours a day. Second group included patients who work standing for more than 4 hours a day and the last group included patients who work in jobs with a heavy workload. These groups were divided into subgroups

as female and male and degenerative disk disease and Modic changes were investigated for each groups (Table-1).

Chi-square test and Student t test were performed using SPSS II Version 17.0 (SPSS, Inc, Chicago, IL, USA). $p<0.05$ was considered statistically significant.

RESULTS:

In this study 540 lumbar disk levels and adjacent endplate changes of 108 symptomatic patients were examined and age, gender, lumbar disk degeneration and Mobic changes were recorded (Table-1).

In 49 of 108 patients (45.37%) and in 78 of 540 disk levels (14.44%) disk degeneration (grade 2 and 3) was observed at least one level. Multi level disk degeneration was found as 3 levels in 7 patients, 2 levels in 15 patients, and 1 level in 27 patients (Table-2).

Examination of all patients showed that 32 of 108 (29,62%) have at least one level Modic changes. All of the Modic changes determined adjacent to the degenerative disks. No Modic change was observed in L1-L2 and L2-L3 segments of any patients. Only one patient showed type 1 Modic change in L3-L4 segment. Multi level Modic changes were observed in L3-L4 and L4-L5 segments of 2 patients and L4-L5 and L5-S1 segments of 3 patients. At least one of the multi level Modic changes was determined as Type 1 (Table-2).

When subgroups of Modic changes were evaluated ,in 16 patients (43.24%) Type 1, in 21 patients (56.75%) Type 2 was observed. It was determined that Type 1 changes are mostly in L4-L5 (9/16, 56.25%) and Type 2 changes are mostly in L5-S1 (13/21, 61.90%) adjacent segments. Modic Type 3 change was not seen in any of the segments. In our study the prevalence of Modic changes was (29,62%). When considering total disk levels 6.8% (disk levels of 37/540) was noted. 35 (94.59%) of the Modic changes were observed in L4-L5 and L5-S1 levels. Number of determined Modic changes were 16 (% 43.24) in L4-L5 level and 19 (51.35%) in L5-S1 level (Table-2).

Modic changes were observed in 10 disk levels of 8 female patients (25%) and in 27 disk levels of 24 male (31.57%) patients. It was determined that 2 of the multi level changes were female, while 3 of them were male. When female and male genders were statistically compared, even though the percentage of Modic changes observed in male was higher, there was no statistically significant difference determined ($p>0.05$).

Distribution of Modic type changes according to occupational groups are shown in Table-1 and Table-3. Determined modic changes were 30% for the group with heavy workload, 35.71% for standing workers and 26.66% for sedentary workers. Comparison between occupational groups showed no statistically significant difference in terms of Modic types and prevalence of Modic changes ($p>0.05$).

Table-1. Relation between age, gender and occupational distribution of patients with degenerative disc disease and Modic changes.

		Number of Patients Average	Age		DDD*		Modic**	
			Range	n	%	n	%	
Men		76	30,84	20-40	35	46,05	24	31,57
Women		32	31,34	20-40	14	43,75	8	25
Total		108	30,99	20-40	49	45,37	32	29,62
Sedentary	**Men**	38	30,84	22-40	14	36,84	11	28,94
	Women	22	31,45	20-40	9	40,90	5	22,72
	Total	60	31,06	20-40	23	38,33	16	26,66
Middle	**Men**	18	30,05	22-38	10	55,55	7	38,88
	Women	10	31,10	24-36	5	50	3	30
	Total	28	30,42	22-38	15	53,57	10	35,71
Heavy	**Men**	20	31,55	20-40	11	55	6	30
	Women	0	0	0	0	0	0	0
	Total	20	31,55	20-40	11	55	6	30

*DDD: Number of patients with degenerative disc disease at least one level
**MODIC: Number of patients with any type of Modic changes at least one level

Table-2. Distribution of degenerative changes, Modic changes and Modic Types according to all examined disc levels.

LEVEL	DEGENERATIVE DISC	MODIC CHANGES	TYPES OF MODIC CHANGES		
			TYPE 1	TYPE 2	TYPE 3
L1-L2	2	0	0	0	0
L2-L3	5	0	0	0	0
L3-L4	8	2	1	1	0
L4-L5	28	16	9	7	0
L5-S1	35	19	6	13	0
Total	78 (14.44%)	37 (6.8%)	16	21	0

Table-3. Distribution of Modic changes according to occupational groups [Multilevel changes are shown with (+)]

		Number of patients					
		Degenerated Disc	**Modic Changes**	**Modic Type 1**	**Modic Type 2**	**Modic Type 3**	**Multi level Modic Changes**
Group 1	E	14	11	3	8	0	
	K	9	5	1 (+)	4	0	+
	D	23	16	4	12	0	
Group 2	E	10	7	4 (+)	3	0	+
	K	5	3	2	1 (+)	0	+
	D	15	10	6	4	0	
Group 3	E	11	6	2 (++)	4	0	++
	K	0	0	0	0	0	
	D	11	6	2	4	0	
All Working Groups		49	32	12 (16)	20 (21)	0	5

DISCUSSION:

Modic changes, first described in 1980, are associated with degenerative disks and seen almost together. These are MRI changes in bone marrow and end plates adjacent to degenerative lumbar disks. As mentioned above, according to T1 and T2 weighted sequences Modic et al described 3 different types of changes[4,17,18]. These types present different stages of the same pathological process[3].

Modic et al also investigated histopathological changes in end plates. They found out that, Type-1 changes were associated with fibrous degeneration and fissuring of end plates and hypervascularization of the vertebral body, adjacent to degenerated endplate. Type-2 changes were associated with fatty replacement in bone marrow. Also, they concluded that Type-1 changes reflected the inflammatory phase of degenerative disk disease, whereas Type-2 changes reflected chronic and stable phase of degenerative process. Later, they found sclerotic Type 3 changes as the final stage of degeneration[1,4,5,17,18]. Modic classification has been evaluated as reliable and reproducible, simple and easy to apply and useful in clinical research and practice[8].

In patients with degenerative disk disease (DDD), prevalence of Modic Changes has been reported as between 19%-59%[3,4,17,20]. The wide range of prevalence of Modic changes is the result of sampling errors and variations among the studied populations[20]. In our study we have found a prevalence of 29.62%. We aimed to investigate Modic changes in symptomatic young patients.

Modic changes are seen less often in asymptomatic individuals[7,16,20,24]. Weishaupt et al studied 60 asymptomatic individuals between the ages of 20-50 and reported a prevalence of 3%-10%[27]. Kjaer et al investigated 40-year old Danes and found the prevalence of 9.6% without DDD, while it's 34.1% with DDD[12]. Jensen et al reported median prevalence rates in a review article. In symptomatic group, median prevalence was 43% and in asymptomatic group, the median prevalence of Modic changes was 6%. In this study, they also reported an increase of 11% in the prevalence per 10 years [7].

Since disk degeneration and intradiscal destruction are age-related problems, the occurrence of Modic changes increases with age[17]. Kuisma et al reported that Modic changes are associated with age positively (P = 0.009)[18]. In the present

study, the population was limited with young patients (with mean age 30.99). This was the reason of the lower rate in the prevalence of Modic Changes.

All of the recent publications agrees with the relation between age and Modic changes[14]. Most of the earlier studies, conducted in a wide range of ages showed that the prevalence of Modic changes tended to be higher in older population[7,20]. Takatalo et al studied with young adults between the ages 20 to 22 and found 1.4% of Modic changes were at least level one[23]. Only 2 Modic changes were observed in the 13-year-old Danish population [11].

There is a disagreement about the dominant type of Modic changes. Several studies have shown that Modic type 2 changes are the most frequent with a percentage up to 90% [4,9,13,14,18]. On the other hand, some studies have suggested that type 1 Modic changes may be more common with a percentage of up to 68% [3,10,28]. We observed type 1 changes in 16 patients (43.24%) and type 2 changes in 21 patients (56.75%). In our study, type-2 predominance was found.

First, Modic et al described a linear progression pattern from Modic type-1 to Modic type-2, and then to Modic type-3 [8,10,19]. Kuisma et al followed lumbar spine Modic changes for 3 years[13]. They found Modic Type 2 lesions can convert to Modic type-1. They concluded that type-2 changes may be less stable than previously assumed.

Hutton et al investigated natural history of Modic changes and reported dynamic reversible changes[5]. They suggested that Modic changes should not be used as a surgical or clinical outcome measure. Also, one of the their results was that Modic changes do not necessarily follow a progressive pattern from Type-1 to Type-2 and then to Type-3. With the reflection of natural history, predominance of Modic type changes may be various[14].

Modic changes are most common at L4-L5 and L5-S1[10,18,19,21]. This changes are mostly seen as adjacent to disk degeneration[4,9,17,18]. In our study, we observed 43.24% at L4-L5 and 51.35% at L5-S1. 94.59% of Modic changes have been found at the lowest two levels of the lumbar spine. Also, disk degenerations were mostly seen in lower lumbar regions. Wang et al reported 74.5% of endplates with Modic changes were in the lower lumbar region (with mean age 51.4)[26]. Martinez-Quinones et al reported that percentage of Modic changes in the lower lumbar region is 98% (with mean age 30.45) similar to our study[16]. We assumed that in young patients it is quite rare to observe Modic changes in upper lumbar regions.

Infective discitis may mimic Type-1 Modic changes as low signal intensity on T1WI and high signal intensity on T2WI. The presence of increased signal intensity on T2WI, eroded vertebral endplates and epidural or paraspinal inflammation should orient the diagnosis toward an infectious process. In addition to radiologic signs, laboratory tests such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) can help differential diagnosis[6,15].

Relation between modic changes with degenerative disk segment and male gender is emphasized in many publications[9,10]. Karchevsky and colleagues presented that within etiological factors, especially male gender has a distinct relation with Modic changes[9]. On the other hand, our study did not reveal a significant difference between gender and Modic changes, while entire Modic changes were observed in an adjacent segment to the degenerated disk.

After all, it is still not revealed why Modic changes are observed in some of the degenerated disks and not observed in some others. Predisposing factor is the typology of age, men gender and working samples[3].

In our study, we investigated the effect of occupation type to the emergence of Modic changes. There are not many studies in the literature, which investigate the relation between the occupation and Modic changes. Schenk et al compared nurses and women with desk work jobs, who suffer from back pain and observed that Modic changes are at similar rates (30.4% ve 29.4%) in both occupational groups[21]. Kuisma et al compared train workers and sedentary workers and reached to similar results related Modic changes in both occupational groups[14]. In our study, we also determined similar rates of Modic changes in different occupational groups.

Prevalence of Modic changes in symptomatic young adult patients was 29,62%. Especially, localization in lower lumbar area was significant. Contribution of this study to literature was the relation between occupational groups and Modic changes, and no significant difference was determined. A remarkable point in our study was that we observed similar rates of Modic changes in sedentary workers and workers with heavier jobs. We concluded that occupation type has no effect on the emergence of Modic changes.

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Volume: 27, Issue:1, January 2016 pp: 35-39 ORIGINAL ARTICLE / ORJİNAL MAKALE

TRANSFORAMINAL INTERBODY FUSION AT CONUS LEVEL OF OUR EXPERIENCE AND CLINICAL RESULT

KONUS SEVİYESİNDE TRANSFORAMİNAL İNTERBODY FÜZYON UYGULAMALARIMIZ, KLİNİK SONUÇLAR

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SUMMARY:

Introduction: Via the application of the interbody fusion, the height of the disc is reconstructed, sagittal contour is preserved and the long term stabilization of the operated segment is ensured. The support to the anterior coloumn is helpful in increasing stability, reducing the stress on the pedicul screws, and incresing the fusion rates. The level of L1-2 and above are considered to be in relation with the conus and cord. The application of the transforaminal interbody fusion is done with the fusion material via a far lateral posterior approach.

Material-Method: This study was a retrospective case series and was approved by Department of Neurosurgery, Bakırkoy Research and Training Hospital for Neurology, Neurosurgery and Psychiatry. The eligible cases were the patients who underwent posterior decompression on the first one or two levels on the lombar vertebrae using TLIF with wide decompression for 1 or 2 level spinal stenosis with or without spondylolisthesis, between 2012- 2014.

Results: The preoperative and postoperative VAS score of the patients were calculated to be 6.53(5-8) and 3.2(2-5) respectively. Also, the preoperative and postoperative ODI value of the patients were calculated to be 68%(55-80%) and 26%(10-40%) respectively.

Discussion: With the right technique, neurologic damage risk of the posterior TLIF application on the conus level is very low. Also because there will be no need for an anterior approach, there will be no second incission or a second surgery which lowers the morbidity and mortality of the added second abdominal incission.

Keywords: Transforaminal interbody fusion, conus, spinal stenosis, spinal listesis

Level of evidence: Cohort study, Level III

ÖZET:

Giriş: Lomber interbody füzyon ile disk mesafesinin yüksekliği yeniden sağlanır, sagital kontür korunur, opere segmentin uzun dönemli stabilitesi sağlanır. Anterior kolonun yapısal desteği stabiliteyi güçlendirir, vidalar üzerindeki stersi azaltır, füzyon oranlarını arttırır. L1-2 disk seviyesi ve bu seviyenin yukarısında yer alan disk seviyeleri konus ve kord ile ilişkili disk seviyeleri olarak tanımlanabilir. Transforaminal interbody füzyon uygulamasında Füzyon materyali posterior yaklaşımla far lateralden hazırlanmış disk mesafesine yerleştirilmektedir.

Materyal-Metot: Bu çalışmamızda Bakırköy Prof. Dr. Mazhar Osman Ruh Sağlığı ve Sinir Hastalıkları Eğitim Araştırma Hastanesinde yapmış olduğumuz vakaları retrospktif olarak inceleyeceğiz. Vakalarımız 2012-2014 yılları arasında spinal stenozlu veya spinal listezisi olan hastalardan oluşmaktadır. Bu hastalara stabilizasyo,posterir dekompresyon ve transforaminal interbady füzyon uyguladık

Sonuçlar: Preoperatif VAS skoru 6.53 (5-8) ve postoperatif VAS skoru 3.2 (2-5) olarak hesaplandı. Preoperatif ODI değeri %68 (%80-55) ve postoperatif ODI değeri %26 (%10-40) olarak hesaplandı.

Tartışma: Konus seviyesinde posteriordan yapılacak TLIF uygulamasının nöral hasar oluşturma ihtimali uygun teknik ile çok azdır. Ayrıca anterior yaklaşım olmayacağı için ikinci bir seans yada ikinci bir insizyona gerek duyulmaz, cerrahi süre uzamaz, ilave olarak abdominal cerrahinin getireceği morbidite ve mortalite riski olmaz.

Anahtar Kelimeler: Transforaminal interbody füzyon, konus, spinal stenoz, spinal listezis

Kanıt Düzeyi: Olgu serisi, Level III

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INTRODUCTION:

The traditional way to operate on the spine is through a posterior approach. The main aim of the implantation is to create a stable fusion. Posterior instruments tries to maintain a mechanical stabilization on the spine[20]. Although the pedicul fixation systems are highly resistant to translational and scoloiotic deformations, they're not strong enough for high axial load[1]. Via the application of the interbody fusion, the height of the disc is reconstructed, sagittal contour is preserved and the long term stabilization of the operated segment is ensured. The support to the anterior coloumn is helpful in increasing stability, reducing the stress on the pedicul screws, and incresing the fusion rates[3,17].

Transforaminal interbody fusion (TLIF) was first used in 1982 as being described as a modified PLIF[5]. Fusion material is applied to the interbody space prepared from a far lateral approach. The traditional advise was to not us for levels above lumbar 2-3.

With a normal embryological maturation the conus is at level L2-3 at birth. At 3 months, the conus moves up to the adult level of L1-2 [2,4,12,14,15]. L1-2 disc level and levels above are described as levels related to the conus and the cord.

In the upper lumbar and thoraxic region, interarticulary pars is small and the inferior border of the lamina usually goes along to the disc level. This is why posterior interbody fusion operations have a higher risk of neurological damage. On the other hand, anterior approach gives way to disc clearance without retraction of the neural components. Anterior approach has its limitations on the basis of the approach. The fusion application is harder, reconstruction of the lordosis is much limited and there is a considerable higher risk of greater vascular injuries. Transforaminal interbody fusion gets most the advantages of these both approaches which makes it a better option for using the levels of conus and the cord.

In our study, we analysed the outcome of the patients whom we operated for spinal stenosis and listesis on the levels of the conus and the cord with transforaminal interbody fusion.

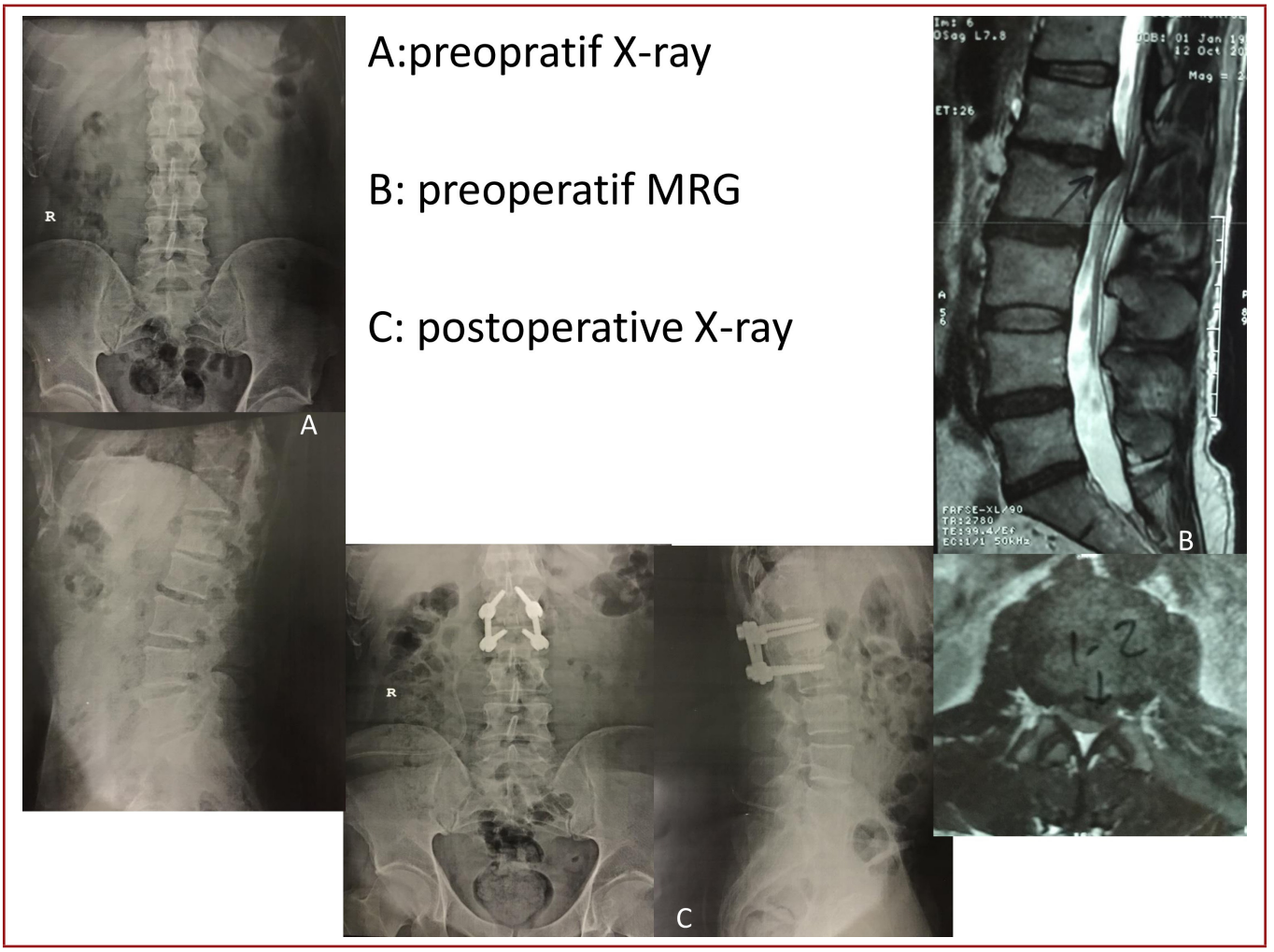
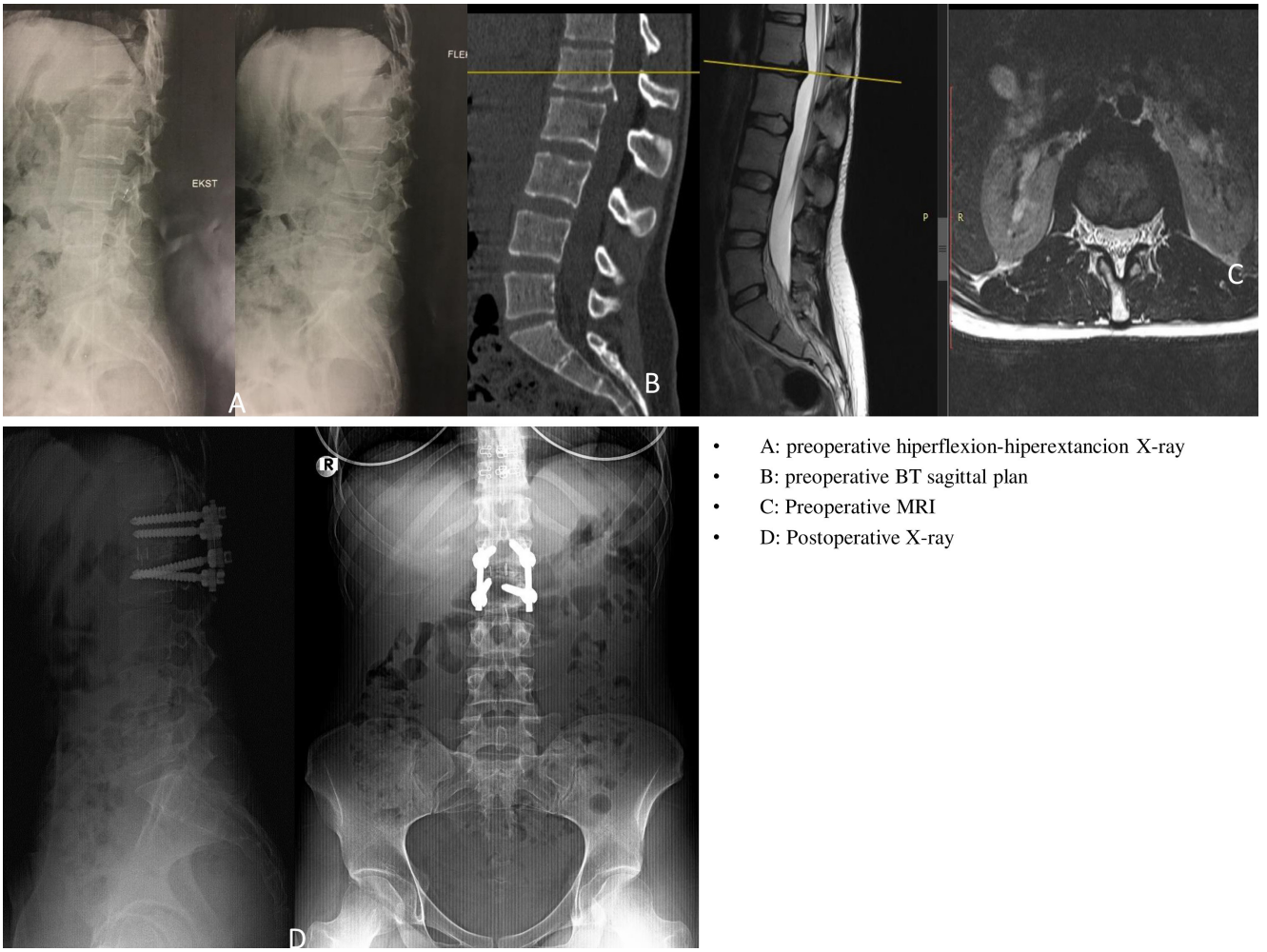


Figure-1. Case one



- A: preoperative hiperflexion-hiperextancion X-ray
- B: preoperative BT sagittal plan
- C: Preoperative MRI
- D: Postoperative X-ray

Figure-2. Case two

MATERIAL-METHOD:

This study was a retrospective case series and was approved by Department of Neurosurgery, Bakirkoy Research and Training Hospital for Neurology, Neurosurgery and Psychiatry. The eligible cases were the patients who underwent posterior decompression an one or two level lumbar üst seviye TLIF with wide decompression for 1 or 2 level spinal stenosis with or without spondylolisthesis, between 2012- 2014. Ultimately, cases were included in the current study.

The main symptoms of the patients on admitance were back pain, radicular pain, and neurological claudication, and these sympsomts were present on all of our patients. All our patients has full muscle strength on neurological examination and some had sensory loss on some dermatomes. All retained the normal sphincter function.

Surgical Procedure; All patients were operated under general anestesia in prone position. All related segments were stabilizied via transpedicular screws from posterior approach. Decompression was done on necessary levels. Posterior osteotomy(facetectomy and pars interarticularis resection) was performed on the side of the level which TLIF was going to be applied. Upper and lower roots were identified. Fusion was prepared through radical discectomy and curetation of the end plates. Disc level then was retracted using the posterolateral screws. Appropriate size PEEK cage which are filled with autogreft tissue is applied. Distraction of the screws and manual kiphosis through surgical table position was then applied to reduce the disc height posteriorly. Posterolateral stabilization was then lock permenantly. No need for retraction of the neural elements were necessary during these procedures. Our patients were all mobilized on postoperative first day with lumbosacral corset.

Pre- and post-operative clinical outcomes were compared between the groups by using the scores obtained with the visual analog scale (VAS) and Oswestry disability index (ODI).

We also compared the clinical outcomes pre- and post-surgery by using a paired t-test and Wilcoxon signed-rank test. Descriptive data were presented as mean±SD, and statistical significance was accepted as $p<0.05$.

Table-1. Demografic data

Number of patients	15
Sex (Male/Female)	5/10
Main age	52.3 (24-71)
Diagnosis (Spinal stenosis / Spondylolisthesis)	10/5
Level (T12-L1/L1-2)	11/4
Follow-up	18.2 (8-40)

Table-2. Results ODI and VAS (p<0.001)

Preoperative VAS	6.53
Postoperative VAS	3.2
Preoperative ODI	68
Postoperative ODI	26

RESULTS:

15 patients were included in our study with 5 of them male and 10 female. The median age was 52.3 (24-71) and average follow up was 18.2 (8.40) months. 10 spinal stenosis and 5 spinal listesis was diagnosed in our patients from thoracolombar degenerative disease. The preoperative diagnosis, extent of the operation, and operative levels are presented in Table-1.

The preoperative and postoperative VAS score of the patients were calculated to be 6.53 (5-8) and 3.2 (2-5) respectively. Also, the preoperative and postoperative ODI value of the patients were calculated to be 68% (55-80%) and 26% (10-40%) respectively. Postoperative improval on VAS score ODI value shows that our technique renders acceptable results. Our results came statistically meaningful (p<0.001) (Table-2).

DISCUSSION:

In the posterior stabilization on conus level, it is healthier to include anterior fusion on patients which decompression was necessary. Transforaminal approaches enables anterior fusion from a posterior approach on these patients. With the right technique, neurologic damage risk of the posterior TLIF application on the conus level is very low. Also because there will be no need for an anterior approach, there will be no second incission or a second surgery which lowers the morbidity and mortality of the added second abdominal incission. Also, since the posterior approach is better excersized by spinal surgeons it is more practical fort he operator.

To prepare the level of the fusion, a lateral approach should be done through facetectomy; and, both the upper and lower roots should be identified prior to the application. If done with this technique there no further retraction of neural elements are necessary. Operation can then continue with discectomy and the application of the fusion material.

The fusion rate of posterolateal fusion (PLF) is known to decrease as the number of fusion levels increases[9]. It has also been reported that the fusion rate of PLF is lower than that of posterior lumbar interbody fusion[4,13].

Sahn Jin Wang et al.[19] reported their 18 patient TLIF series with no cases on the conus level, Chong Suh Lee et al.[11] reported their 74 patient anterior approach series with no cases of TLIF application. Seok Ki Lee et al.[10] reported their 17 patient series with only 1 patient with the appliaction on the conus level, and they reported it as a posterior lumbar interbody fusion. PLIF application on this level is not advised by us since it will give way to more complications. TLIF application would render same results through lower risks.

Akira Hioki et al.[7] reported in their 17 patient TLIF series that only 7 of them were on the conus line and no above. He also reported like us that TLIF application on these levels gives less complication risks and lesser mortality and morbidity than alternative techniques.

Suhel et al.[18] reported their series of interbody fusion from a transpsoas approach on patients with degenerative lumbar scoliosis. We believe that through TLIF approach a need to create a second surgical corridor is not necessary therefore gives out better results.

There are numerous disadvantages for ALIF some of them being, abdominal organ and vascular damage, retrograd ejaculation risk through hypogastric plexus damage and anterior tension loss through anterior longitudinal ligament damage[16]. We favor the TLIF because of the less disadvantages it has.

Earlier studies have reported that TLIF is less invasive than conventional techniques, as evidenced by shorter operating time, less blood loss, shorter hospital stay, and lower incidence of complications[6,8].

Retrospective analysis of the clinical outcomes of the TLIF procedure for patients with upper lumbar degenerative diseases showed that TLIF provided satisfactory amelioration of clinical symptoms, sagittal alignment, and solid bony union, without any neurological complications.

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Volume: 27, Issue:1, January 2016 pp: 41-47 ORIGINAL ARTICLE / ORJİNAL MAKALE

VERTEBROPLASTY FOLLOWING VERTEBRAL COMPRESSION FRACTURE IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE PATIENTS

KRONİK TIKAYICI AKCİĞER HASTALARININ OMURGANIN ÇÖKME KIRIKLARINDA VERTEBROPLASTİ UYGULAMALARI

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SUMMARY:

Objective: The aim of this study was to demonstrate the appropriateness and efficacy of vertebroplasty application in patients who developed osteoporotic vertebral compression fracture (OVCF) during their chronic obstructive pulmonary disease (COPD) treatment.

Patients and Methods: Nine patients who underwent vertebroplasty between 2003 and 2013 due to vertebral compression fractures developed during their COPD treatment, received pulmonary function tests (PFT) pre- and postoperatively, and had a minimum follow-up period of 6 months were included in the study. Patients' VAS scores, respiratory parameters, vital capacity percentages (VC %), forced vital capacity percentages (FVC %) and forced expiratory volume in 1 second (FEV1 %) were measured.

Results: Patients presented to our clinic with an increase in shortness of breath, and waist and back pain. The average time between the onset of symptoms and surgery was 31.3 days. Patients' preoperative mean VAS score was 9 whereas it was noted 2 on the postoperative first day, 1.9 at the 1st month and 1.6 at the 3rd month follow-ups. A significant difference was detected between the preoperative and postoperative VAS scores ($p<0.01$). However, no significant difference was found between the VAS scores measured at follow-up visits. The average time between the surgery and PFT was 54 days. Patients' FVC developed from 58 to 64% ($p<0.05$), predicted FEV1 from 59 to 62% ($p<0.05$), and the (FVC/pred. FVC) ratio from 101.7 to 107.4% ($p<0.05$).

Conclusion: Vertebroplasty is an effective method in treatment of COPD patients with osteoporotic compression fractures. One should not insist to wait for the results of the three-month conservative treatment period before considering a surgical intervention for patients who developed COPD and OVCF.

Keywords: Chronic obstructive pulmonary disease; compression fracture; vertebroplasty.

Level of Evidence: Retrospective Clinical Study, Level III

ÖZET:

Giriş: Bu çalışmanın amacı kronik obstrükitf akciğer hastalığı (KOAH) tedavisi alırken ve osteoporotik vertebra çökme kırığı gelişen hastalarda vertebroplastinin yeri ve etkinliğini göstermektir.

Materyal Metod: Çalışmaya 2003-2013 yılları arasında KOAH tanısı ile tedavi alırken gelişen vertebra çökme kırığı sebebiyle vertebroplasti yapılmış, ameliyat öncesi ve sonrası solunum fonksiyon testi (SFT) yapılmış ve en az 6 ay takip edilen 9 hasta çalışmaya dahil edildi. VAS skorları ve respiratuar parametreleri; Vital kapasite yüzdesi (%VC), zorlu vital kapasite yüzdesi (%FVC) ve bir saniyedeki zorlu ekspiratuar hacim yüzdesi (%FEV1) elde edildi.

Sonuçlar: Hastaların hastaneye başvuru sebepleri daha önceden var olan nefes darlığı şikayetinin artışına ek olarak sırt ve bel ağrısı olarak saptandı. Şikayetlerin başlamasıyla operasyon arasında geçen sure 31.3 gün olarak bulundu. Ortalama preop VAS skoru 9 postop 1. günde 2, 1. ayda 1.9 ve 3. ayda 1.6 ise olarak saptandı. Ameliyat öncesi VAS skoru ile ameliyat sonrası arasındaki fark anlamlı bulunurken ($p<0,01$) ameliyat sonrası takipler ki VAS skorları arasında fark bulunamadı. Ameliyat ile solunum fonksiyon testi yapılması arasındaki süre 54 gün olarak bulundu. Hastaların yapılmış olan solunum fonksiyon testlerinin değerlendirilmesinde zorlu vital kapasitelerinin (%FVC) %58 den %64'e ($p<0,05$), 1. Saniye zorlu ekspiratuar hacmi ($p<0,05$) Pred FVC) %59 dan %62'e çıktığı ($p<0,05$) , (%FVC)/(Pred FVC) oranı ise 101.7 den 107.4'e ($p<0,05$) çıktığı saptandı

Tartışma : Vertebroplasti osteoportik çökme kırığı olan KOAH hastalarında etkin bir yöntemdir. KOAH olan ve OVÇK gelişen hastalarda cerrahi kararı alınırken 3 aylık konservatif tedavi süresinin beklenmesi konusunda ısrarcı olunmamalıdır.

Anahtar Kelimeler: Kronik obstrüktif akciğer hastalığı, KOAH, kompresyon kırığı, vertebroplasti

Kanıt Düzeyi: Retrospektif Klinik Çalışma, Düzey III

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INTRODUCTION:

Osteoporosis is a major problem of morbidity and mortality for the elder population. Compression fractures of the spine are the most commonly encountered type of osteoporosis-related fractures. However, as they present with no symptoms of pain, their diagnosis is often missed. The most common localization of these fractures is the dorsolumbar region. Osteoporotic vertebral compression fractures (OVCF) in the patient group with clinical symptoms cause especially activity-induced pain and have a significant impact on the quality of life of these patients[7,10]. In particular, the impact of this pain on respiratory functions and the efficacy of post-fracture percutaneous vertebroplasty (PVP) on pulmonary capacity in the long-term has been often debated[9,12]. Thirty-six to 60% of the patients with chronic obstructive pulmonary disease (COPD) also suffer from osteoporosis, a prevalence equal to two to five times of those of the same age but has no COPD[3,12]. The real reason to high prevalence of osteoporosis in patients with COPD is unknown, however, parameters such as advanced age, female sex, and body mass index are known to play a role in it.

Chronic obstructive pulmonary disease is a disorder which develops following the obstruction of the airways and caused respiratory problems. Patients with COPD need to use inhaler medications which require deep inhalation. The pain, which gets more significant due to ineffective use of the medications or after the vertebral fracture caused by deep inhalation, will further aggravate the present complications. Moreover, the patients will hardly tolerate the bracing applied for limiting the patients' activities and enabling immobilization.

Our aim in this study was to determine the clinical efficacy of PVP on the treatment of OVCF in patients followed up due to diagnosis of COPD.

PATIENTS AND METHODS:

Records of 140 patients that underwent PVP due to OVCF between 2003 and 2013 at our institution were found and retrospectively scanned. Medical files of the patients with severe back pain, unresponsive to conservative treatment, and those with a fracture no older than three months were evaluated. Patients with radicular or neurological symptoms, a major trauma, pathological fracture and those with a narrowed spinal canal due to bone fragments were excluded.

Twenty of these patients, diagnosed with COPD by our Department of Respiratory and Pulmonary Diseases and receiving inhaler medication treatment, were enrolled for the study. Of these, nine patients, whose respiratory statuses were checked preoperatively and at least for once in the postoperative three months with pulmonary function tests (PFT) were included in the study. The reason to preoperative PFT was to prepare the patient for surgery, due to the probability of performance of the surgery under general anesthesia.

Radiological evaluation of the patients with direct radiographs revealed the compression in the spine and the magnetic resonance imaging performed to support this diagnosis confirmed the edema. Osteoporotic statuses of the patients were determined with bone densitometry. Following all clinical and radiological assessments, patients with a vertebral compression fracture on direct radiographs, bone marrow edema in MR findings, and those with no bone fragments in the spinal canal were included in the study.

Surgical procedure:

All patients were told about the risks and complications of the surgical procedure and their written consents were obtained before surgery. All patients were preoperatively assessed by anesthesiology and other related departments and surgical preparations were completed. Surgery was performed percutaneously as bipedicular vertebroplasty in the supine position and under general or sedation anesthesia combined with local anesthesia. A mean of 1.4 (0.0 to 2) cc of polymethylmethacrylate (PMMA) was injected through each pedicle. All procedures were carried out under fluoroscopic guidance and monitorization of the patient's vitals. Each patient was administered 1 g of cefazolin for antibiotic prophylaxis right before surgery. Patients were closely followed up in the postoperative term and their treatments were planned with analgesics and anti-inflammatory drugs. Patients were neurologically examined after they returned to their beds and were immobilized six hours after surgery. Clinical evaluations of the patients were made on the postoperative first day and at the first and third months.

Pulmonary function test:

Patients' vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were measured using a computerized spirometer (SensorMedics Vmax Spectra 22; SensorMedics Corp., Yorba Linda, CA, USA) and their respiratory functions were evaluated according to the results in percentage. VC percentages (VC%), FVC percentages (FVC%) and FEV_1 percentages (FEV_1%) were recorded. Pulmonary function test was performed at least three times and the best results for VC, FVC, and FEV_1 according to the American Thoracic Society were noted.

Statistical analysis:

The visual analog scale (VAS) of 0 to 10 was used in assessment of the severity of pain. A score of 0 meant 'no pain at all' and 10 'the worst pain experienced ever'. Assessments were performed before the PVP surgery, on the postoperative first day, and at the first and third postoperative months. Wilcoxon's

signed-rank test was used in comparing the preoperative and postoperative results for VC, FVC and FEV_1 percentages. Statistical significance level was set at $p<0.05$.

RESULTS:

Twenty painful vertebral compression fractures of nine patients (8 females, 1 male; mean age: 62.6, range: 46 to 70 years) were operated in 13 sessions. Levels of the fractured vertebrae are shown in Table 1. Seven patients have been treated with inhaler steroids whereas other two patients have used oral steroids; all for more than a year. The average time between the onset of symptoms and surgery was 31.3 (range: 7 to 62) days. Eight patients (7 females, 1 male) were operated under general anesthesia and one (female) under sedoanalgesia. Five sessions of vertebroplasty had to be performed on eight vertebrae of a 70-year-old female patient at different times throughout a period of four years (Fig. 1).

Table-1. Localizations of the operated vertebrae.

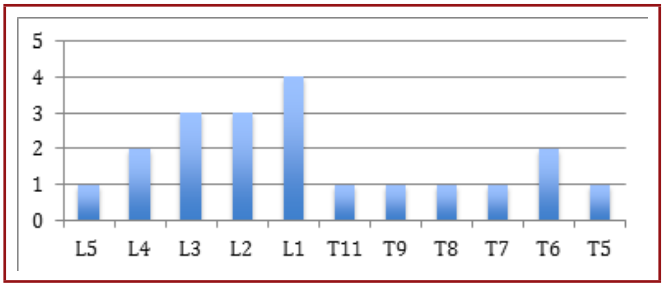
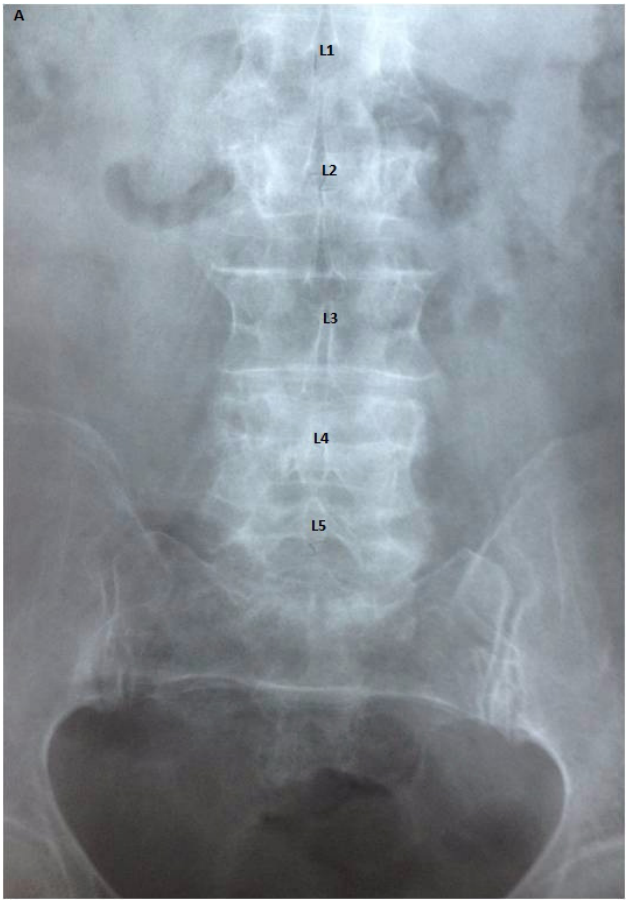
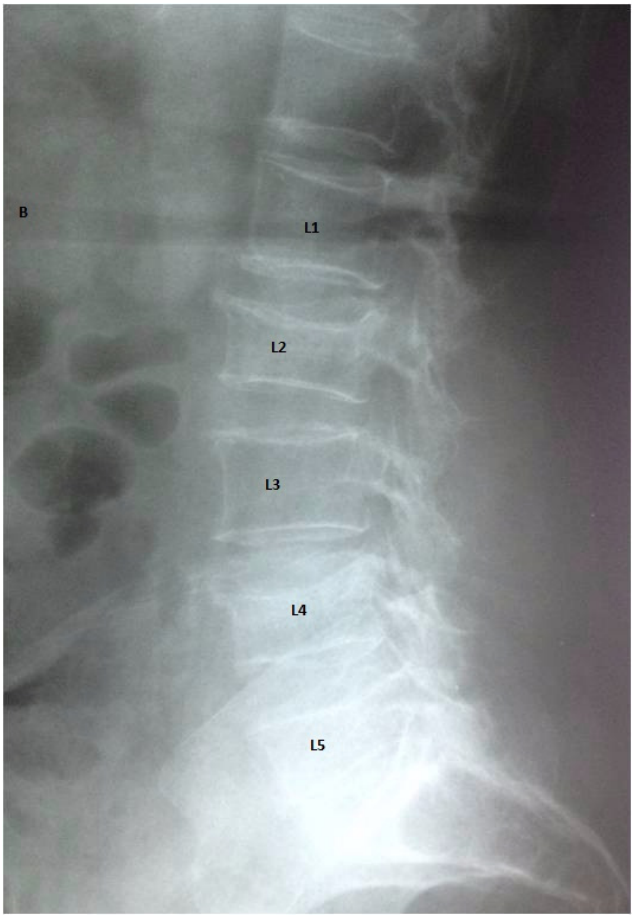


Table 2. List of the patients operated and their results.

Patient no.	1	2	3	4	5	6	7	8	9
Age	70-71-71-72-72	65	46	59	68	52	74	67	63
Sex	F	F	M	F	F	F	F	F	F
Means of steroid use	Inhaler	Inhaler	Inhaler	Oral	Inhaler	Oral	Inhaler	Inhaler	Inhaler
Period of steroid use (years)	8-9-9-10-10	1,5	5	6	3	2,5	4	3	1
Level (in order)	(L2,L4) (T11) (T6,T7) (T9) (T8,T5)	L1	L1, L2	L1, L2, L5	L3	L3, L4	L3	L1	T6
Preoperative VAS score (in order)	8-9-9-9-8	9	10	10	8	9	9	10	9
VAS score on postoperative Day 1 (in order)	2-2-1-1-3	3	3	2	3	2	1	2	2
VAS score at postoperative Month 1 (in order)	2-2-1-1-3	3	2	2	3	2	1	2	1
VAS score at postoperative Month 3 (in order)	2-1-1-2-1	3	2	1	2	2	1	2	1
Time between onset of pain and surgery in days (in order)	28,22,21,10,15	35	58	30	62	30	37	29	40


A
L1
L2
L3
L4
L5


B
L1
L2
L3
L4
L5


C
L1
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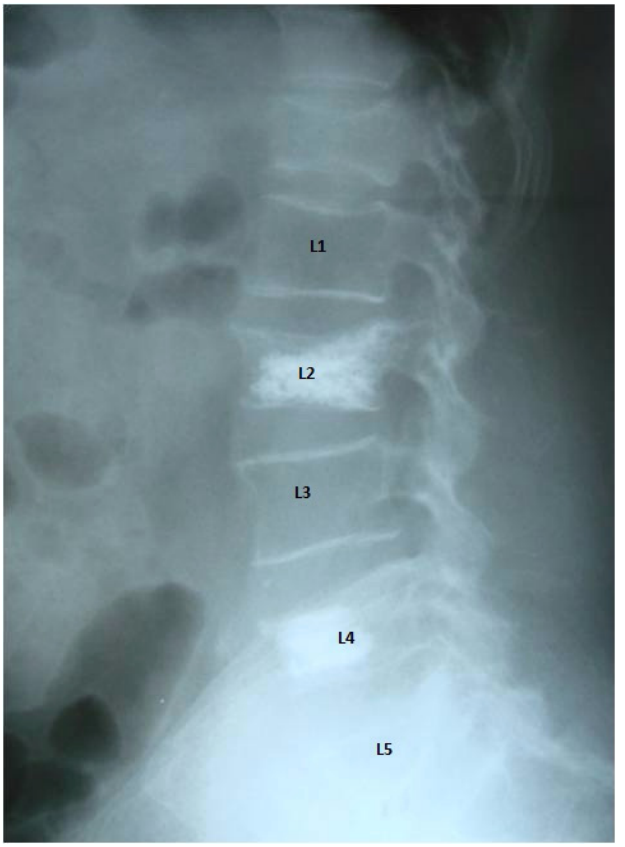
L5


L1
L2
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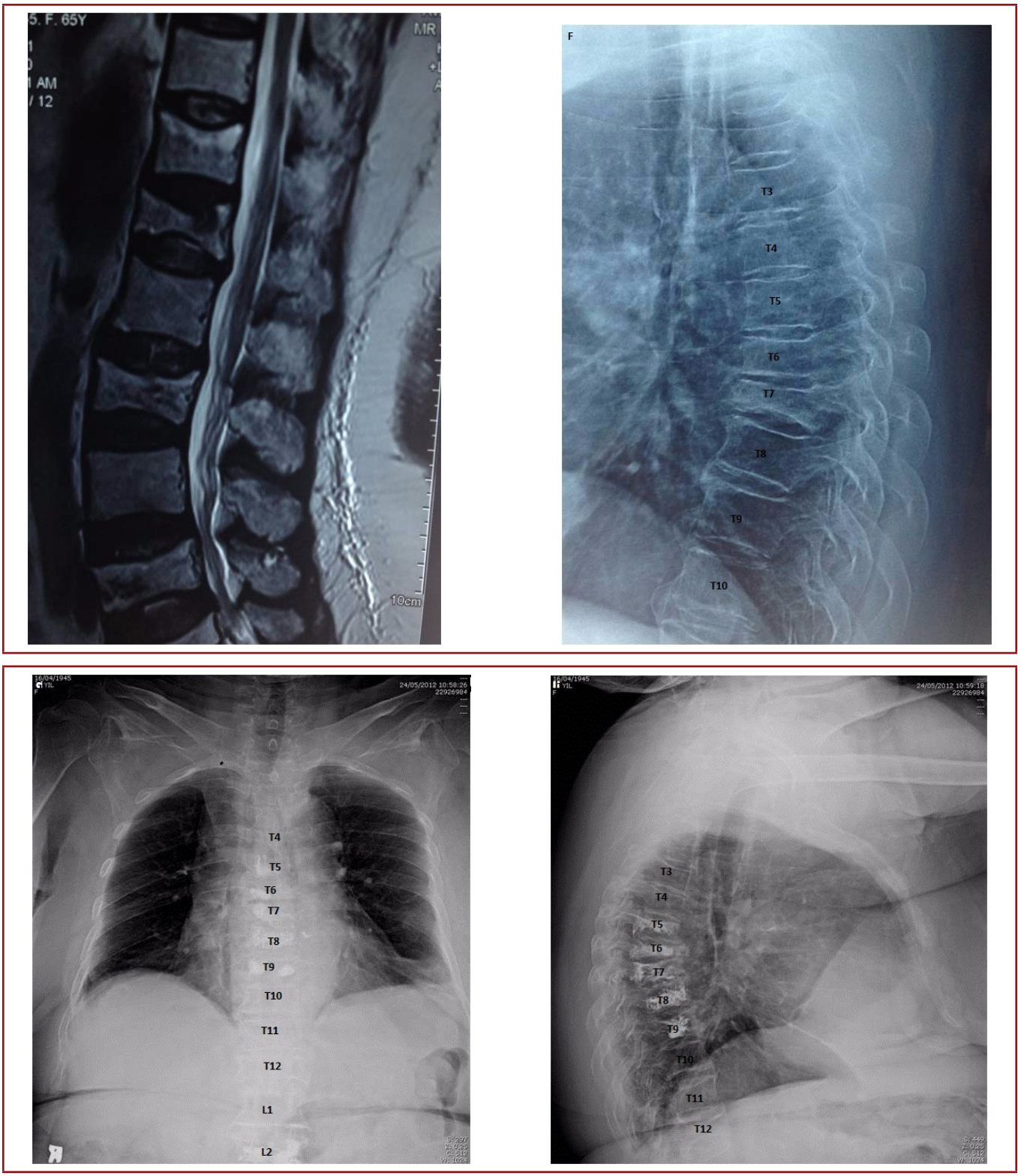

Fig. 1. Images of a 70-year-old female, COPD patient who has been using inhaled glucocorticoids for the last eight years. Vertebral compression fracture at the L2-L4 level can be seen on the **(A)** anteroposterior and **(B)** lateral lumbar radiographs. **(C)** Edema at the L2 and L4 vertebrae on the T2-weighted sagittal MRI. **(D)** Lateral lumbar radiograph of the patient after PVP surgery. **(E)** T2-weighted MR image of the T11 vertebra fracture, six months after the primary fracture. **(F)** Lateral thoracic radiograph and **(G)** T2-weighted sagittal MR images taken at the first year follow-up. **(H)** Compression fracture at the T6-T7 vertebral level is seen on the lateral thoracic radiograph of the patient taken at the second year follow-up. **(I)** Lateral thoracic radiograph of the patient from the final follow-up.

Seven patients (7 females) were performed single-level, five patients (4 females, 1 male) two-level, and one patient three-level vertebroplasty in 13 surgical interventions. Demographic data of the patients are shown in Table 2. Cement leakage into the spinal canal was observed in four vertebrae (20%) of three patients (33.3%), however, no neurological deficit developed. Patients' preoperative mean VAS score was 9 whereas it was recorded as 2 on the postoperative first day, 1.9 at the 1st month and 1.6 at the 3rd month follow-ups. A significant decrease was detected in the postoperative VAS score when compared with the preoperative one ($p<0.05$). However, no significant difference was found between the VAS scores measured at follow-up visits ($p>0.05$).

Patients' examinations at initial presentation revealed pain in the fractured vertebral region and shortness of breath. Patients were followed up by the Department of Respiratory and Pulmonary Diseases in the preoperative and postoperative period. The average time between the surgery and PFT was 54 (range: 23 to 89) days. Patients' FVC developed from 58 to 64% ($p<0.05$), predicted FEV_1 from 59 to 62% ($p<0.05$), and the (FVC/pred. FVC) ratio from 101.7 to 107.4% ($p<0.05$).

DISCUSSION:

Inhalers and oral glucocorticoids are widely used among COPD patients and cause osteoporosis mostly in the spine.[5] The incidence of fractures in this patient group is 20% more when compared with the normal population and the increase is related with the drug dosage and its duration of use.8 Other predisposing factors such as tobacco use or immobilization are still debated on[4,11,13] Another matter of controversy is the negative impact of OVCF over respiratory functions[3,6,14]. As the condition inhibits the thoracic mobility and causes postural deformity, the magnitude of such an impact in COPD patients is much higher.1 Waist and back pain with acute and subacute onsets limit the movement of the thorax, deteriorates the respiratory functions in COPD patients and cause overexertion of the pulmonary muscles[12,14].

In our study, we investigated the efficacy of vertebroplasty performed on COPD patients with OVCF. The efficacy of the surgical treatment was evaluated using the 11-point VAS and the changes in pulmonary functions were measured using spirometric parameters like FC, FVC and FEV_1.

Masala et al. observed a progressive increase in VC and FVC values of their PVP patients during the first three preoperative days. The increase reached its plateau after three months and then followed a constant value[9]. The increase in maximal voluntary ventilation (MVV), however, started by the third month. Nevertheless, we should also consider that the patients were given conservative treatment for three months in this study before the authors opted for surgical intervention. In our study, however, we preferred not to wait for this three-month conservative treatment period as it could affect the patients' quality of life. We also assumed that the wait could aggravate the symptoms especially in COPD patients with reduced pulmonary capacity.

There was a significant correlation between the decrease in VAS scores and the increase in pulmonary function indicators[3]. MVV is an indicator for the endurance of respiratory muscles and inactivity in osteoporotic patients. The decrease in the mobility of the ribs in a typical osteoporotic patient results in a decrease in the endurance of respiratory muscles and strength of isometric muscles, and thus a decline in respiratory functions[2].VC and FVC values are directly related with the restrictive functions of the lungs and therefore thoracic pain. The analgesic effect of PVP causes an increase in the forced thoracic movement which in turn improves the ventilation in COPD patients. Studies has shown that the only factor that could explain the recovery of respiratory functions is that the relief of pain during the movement of the thorax/ribs will allow for a bigger expansion of the rib cage.[9] However, the fractures in our patients was at the thoracic and lumbar levels. The decline in our VAS scores in the early-term was bigger when compared with other studies in the literature. Our results show that the patient satisfaction in this group is higher than those without respiratory problems.

Taginawa et al. compared the results of respiratory tests with the number (single- or multi-level) and localization (thoracic, thoracolumbar, lumbar) of the fractures in acute/subacute OVCF patients and observed a decrease in pain in all patients regardless of the level and number of fractures. However, the authors reported a significant increase in FVC values of patients with fractures in the thoracic region, regardless of the number of fractures and concluded that the fracture-related pain is the main reason to emergence of the restrictive syndrome and decline in thoracic movement. In addition, they also purported that the decrease in the local kyphosis angle (LKA) in multi-level OVCF patients is the leading cause in deterioration of pulmonary functions[12].

There are several studies in the literature reporting a time-dependent decline in respiratory function test results of OVCF patients who were not performed a surgical treatment. However, it has also been shown that the MVV reaches its peak value after three months even in patients who received conservative treatment for three months[12]. The decrease in the respiratory capacity due to ineffective use of respiratory muscles will further lead to a decrease in the already low values of COPD patients under conservative treatment versus those of the normal population. It might take some time for the muscles to return to their previous capacities following surgery due to the probability of atrophy that might develop after ineffective use of the muscles during conservative treatment.

In studies assessing the efficacy of vertebroplasty on pulmonary functions, COPD patients were excluded[3,6]. This is due to an attempt in establishing standardization of the spirometric values. Unlike previous studies, our study was conducted only on COPD patients.

There are several limitations of our study. First, our study is not a randomized and prospective one. It would be possible to obtain more objective results if we could follow up our COPD patients with compression fractures with respiratory function tests in the period before and after the fracture, and in the postoperative term in addition to comparing their pain scores with the drug use data. The one-month period between the surgery and PFT is adequate to do comparison with the preoperative term. However, repeating the test in the long-term at frequent intervals will better exhibit the efficacy of the treatment.

The biggest difference of COPD patients than the normal population is the methods of use and side effects of their medication. The use of vital inhaler medication which requires deep inhalation is more challenging in these patients. For these reasons, applying a conservative treatment in these patients, especially after an OVCF, will aggravate the already existing pulmonary problems. In making a decision for surgical treatment, one should take the current status of the patient into account and not insist for conservative management.

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Volume: 27, Issue:1, January 2016 pp: 49-54 CASE REPORT / OLGU SUNUMU

POSTERIOR FOSSA DECOMPRESSION AND CONCURRENT CORRECTION OF KYPHOSCOLIOSIS ASSOCIATED WITH CHIARI I MALFORMATION:

CHIARI I MALFORMASYONU İLE EŞLİK EDEN KİFOSKOLYOZUN AYNI SEANSTA POSTERİOR FOSSA DEKOMPRESYONU VE KORREKSİYONU: OLGU SUNUMU

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Can Hakan YILDIRIM[2],
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SUMMARY:

A 16.5-year-old boy underwent concomitant posterior fossa decompression (PFD) for CM-I and spinal curve correction. Preop MRI evaluation revealed a CM-I, cervicothoracic syringomyelia. A thoracic kyphosis (62°) with a double thoracic scoliotic curve (40°, 42°) diagnosed. A preoperative neurological examination revealed numbness in the left arm and a slight loss of motor function. Under intraoperative neurophysiological monitoring (IONM), a PFD and resection of C1 vertebra were performed before the surgical correction of the spinal deformity. Posterior pedicle screws were applied to vertebrae between T2 and L1. IONM revealed a clear improvement in the left arm following PFD. A postoperative magnetic rezonans imaging revealed a satisfactory decompression at the craniocervical junction and a significant improvement of the syrinx. Follow-up study after 3 years later showed that proximal thoracic angle was 10°, main thoracic angle was 10°, and lateral Cobb angle was 42°. Deformity correction surgery and treatment for CM-I performed in one session seems relatively new. IONM is vital in assessing a patient's condition prior to surgical operation and changes, which occur during surgery, as well as evaluation the follow-up period. Our study showed that PFD and spinal curve correction can be conducted in a single surgical session.

Keywords: Chiari malformation; scoliosis; kyphosis; syringomyelia; posterior fossa decompression

Level of Evidence: Case report, Level IV

ÖZET:

Omurga eğriliği ve CM-I olan 16.5 yaşında erkek bir hastaya eş zamanlı olarak deformite düzeltilmesi ve posterior fossa dekompresyonu (PFD) uygulandı. Preop MRG ile CM-I ve servikotorasik siringomyeli, radyolojik olarak torakal kifoz (62°) ile çift torakal skolyoz eğriliği (40°, 42°) gözlendi. Preop nörolojik muayenede sol kolda uyuşukluk ve motor fonksiyonun hafif kaybı tespit edildi. İntraoperatif nörofizyolojik monitörizasyon (IONM) altında posterior fossanın ve C1 posteriorunun dekompresyonu omurga deformitesi düzeltilmesi öncesi aynı seansta uygulandı. Posterior pedikül vidaları T2-L1 vertebralar arasına uygulandı. PFD nu takiben IONM da sol kolda belirgin bir düzelme gözlendi. Cerrahi prosedür sırasında herhangi bir olumsuz yan etki gözlenmedi. Postoperatif MRG ile kranioservikal bileşkede belirgin bir dekompresyon ve sirinkste düzelme gözlendi. Postoperatif 3 yıl takip sonucunda her iki torakal açı 10° ve lateral Cobb açısı 42° olarak ölçüldü. Eş zamanlı omurga deformitesi ve CM-I in düzeltilmesi daha önce tanımlanmamıştır. Cerrahi öncesi, sırasında ve sonrası gelişebilecek nörolojik değişikliklerin değerlendirilebilmesi için IONM kullanılması çok önemlidir. Uygun olgularda PFD ve omurga eğriliği düzeltilmesi eş zamanlı olarak gerçekleştirilebilir.

Anahtar Kelimeler: Chiari malformasyonu, skolyoz, kifoz, siringomiyeli, posterior fossa dekompresyonu.

Kanıt Düzeyi: Olgu sunumu, Düzey IV

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INTRODUCTION:

Chiari malformation (CM) associated with syringomyelia is one of the most common intraspinal anomalies in scoliosis[6,15]. Chiari malformation type 1 (CM-I) is defined as herniation of the cerebellar tonsils caudal to the foramen magnum[1,4]. Magnetic resonance imaging (MRI) also reveals a >4-5-mm herniation CM of the tonsils caudal to the foramen magnum[4,7,17]. Previous reports have indicated that scoliosis is found in 50-90% of CM patients and 15-65% of CM-I patients[12,19]. Several studies have investigated the development of scoliosis with CM or syringomyelia, but the mechanism is not fully understood[28]. Due to the neurological risks, posterior fossa decompression (PFD) or a syrinx shunt is recommended 3-6 months before spinal fusion[5]. Our study demonstrates a regression of the neurological findings and the deformity after a concurrent PFD and spinal fusion in an adolescent with CM-I, cervicothoracic syringomyelia and kyphoscoliosis deformity.

CASE REPORT:

Double thoracic scoliosis and kyphosis deformities were observed by radiography in a 16.5 year-old male. The AP Cobb angles were 40° (T2-T5) and 42° (T6-T10), and the lateral thoracic Cobb angle was 62° (Fig 1).CM-I malformation (cerebellar tonsils extending18 mm caudal to the foramen magnum) and an extensive syringomyelia cavity in the central spinal cord (between C4-T9, with the widest areas 5 x 6 mm at the level of C6 and 7 x 9 mm at the level of T6) were identified on MRI (Fig 1). During the preoperative neurological evaluation, there was a slight loss of sensation and motor function in the left arm and. No an abnormal superficial abdominal reflex was found. Together with intraoperative neurophysiological monitoring (IONM), successive PFD and T2-L1 intervertebral fusion were implemented. The rods were successively placed with segmental compression on the convex side and at the original position on the concave side to prevent spinal cord tension (Fig 2).

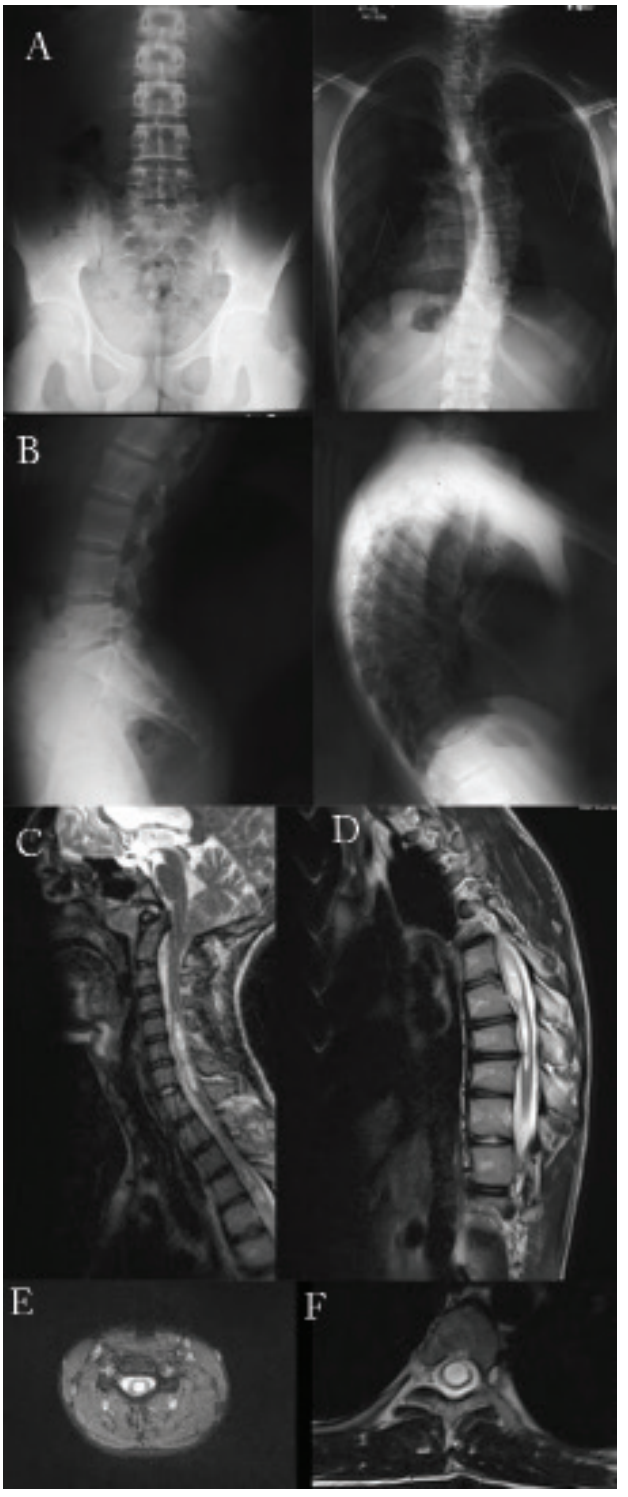

Figure 1. (A-B) Preoperative AP X-ray film indicating double thoracic scoliosis curvature (Cobb angle; 40° and 42°), Cobb angle on lateral graphy is 62°. **(C-F)** MRI showed extensive syringomyelia in CM-I and cervical and thoracic region (Syrinx level is between C4 and D9, Syrinx Width is 5 mm at C6 level and 7 mm at T6 level).

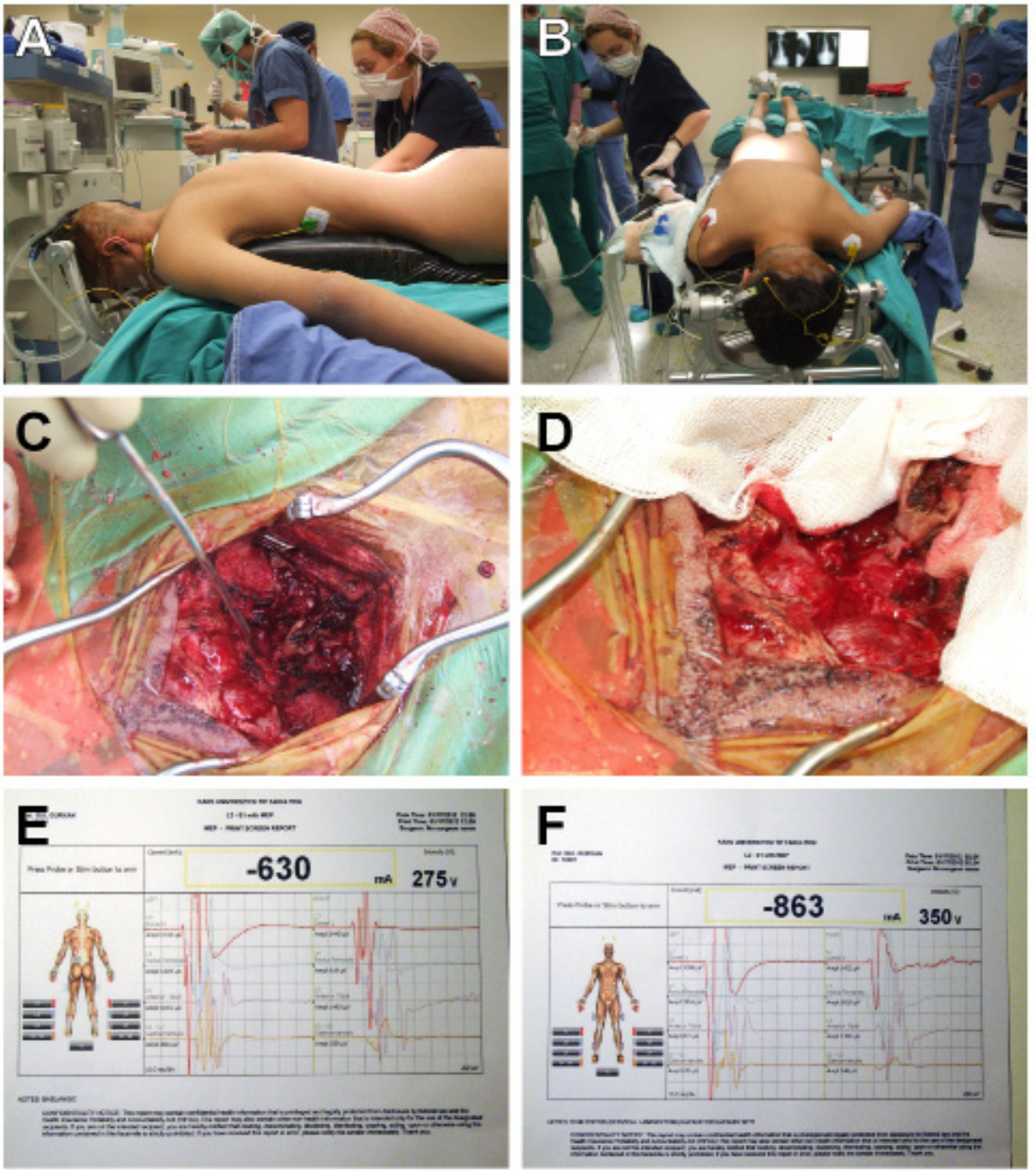

Figure 2. (A-B) Patient position. **(C-D)** Posterior suboccipital decompression and C1 laminectomy for CM-I and Syringomyelia. On IONM, an apparent recovery was observed on the left arm following suboccipital decompression. **(E)** Beginning and **(F)** post-decompression.

The operation lasted a total of 8 hours (1.5 hours decompression, 6.5 hours posterior instrumentation). The total blood loss was 1500 cc. On IONM, apparent recovery was observed in the left arm following PFD. No complications were observed during the surgical procedure. The patient was mobilized on post-op day 2 and discharged on day 7. A soft collar was used during post-op week 1. The patient was observed postoperatively in 3th, 6th and 12th months. In the final follow up at the end of 3 years, the AP Cobb angles were 10° both in T2-5 and T6-L1 levels, and the lateral Cobb angle was 42° at T2-L1 level. A recovery of neurological function and an evident decrease in the size of the syringomyelia were observed in MRI (between C4 and T8, with the widest areas 1.8 mm at the level of C5 and 3.9 mm at the level of T6) (Fig 3).

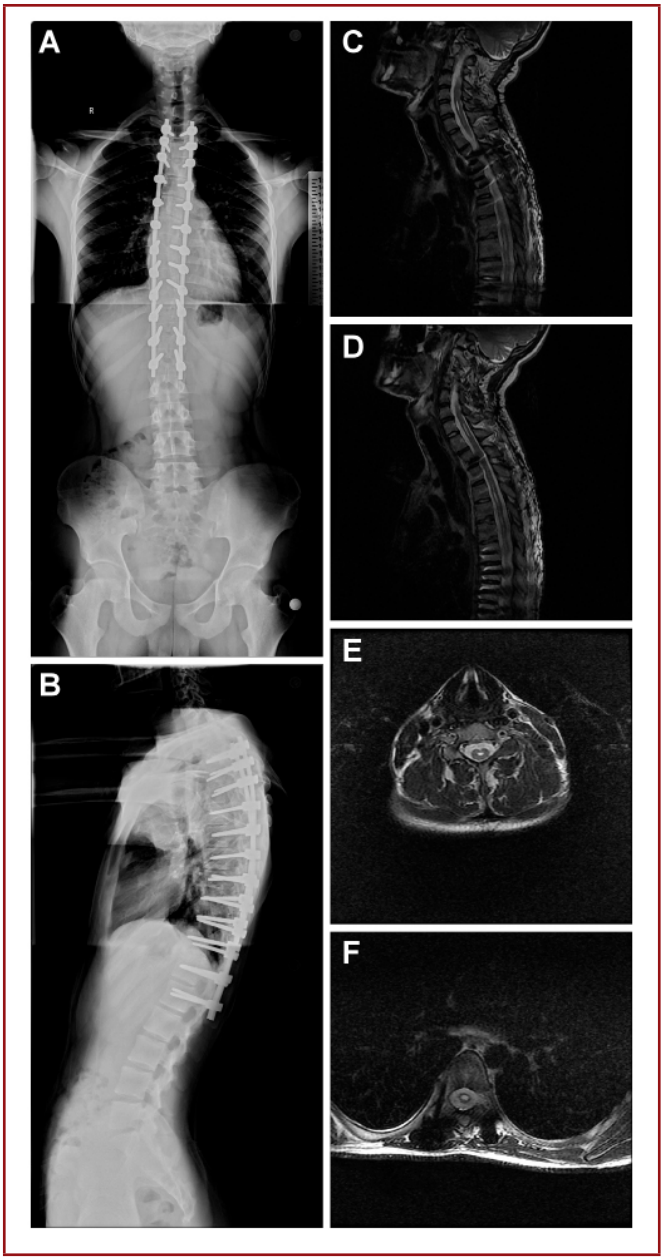

Figure 3. (A-B) During the final check in the end of postoperative 2.5 years, AP Cobb angle was 10° (T2-5) and 10° (T6-L1); lateral Cobb angle was 42° (T2-L1). **(C-F)** An evident decrease in the size of syringomyelia cavity was observed on MRI (Syrinx level is between C4 and T8, Syrinx Width is 1.8 mm at C5 level and 3.9 mm at T6 level).

DISCUSSION:

Neurosurgical treatment of neural axis malformations is recommended prior to correction of a spinal deformity due to high risk of neurological disruption during the correction[1,5,9,22]. First, PFD or syrinx shunt application, then a vertebral correction 3 to 6 months later is recommended[5]. The probability of observing a tethered cord with CM-I is 14%[16,23]. Intervention for intraspinal anomalies is recommended before the surgical decompression of the CM[2,16,20]. Most intraspinal anomalies identified with scoliosis are small syrinx or minimal cerebellar ectopies that do not require surgical intervention[24]. In most cases, rather than prophylactic neurological operations, careful observation is recommended for asymptomatic syringomyelia[12]. Some authors report that brace treatment in scoliosis with CM-I or syringomyelia is ineffective[8]. Others defend the use of brace treatment on skeletally immature patients with a Risser grade lower than 3 and a curvature between 20 and 50° [29]. In addition to PFD, it was shown that the use of bracing prevents curve progression, with the exception of double major curvature (64%)[26].

It was shown that PFD conducted in younger patients, when the curvature is small, will mostly be beneficial for correction of the scoliosis curvature when scoliosis is present with CM-I[29]. Sengupta reported that 37.5% of 16 patients had fixed curvature, and 71.4% of those with fixed curvature were younger than 10 years old at the time of PFD[25]. Muhonen reported that scoliosis regressed in all patients under 10 years during decompression, including those with curvature greater than 40°[18]. Eule presented correction in 5 of 5 cases younger than 8 years old after decompression[8]. Bhangoo et al. reported that the required average age for scoliosis surgery was 158 months with an average Cobb angle of 76° in 13 patients with symptomatic CM and clinically-identified scoliosis who received PFD. These authors stated that the age (>10) and Cobb angle (>30°) were clearly related to the need for additional scoliosis surgery[2]. Flynn et al. found that the reasons for scoliosis progression in patients who received post-neurosurgical intervention were related to older age (>11), the existence of neurological symptoms, rotation of the vertebra object, double scoliosis curvature, and the presence of a wide curve (>50 kyphosis or >40 scoliosis)[10]. Brockmeyer et al. noted that patients with CM-I and syringomyelia in addition to scoliosis, who had PFD and duraplasty curvature greater than 50° and who were older than 12 years have a low chance of correction, whereas the percentage of correction or stabilization of a small curvature in patients younger than 10 years is high (62%)[3]. According to the Kelly et al., spinal deformities are more likely to improve after CM decompression of the hindbrain in young patients (<10 years old) with small coronal Cobb measurements (<40°). Spinal fusion is reserved for those curves that progress to deformities greater than 50°. Spinal deformity surgery may be more challenging in these patients, in part because of difficulties with intraoperative neurologic monitoring challenges[13]. Early neurosurgical intervention for intraspinal anomalies in younger patients ensures correction of the accompanying scoliosis deformity, and this is not possible in older patients and late interventions for curvature[2,3,10,13,18,20,21,25].

Xie et al. suggested that PFD is not always required before spinal deformity correction in adolescents suffering from CM-I and scoliosis. Among 13 patients with adolescent scoliosis and CM-I with a wide curve who presented evident progression, 7 patients were treated with single-stage total posterior vertebral column resection (Cobb angle >90°), and 6 patients were treated with posterior pedicle screw fixation and deformity correction (Cobb angle >90°); no neurosurgical actions were taken to address the CM[27]. Xie et al. recommended a gradual primary correction of the deformity with segmental compression on the convex side during the procedure[27]. In our case, we also implemented segmental compression starting from the convex side first, as described by Xie et al., during the placement of rods after PFD and during the correction operation.

According to Zhu et al., for patients with both CM-I and spinal deformity, PFD may be effective for the regression of scoliosis in 64.8% of younger patients, whereas it may not prevent the progression of scoliosis in patients with a Cobb angle ≥ 44.5° and double curvature[29]. In our case, we also considered that PFD may be insufficient due to the age of the patient (16.5 years) and the presence of a double thoracic curve (42° and 40°) and kyphosis (62°) deformity, and we implemented the deformity correction during the same session.

During spinal surgery, IONM enables the evaluation of the intraoperative integrity of the corticospinal tract[29]. IONM is recommended during pathological treatment and spinal correction to minimize and prevent risks; it is particularly important in evaluating neurological correction during surgery. IONM is vital in assessing a patient's condition prior to surgical operation as well as the changes that occur during surgery, and for evaluation during the follow-up period[14]. Godzik et al. reported that the surgical management of spinal deformity in patients with underlying CM-I and syringomyelia carries a higher risk of new neurological deficit, despite adequate neurosurgical decompression and IONM[11]. We assessed our patient with IONM during surgery. Upon the completion of PFD, we detected an evident increase in the stimulation of the left upper extremity.

We performed a deformity correction during the same session and observed that the correction was maintained and no additional pathological changes developed. At the end of the 2.5-year postoperative period, we obtained satisfactory clinical and radiological results in a patient who was submitted to PFD and deformity correction surgery during the same session.

Deformity-correction surgery and treatment of CM-I performed in one session seems to be a relatively new approach. IONM is vital in assessing a patient's condition prior to surgical operation, as well as the changes may occur during the surgery, and for evaluation during the follow-up period. Our study demonstrated that PFD and spinal curve correction can be conducted in a single surgical session.

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CONVERSATION WITH PROF. NAFIZ BILSEL: CERRAHPAŞA AND SPINE SURGERY

PROF. DR. NAFİZ BİLSEL İLE SÖYLEŞİ: CERRAHPAŞA VE OMURGA CERRAHİSİ

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SUMMARY:

Prof. Nafiz Bilsel was born in Bornova, Izmir in 08.10.1950. He graduated from Istanbul University Faculty of Medicine, in 1973. He became a surgeon of Orthopaedics and Traumatology at Istanbul University Cerrahpaşa Faculty of Medicine, in 1979. He passed the associate professorship examination of Orthopaedics and Traumatology in 1985. In 1995, he became the professor of the Orthopaedics and Traumatology at the same faculty. Below, you will find a conversation with Prof. Dr. Nafiz Bilsel, who is an invaluable member of our faculty and has important contributions to the advancement of spine surgery in both Cerrahpasa Faculty of Medicine, Orthopedics and Traumatology Department and our country.

Key words: Nafiz Bilsel, Cerrahpasa Faculty of Medicine, spinal surgery, scoliosis.

Level of evidence: Biography, Level V

ÖZET:

Prof. Dr. Nafiz Bilsel 1950 yılında İzmir Bornova'da doğdu. 1973 yılında İstanbul Tıp Fakültesi'ni bitirdi. 1975 yılında Cerrahpaşa Tıp Fakültesi Ortopedi ve Travmatoloji kliniğinde asistan olarak uzmanlık eğitimine başladı. 1979 yılında aynı klinikte Ortopedi ve Travmatoloji uzmanı oldu. 1985 yılında doçent, 1995 yılında profesör oldu. Kliniğe girdiği günden bu güne, çalıştığı aynı bölümde, hocalarından aldığı ışığı daha da yukarılara taşıdı. Türk Omurga Cerrahisinin gelişimine büyük katkılarda bulundu. Aşağıda onunla ilgili bir biyografik çalışmayı söyleşi formatında bulacaksınız.

Anahtar Kelimeler: Nafiz Bilsel, Cerrahpaşa Tıp Fakültesi, Omurga Cerrahisi, Skolyoz

Kanıt Düzeyi: Biyografi, Düzey V

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INTRODUCTION:

Prof. Dr. Nafiz Bilsel, is an invaluable member of our faculty and has important contributions to the advancement of spine surgery in both Cerrahpasa School of Medicine, Orthopaedics and Traumatology Department and our country.

BIOGRAPHY:

Dear Professor, could you please briefly talk about your background?

I was born in Bornova, Izmir on 08.10.1950. Due to my father's profession, I studied primary school in five different locations. After I graduated from Pendik High School in

1967, I began studying as a medical student at İstanbul University School of Medicine, where I graduated in 1973. After finishing my military services in March 1975, I worked as an assistant physician in Göztepe Hospital for two months. In this period of time, I passed the residency examination for general surgery and worked as a resident in Beyoğlu Ilk Yardım Hospital for a short time. Meanwhile, registration for Cerrahpaşa Medical Faculty, Orthopaedics and Traumatology surgery residency exam was began.

I passed the exam and began my training in my most favorite branch of surgery in August 1975. In Fall 1979 I graduated as a specialist in Orthopaedics and Traumatology surgery, presenting my thesis on "Surgical Treatments in Olecranon Fractures" and began to work as chief resident in the same clinic.

I gained associate professor title in 1985. I was appointed as Professor in 1995.

I married Hikmet Bilsel in 1977 and we have a son. I am still working in Cerrahpaşa School of Medicine, Orthopaedics and Traumatology Department (Figure-1).

Figure-1. Prof. Nafiz Bilsel and his family.

Figure-2. Relton-Hall Frame.

THE CONTRIBUTION OF THE SPINAL SURGERY:

How your interests in vertebral diseases began?

In my residency years, there were no surgeon focusing on vertebral diseases and traumas in our department. For this reason, we were redirecting spinal deformity cases to Istanbul School of Medicine, to Dr. Bahattin Oğuz Timuçin; spinal infection cases to Baltalimanı Bone Disease Hospital and vertebral fracture cases to Cerrahpaşa Neurosurgery Department, to where they were performing laminectomy for all vertebral fractures.

In my second year of chief residency, I went to United Kingdom for 9 months to improve my knowledge and experiences. I worked as an observer in Birmingham Royal Orthopaedic Hospital with Mr. Harry Piggott FRCS. Dr. Piggott was a very benevolent and knowledgeable person. Spinal deformities were his main interest alongside with pediatric surgery and general orthopaedics. He worked with Harrington for a while and was performing Harrington procedure for scoliosis.

When I arrived Turkey, with the great support of Prof. Dr. Kemal Bayraktar and Prof. Dr. Macit Uzel, I began to work on diagnosis and treatment of vertebral diseases.

What were the difficulties ahead of you in this duration?

There wasn't any knowledge and experience in our clinic at that time about this issue. Also, the shortage of surgical instrument forced me to obtain everything individually by myself.

At 1983, while Deanery was short on budget, I managed to purchase a vertebral surgical set and Harrington set by myself. Also I had a Relton-Hall Frame made by a blacksmith, which at that time, I thought, was an essential part of the surgery (Figure-2).

Stryker Frame which is used in post-operative period after Harrington surgery was very expensive, I could not even suggest buying it. After Harrington surgery, Risser casting had to be applied, so I had a blacksmith to make me a replica of a Risser casting table, which was at the Istanbul University Medical Faculty, Orthopedics and Traumatology Department. Because we didn't have a Stryker Frame at that time, after Harrington surgeries, I had my patients lie down on a cast-made bed until Risser casting was applied. One of my patients had a broad gluteal necrosis because of the cast- made bed, so we started to search for a Stryker frame. One company's representative said that they had sold one of these to Vakıf Gureba Hospital many years ago. I found out that the frame was at their store. After the permissions from deanery, we went to the store and we saw an unused Stryker frame tossed in to a corner. Supposedly it was bought many years ago, never used or even nobody knew where to use it. Besides all our efforts, we could not be able to transfer it for Cerrahpaşa Hospital (Figure-3).

With the help of a philanthropist and a very skilled blacksmith, we managed to build two of it, by copying the original one. We used those for many years not even just for scoliosis. After sometime, more stable systems became available, so we decided to give those two frames to physiotherapy clinic for rehabilitation of the paraplegic patients (Figure-4).

Could you give information about evolution of surgical applications in your clinic?

After I returned to Turkey I had performed standard 'Harrington Surgery' until 1985. At the beginning of 1985, I went to Birmingham again for 3 months. 'Sublaminar wiring' technique and 'segmental spinal instrumentation' systems had begun to be used in Birmingham. When I was in the United Kingdom, A.F. Alves, a Portuguese general surgeon, made a presentation with a large patient series, which was named 'The Portuguese method in surgical treatment of scoliosis' and was followed with interest by the participants at the meeting of 'British Scoliosis Society', held in 1985. Accomplishing the correction by ligaturing the cerclage wires which were passed from the bottom of the spinous process in the curvature site to a 4,5 mm coil, was an interesting method for me. Before arriving to Turkey, I visited Portugal and I attended operations with A.F. Alves. After I arrived, I started to use this method in some cases.

Between 1985 and 1990s, I used 'Harri-Luque', 'Luque' and 'Hartshil rectangle' segmental spinal instrumentation (SSI) system which was being applied with using sublaminar wire, in all spine operations those require instrumentation.

Towards the end of the 1980s, I also started using double rod correction and stabilization systems which was developed by Prof. Dr. Emin Alıcı who made huge contributions to the development of spine surgery in our country. After that, we have come to these days, using CD system and pedicle screw systems.

Sublaminar wiring, SSI was applied widely in our clinic and for the first time in our country by me. Today, I still use this method when needed and I think everyone should learn this method

Figure-3. Stryker Frame.

Figure-4. Risser Frame.

Which complications did you encounter in sublaminar wiring applications ?

I believe there is no operation without complications. While there are reports about high complication ratios of sublaminar wiring applications in some publications, we haven't encountered any complications causing neurological deficit. In only one patient, dural fistula was developed and was recovered after a long treatment period.

What are the other applications which can be termed as "innovation" in your clinic besides sublaminar wiring?

"Wake Up Test" developed by Stegnara, was an important test especially in sublaminar wiring, to detect and prevent the complications which may occur during spine surgeries. I brought the information about this test with me while returning to Turkey in 1985. I shared my knowledge with my anaesthesist friend, Dr. Güner Kaya. After June 1985, we began to apply the test on every scoliosis and kyphosis operation routinely. "Wake Up Test" was applied by our aneasthesia team for the first time in our country in 1985 and it was presented in our national congress in 1987.

How did your clinic react to your interest in spine surgery?

The most important part of this long story was the great support from my teachers and colleagues in our clinic, of course. During my chief residency period, I had to perform other routine orthopaedics and traumatology operations which were too intensive alongside with spine surgeries. From the year I became assistant professor (1985), in addition to my routine surgery day, a different operation table which was named "scoliosis table" was arranged for me to perform only spine surgeries on Thursdays. Furthermore, once in a week, in a different day from my normal out-patient clinic day, I started seeing spine patients in afternoons. Thus, we had large patient series in our clinic.

Dr. Önder Aydıngöz's interest in this subject after he became specialist, was also really useful for me. There was no one but me interested in spine diseases in our clinic, my colleagues didn't have much knowledge about this particular subject, they were not able to criticize me and they were just passing over my cases by saying; "Probably, that's the right way!". My longing for discussing the cases had come to an end by this way.

We know that you are also interested in conservative treatment of spine deformities. Would you like to say something in this topic

Conservative treatment of spine deformities like scoliosis and kyphosis is important in especially developed countries. I believe that conservative treatment which is performed properly, lowers the rate of surgical treatment significantly.

Manufacturing of "corrective brace" which is the only choice in conservative treatment should be taken seriously. The most ideal systems are Boston type braces which are manufactured by application of a prefabricated module and made with a mold taken from a person who has no spine deformity. But these systems are not imported to Turkey since they are not widely used due to economic reasons. Instead of using original prefabricated modules, we still use braces produced by taken from the patient's deformed body (scoliosis or kyphosis) and then wrapping them with barely suitable plastic and placing correction-derotation pads. It is not easy to get good results with these orthesis which the quality fully depends on skills of the manufacturer. For many years, my colleagues and I have endeavored to make effective braces by establishing close contact with orthotic technicians in our clinic. But, due to lack of materials and difficulties in providing qualified technicians, I still think that we have not reached the level of developed countries yet.

During spinal surgery development process in your clinic, have your relations with neurosurgery clinic changed?

When I started to deal with the treatment of spinal fractures naturally bittersweet controversies began between our clinic and the neurosurgery clinic. As I mentioned before, they used to treat all spinal fractures before we developed interest. First of all, I tried to persuade them that they should stop performing laminectomy on each case regardless of its nature. They gave up performing laminectomy procedure on each case with the help of Mr. Prof. Dr. Ertuğrul, an honoured member of neurosurgery clinic who passed away at a very young age. Meanwhile, I had a wide range of complicated post- laminectomy patient series and I had written a section on the subject for Prof. Dr. Rıdvan Ege's book about spine. Moreover, the chief of neurosurgery clinic, Prof. Dr. Cengiz Kuday, encouraged Prof. Dr. Murat Hancı, who was a chief resident by that time, to cooperate with us. We have been working together for a very long time now. Dr. Hancı joined us and his cooperation increased our limited knowledge and experience about the neural structures.

Is the development of spine surgery in your clinic and our country has increased the power of representation in the international arena?

In those years, the number of physicians who were interested in spine surgery were very few. We were able to make presentations in national congresses. After the establishment of the association, with Prof. Dr. Emin Alıcı's efforts, we began to organize international conferences. The first congress was in Izmir, and the second was held in Istanbul. Prof. Dr. Ünsal Domaniç and I were appointed as chairmen to 2nd International Congress on Spine Surgery in Turkey on 7-11 September 1992. It was an earlier example of co- chairmanship we see today in politics.

Do you have any hobbies? What are your interests besides your profession?

I love the sea and water sports. I like swimming, fishing and sailing a lot.

My other hobby is working in garden. Especially, I'm very good at tomato grafting and cultivation. I would like to recall the help of the 2nd vice president of EFORT about seed supply. In addition, I have small flock of laying hens.

Who are the celebrities you have taken the treatment so far?

Unfortunately, as far as I know, I did not have the opportunity to treat any of first 1,000 Turkish Celebrities.

Thank you for the interview.

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turkishspine

1- Which animal is preffered in the study of Oltulu et. al.?

a) Pig
b) Dog
c) Cat
d) Rat
e) Sheep

2- Which technique revealed more beneficial results biomechanically in the osteoporotic patients in the study of Oltulu *et al*?

a) Only hook
b) Only tranpedicular screw
c) Only cables
d) Screw with polymethylmetacrylate
e) Cable with screw

3- Which one morphometric value was used in the first study of Demirel *et al*?

a) Hight of disc
b) Sagittal index
c) Spinopelvic inclination angle
d) Sacral slop
e) Sagittal contours (Servikal, thoracic and lumbar)

4- How many patient was evaluated in the first study of Demirel *et al*?

a) 90
b) 100
c) 135
d) 170
e) 200

5- How many patient was evaluated in the second study of Demirel *et al*?

a) 98
b) 108
c) 118
d) 128
e) 138

6- Which sentence of the below <u>is not</u> correct according to the study of Şerifoğlu *et al*?

a) Mean Chamberline-Odontoid Distance was 2.5 ± 1.2
b) Mean Grabb-Oakes was 1.8 ± 1.1 mm
c) Mean Atlantodental Interval was 1.4±0.5 mm
d) Mean Foramen Magnum AP was 34.3 ± 3.2 mm
e) Mean age was 51.7 ± 18.7 years

7- How many cases were presented in the second study of Şerfoğlu *et al* statistically?

a) 100
b) 110
c) 120
d) 130
e) 140

8- Which below sentence was correct according to the study of Bayraktar *et al.* ?

a) The prevalence of the Modic changes was 69.6%,
b) Disk degeneration was 30%.
c) Type 4 predominance was observed.
d) 94.6% of the Modic changes were observed in the lower lumbar segments.
e) Comparison between occupational groups showed a significant statistically difference.

9- Which one of the below is <u>correct</u> about theresults of the upper lumber TLIF application of the study of Erdoğan *et al*?

a) Postoperative VAS scores were not changed
b) Postoperative ODI scores were 68 %
c) Neurologic damage risk of the posterior TLIF application on the conus level is very high.
d) TLIF provided satisfactory amelioration of clinical symptoms, sagittal alignment, and solid bony union, without any neurological complications.
e) N/A

10- What was the postoperative 3rd month follow-up VAS score in the study of Beyaz *et. al.* ?

a) 1,6
b) 2,6
c) 3,6
d) 4,6
e) 5,6

JTSS 27(1) issue CORRECT ANSWERS OF CME QUESTIONS:

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