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Dear Colleagues,

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

There are 7 clinical research articles in this issue. The first three article are about the sagittal plane analysis of the idiopathic scoliosis. In the fourth article, the results of the surgical treatment of the patients with thoracic trauma. In the fifth study, the results of the partial vertebrectomies in the patients with malign spinal tumors are presented. In the sixth study is also about the malign spinal tumors. In the last study, some epidemiological and clinical signs and symptoms of the Tarlow cysts are reported.

In this issue, one case series and one case report are presented. In the case series is about using of F18-FDG PET-CT in the diagnosing, treating and monitoring spinal infections. In the second case report, lumbar intradural disc herniation with cauda equine syndrome is presented.

In this issue, two-review article were included. In the first review article, clinic, classification and the treatment of the fractures of the sacrum and dislocations of sacroiliac joint are reported. Second one is about the classifications of the malign spinal tumors.

In this issue, in the "Frontiers of the Spinal Surgery" section, Prof. Can SOLAKOĞLU who was died due to traffic accident recently which family of Turkish Spinal Surgeons was shocked unfortunately. My dear friend, we will never forget you. Sleep in the lights.

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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EDITORIAL

IDIOPATHIC SCOLIOSIS

SPINAL TRAUMA

SPINAL TUMORS

CASE SERIES AND CASE REPORTS

REVIEW ARTICLES

FRONTIERS OF SPINAL SURGERY

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ORIGINAL ARTICLE

FUNCTIONAL AND RADIOLOGICAL RESULTS OF THORACOLUMBAR / LUMBAR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) TREATMENT WITH POSTERIOR PEDICLE SCREWS

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ABSTRACT

Aim: Correlation between coronal imbalance and radiological parameters in Lenke type 5C curves treated with posterior pedicle screws were studied and effects on the clinical results were evaluated.

Material and methods: Sixteen patients with Lenke type 5C AIS operated between years 2008-2015 were included in this study. Ten patients (62.5%) were female and 6 (37.5%) were males. The average age of patients were 15.5 years and mean follow-up duration was 37 months. The parameters affecting coronal and sagittal balance were measured on patients' pre-operative, post-operative and last control X-rays. SRS-22 questionnaire was applied to the patient for the clinic satisfaction of the patients postoperatively.

Results: Patients were divided to 2 groups. Group 1 consisted of 8 patients with preserved coronal balance, and group 2 consisted of 8 patients with coronal imbalance. Radiological and clinical parameters of the groups were compared statistically in the early and late postoperative period. When patients' demographic data and radiological parameters were compared preoperatively and early postoperatively, no statistical differences were observed between two groups. In the last control assessment in group 2, the major TL/L curvature, minor thoracic curvature, SVL, thoracic apical vertebrae (TAV) translational amount and L4/5 disc angle were found to be significantly different ($p<0.05$). No statistical difference in terms of clinical outcomes were observed between 2 groups.

Conclusion: We found that minor thoracic curvature, TAV translation and L4 / 5 disc angle have an impact on coronal balance in long-term, however no correlation was found between radiological coronal imbalance and clinical outcomes.

Key words: Thoracolumbar/lumbar scoliosis; adolescent idiopathic scoliosis; coronal balance; L4/5 disc angle; posterior selective fusion.

Level of evidence: Retrospective clinic study, Level III.

INTRODUCTION

Lenke type 5C curvatures include compensatory non-structural thoracic curves, along with main structural thoraco-lumbar and lumbar curvature. Aims of surgical treatment of these spinal deformities include obtaining maximal correction, establishment of good spinal balance, and obtaining maximal function. Surgical options include anterior, posterior and combined approaches. Anterior surgical technique which became popular with Dwyer was considered as standard treatment of cases with Lenke type 5C curves till the last 10-20 years. A more mobile spine with better balance and correction is obtained by adding a shorter segment to fusion with anterior surgery. However, observation of high rates of pseudo-arthrosis, thoracic and vascular injury, and unacceptable surgical scar in the patients, with kyphosis development on the upper level of segment on which fusion was done on follow-up of anterior surgical approach have led to predominance of posterior surgical approaches in recent years. Emergence of systems which facilitate correction of spinal rotation with pedicle screws after instrumentation by hook by Shufflebarger and described by Harrington have resulted in routine use of posterior surgical intervention for Lenke type 5C curves currently. Debate continue on determination of proximal and distal instrumentation levels aiming to prevent decompensation that may occur after correction of this type of curvatures from posterior.

We aimed to investigate the correlation between radiologic parameters and coronal balance disorders that develop during follow-up of Lenke type 5C curves which we had treated by correcting with posterior pedicle screws and fusion and its impact on clinical outcomes.

MATERIAL AND METHODS

A total of 16 patients with Lenke type 5C curves who were operated at Akdeniz University Medical School, Clinic of Orthopedics and Traumatology between 2008-2015, and whose medical records could be obtained were included in this study. Inclusion criteria included patients between 11-21 years old, deformities with Cobb's angle between 30-60 degrees, in whom single-step correction with double rod was performed from posterior, who were followed-up for at least 5 months, whose x-rays were taken pre-operatively, at the early post-operative period (week 1) and at follow-up, who had SRS-22 record forms for early post-operative (month 1) and last control examination. Exclusion criteria were as follows: a history of past spinal surgery, deformities with Cobb's angle higher than 60°, patients younger than 10 years of age, Risser stage 0 patients, those with spinal instrumentation extended beyond T3-4-5 levels, and those with lumbar or thoraco-lumbar kyphosis.

PA and lateral scoliosis x-rays were obtained in all patients who would undergo surgery. Bending radiographs were taken between the years 2008-2010, and traction radiographies under general anesthesia were obtained after 2010, in order to evaluate the flexibility of curvature and determine the instrumentation level. Turkish version of SRS-22 questionnaire form was used in evaluation of functional status of all patients. Control x-rays at early post-operative period were obtained on the mean 3rd day, as standing PA and lateral scoliosis x-rays. Post-operative controls were done on the day 15, day 45 , month 3, month 6, month 9, month 12 and month 18, and yearly afterwards. Radiologic parameters were determined according to Spinal Deformity Group Guidelines and manually measured [1]. Angles of major and minor curvatures were measured with Cobb method, with Risser stages, vertebral rotations according to Nash-Moe, Global Coronal Balance), Regional Coronal Balance , truncal shift, vertebral translation , upper instrumental vertebral tilt (UIV) and disc angle, lower (L-3 or L-4) instrumental vertebral (LIV) tilt and disc angles, while Thoracic Kyphosis (TK), Lumbar lordosis (LL), SVL, proximal junction kyphosis(PJK) were measured from lateral x-rays. Global Coronal Balance was determined by measurement of the distance between CSVL and C7 vertebral midline in millimeters. The upper limit of this value was accepted as 20 mm in some studies, while in our study a displacement of 15 mm from the midline was considered coronal imbalance [2]. Regional Coronal Balance is the measurement of the distance in millimeters between L3, L4 and apical vertebral center and CSVL. Lumbar Coronal Balance was determined as the distance between CSVL and midline of lower instrumental vertebrae. Truncal shift is the distance between CSVL line and the midline of lateral margins of ribs in the mid-thoracic region in millimeters. Apical vertebra translation was evaluated by measuring the distance of C7 plumb line and thoracic and lumbar apical vertebrae (TAV, LAV). LIV tilt was defined as the angle between inferior end-plate of the lower instrumented spine and horizontal line. UIV tilt was defined as the angle between upper end-plate of upper instrumented spine and horizontal line. LIV-Disc Angle was defined as the angle between LIV inferior end plate and upper end-plate of the lower level spine. UIV-Disc angle was measured as the angle between UIV upper end-plate and adjacent upper vertebra lower end-plate. The angle between upper end-plate of T5 vertebrae and lower end-plate of T12 vertebrae was measured for thoracic kyphosis, and the angle between upper end-plate of L1 vertebrae and lower end-plate of L5 vertebrae for lumbar lordosis was measured by Cobb's method [3].

The angle between lower end-plate of upper instrumented vertebra and upper end-plate of the vertebra 2 levels above was measured post-operatively, and it was considered proximal junction kyphosis (PJK) if it is above 10° and there is an increase more than 10° in comparison with pre-operative values [4]. Fusion criteria in x-rays of patients at post-operative controls included absence of clinical complaints, absence of segmental movement, presence of radiologic fusion findings and absence of implant insufficiency or absence of radioluscent line around the implant. SRS-22 forms were filled at all control examinations and recorded. Functional outcomes of patients were evaluated by means of data obtained at last evaluation. questions in SRS -22 forms were separated into four groups and were evaluated based on mean values.

Surgical Method

All patients were administered prophylactic cefazoline sodium IV 1 hour before the surgery. Antibiotic prophylaxis was continued till the 3rd post-operative day. All patients were operated under general anesthesia. After invasive monitorization and placement of urinary catheter, traction x-rays were taken manually under general anesthesia.. Before the patients were put in the prone position, silicon supports were placed, leaving the mid portions empty, in order to prevent the abdomen and thorax being exposed to pressure and to prevent development of fat necrosis in the breasts.

Regions adjacent to the bone such as elbow and patella were supported with cotton. Surgical incision was done in the midline, and posterior elements were reached with help of cautery subperiostally till the transverse processes. The capsule of facet joints, and all soft tissues including interspinous and supraspinous ligaments were exposed. Capsule and soft tissues surrounding facet joint were cleaned with cautery and rongeur. The next step was excision of facet joints that would be included in the fusion area.

Osteotome was used in case when needed, in order to excise superior joint process of the inferior vertebra at all levels. Leksell ronguer was used to clean all joint cartilage before excision of joint processes.

Ligamentum flavum was excised at the next step with Kerrison ronguer and, polyaxial segmental pedicle screws (Johnsons&Johnsons and Medtronic) were inserted between proximal and distal end vertebrae and at every level that insertion was possible with free-hand technique.

Pedicle orientation was verified under fluoroscopy control when necessary. After placement of pedicle screws were controlled, next step of the intervention was placement of rod. Titanium rod of 5.5 mm with lordotic shape was placed at the convex side of curvature to obtain lordosis and correct the coronal deformity. Fixation of this rod on the most distal instrumented vertebra first facilitated rod placement. Placement of convex rod was completed with Cantilever maneuver. Concave rod was given less lordosis than the first rod. Less lordosis of this concave rod enabled de-rotation as a block as the rod was being pulled by screws on the concave side. This rod was fixated to the most proximal and distal screws preferentially. After that, middle portion of deformed curve was pulled towards the posterior rod. After placement of two rods, direct vertebral rotation was done. In order to obtain optimal balance, lower instrumented vertebra was tried to be put parallel to sacrum, and rotation was tried to be lowered to 0-1 level with compression and distraction maneuvers, and intra-operative control x-rays and fluoroscopic images were evaluated for this aim. When necessary, these maneuvers were repeated. Cross-link was not used routinely.

Decortication was done till the tips of transverse processes, in addition to facet excision for posterior arthrodesis. Afterwards, autogenous and allogeneic bone grafts were used. Neuromonitorization was used in 7 patients during surgery, while wake-up test was used in all other patients. After correction and arthrodesis procedure, subfascial hemovac drains were placed and structures were closed in accordance with the procedure. After the intervention was completed, x-rays were taken at supine position at the operating room and the patients were taken to the intensive care unit. After the operation, remaining part of the 48 hours extended prophlactic antibiotherapy (Cefazoline Na IV 3x1 g) was continued. When the patients recovered at the intensive care unit, neurological examination was done. As the patients were taken to the ordinary ward from the intensive care unit, urinary catheters were removed. On the post-operative 2nd day, drains were pulled and all patients were mobilized. No corset or casts were used in any patients. Sedentary activities were permitted as tolerated and most sports activities were permitted after 3-6 months from surgery. Post-operative standing PA and lateral control x-rays were taken in all patients. The patients were discharged after a mean 6 days, and sutures were removed on the day 15 . The patients were followed-up on week 6,month 3, 6, 12 and 18 , and yearly afterwards with standing PA and lateral x-rays.

Early superficial or deep wound site infections, opening of incision, atelectasis or other pulmonary complications were not seen. Implant failure, late infections were not seen in the long term. Proximal junctional kyphosis was seen in 3 patients but they did not require treatment.

RESULTS

Among 16 patients included in this study, 10 were females (62,5%) and 6 (37,5%) were males. Their age varied between 11 – 21 years, a mean of 15,5 years at surgery. The duration of follow-up was between 5 - 95 months (Mean 37 months). Risser staging at time of surgery was as follows: 1 patient at stage 1, 1 patient at stage 2, 2 patients at stage 3, 10 patients at stage 4 and 2 patients at stage 5.

Instrumentation and fusion was applied to mean 6 levels (between 3-7). Two opposing pedicle screws were placed at every level in 12 patients, while one instead of two screws due to pedicle conformity problems at one level in four patients.

Early post-operative phase and last control SRS-22 questionnaire forms were evaluated in all patients. Clinical satisfaction scores were between 3,36 and 4,91 in the early post-operative period (mean 3,94). Clinical satisfaction scores at last control was between 3,05 and 5 (mean 4,12).

The pre-operative TL/L Cobb Angle was between 23° - 45° (mean 36°). It was between 2° - 16° at the early post-operative period (mean 7°) and correction was measured as 81%. It was between 1° - 14° at the last control (mean 7°) and the correction was 81%. Pre-operative Thoracic cobb Angle was between 6° - 28° (mean 15°). Thoracic Curve was between 1°- 18° at the post-operative early period (mean 8°) and spontaneous correction was 47%. It was between 1° - 35° at the last control (mean 7°) and correction was 53%.

Preoperative vertebral rotation that was measured with Nash – Moe method was stage 3 in 2 patients, and stage two in 14 patients. In the early post-operative and last control, it was stage 2 in only 1 patient, and stage 1 in 15 patients. Tilt angles of L3 and L4 vertebra were measured in all patients. Pre-operative L3 tilt was between 9° - 29° (mean 20°). It was between 1° - 8° in the early post-operative period (mean 5°). In the last control, it was between 1° - 10° (mean 4°). L4 tilt angle was between 9° - 26° (mean 18°). It was between 2° - 11° in the early post-operative period (mean 6°). In the last control, it was between 2° - 9° (mean 5°).

The pre-operative thoracic kyphosis angle was between 6° - 38° (mean 28°). In the post-operative early period, it was between 12° - 48° (mean 26°). At the last control, it was between 15° - 51° (mean 32°). The pre-operative lumbar lordosis angle was between 7° - 60° (mean 38°). In the post-operative early period, it was between 20° - 61° (mean 41°). At the last control, it was between 22° - 68° (mean 45°). The pre-operative truncal shift amount was between 3 mm - 38 mm (mean 14 mm). Post-operative early period values were between 1 mm - 33 mm (mean 11 mm). At the last control, these were between 1 mm - 25 mm (mean 8 mm). PJK development was observed in 3 patients during follow-up, but these did not require treatment as they did not cause any complaints.

The patients were evaluated in terms of coronal balance.. Patients with a distance longer than 15 mm were considered to have coronal imbalance, which was present in 8 of 16. The patients were classified in two groups according to coronal balance (CB). Group 1 included patients with good coronal balance and Group 2 included patients with coronal imbalance, both groups consisting of 8 patients **(Figure-1 and 2).**

In the comparison of Group 1 patients and Group 2 patients, measurement values were calculated as means and standard deviations in statistical methodology. Mann Whitney U test was used in order to detect whether measurement times differed between groups or not. Friedman test was used in the investigation of differences in measurement times of the patient groups. Bonferroni dual comparison test was used to detect different measurement times (post hoc test). Values of <0,05 were considered as statistically significant. The analysis were done with SPSS 22.0 software.

The pre-operative TL/L curve, minor thoracic curve, apical rotation, TAV translation, coronal balance, lumbar coronal balance, truncal shift, thoracic kyphosis, PJK, lumbar lordosis, SVL, LAV translation, age at surgery, UIV tilt, L3 vertebra tilt, L3/4 Disc Angle, L4 vertebra tilt, L4/5 Disc Angle, LEV level and CSVL level at Lumbar vertebra measurements were similar in patients in Group 1 and Group 2, without statistically significant differences (p>0,05) **(Table-1).**

Mann. Whitney U test was used in investigation of differences between groups in terms of early post-operative measurements and the results are presented in Table-2. Coronal balance and truncal shift measurements were different in Groups in early post-operative measurements (Mann U *z*=-3,82,-3,35, p<0,05) **(Table-2).**

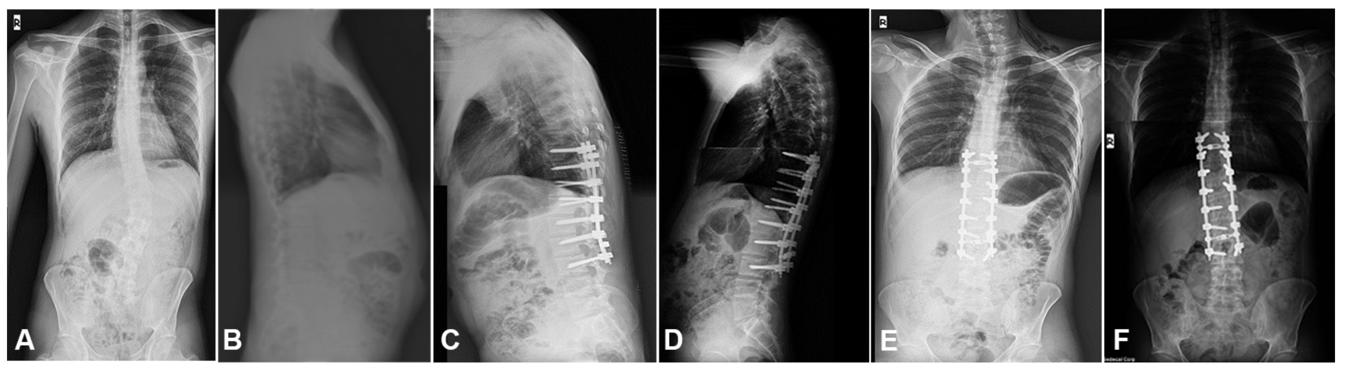

Figure-1. Male case aged 21 years from Group 1 patients. PA and lateral control x-rays in the pre-operative, early post-operative period and at month 27. Coronal balance is seen to be preserved at the early phase and at the last control.

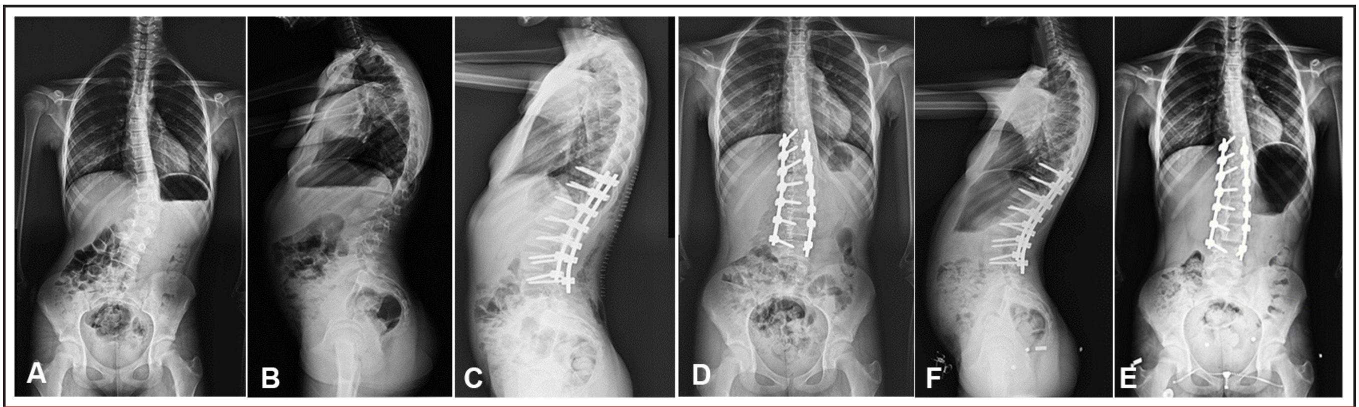

Figure-2. Female patient aged 14 years from Group 2. PA and lateral x-rays in the pre-operative and early post-operative period and at the month 14 control.

Mann. Whitney U test was used in investigation of differences in last control measurements according to groups and the results are presented in Table 3. Differences were found between last control measurements of patients in Group 1 and Group 2 in terms of major TL/L Curve, minor thoracic curve, SVA, TAV translation amount, and L4 disc angle. The cause of differences was found to be higher values of major TL Curve, minor thoracic curve, SVA, TAV Translation, L4 disc angle measurements of patients in Group 2 in comparison to Group 1 (Mann U z=-2,86,-4,61, 2,60 2,84,-3,14,p<0,05) **(Table-3).**

Table-1. Investigation of differences in preoperative measurements according to groups

Measurement	Group	N	Mean	s.ds	Mann U z	P
Major TL/L Curve	Group1	8	34,88	6,33	-0,59	0,57
Group 2	8	36,50	4,60			
Minor Thoracic Curve	Group1	8	13,25	5,63	-1,04	0,32
Group 2	8	16,88	8,10			
Apical Rotation (Nash-Moe)	Group1	8	2,25	0,46	1,53	0,15
Group 2	8	2,00	0,00			
Thoracic Apical Vertebra (TAV) Translation	Group1	8	14,75	7,59	-2,17	0,05
Group 2	8	21,50	4,44			
Coronal Balance	Group1	8	14,13	12,47	-1,73	0,10
Group 2	8	24,13	10,51			
Lumbar Coronal Balance	Group1	8	43,63	20,49	0,03	0,98
Group 2	8	43,38	19,06			
Truncal Shift	Group1	8	12,75	10,90	-0,29	0,78
Group 2	8	14,38	11,46			
Thoracic Kyphosis	Group1	8	28,13	7,99	0,88	0,39
Group 2	8	24,00	10,56			
PJK	Group1	8	10,00	5,04	-0,10	0,92
Group 2	8	10,25	4,74			
Lumbar Lordosis	Group1	8	37,88	16,06	-0,21	0,83
Group 2	8	39,50	14,42			
SVA	Group1	8	10,38	23,63	-1,56	0,14
Group 2	8	51,25	70,42			
Lumbar Apical Vertebra (LAV) Translation	Group1	8	30,75	10,44	0,95	0,36
Group 2	8	25,13	13,10			
Age at surgery (Months)	Group1	8	199,38	32,52	1,79	0,09
Group 2	8	175,00	20,59			
UIV Tilt Angle	Group1	8	8,88	3,27	0,19	0,85
Group 2	8	8,50	4,63			
UIV Disc Angle	Group1	8	4,00	2,39	1,19	0,25
Group 2	8	2,75	1,75			
L3 Tilt Angle	Group1	8	19,63	6,50	0,08	0,93
Group 2	8	19,38	5,21			
L3 Disc Angle	Group1	8	3,38	2,39	-1,33	0,21
Group 2	8	5,75	4,46			
L4 Tilt Angle	Group1	8	20,38	3,16	2,19	0,05
Group 2	8	16,25	4,30			
L4 Disc Angle	Group1	8	9,38	3,66	2,02	0,06
Group 2	8	5,13	2,90			
CSVL Lumbar Level	Group1	8	4,63	0,52	0,97	0,35
Group 2	8	4,38	0,52			

Table-2. Investigation of differences in early post-operative measurements according to groups

Measurement	Group	n	Mean	S.D	Mann. U z	P
Major TL/L Curve	Group1	8	7,25	5,65	-0,05	0,96
	Group 2	8	7,38	5,37		
Minor Thoracic Curve	Group1	8	7,25	4,80	-0,69	0,50
	Group 2	8	9,13	5,96		
Apical Rotation	Group1	8	1,13	0,35	1,00	0,33
	Group 2	8	1,00	0,00		
TAV Translation	Group1	8	15,63	5,66	-2,04	0,05
	Group 2	8	24,25	9,66		
Lumbar Coronal Balance	Group1	8	24,88	13,54	-1,40	0,18
	Group 2	8	33,13	9,76		
Truncal Shift	**Group1**	**8**	**3,63**	**2,00**	**-3,35**	**0,01***
	Group 2	**8**	**19,13**	**12,94**		
Thoracic Kyphosis	Group1	8	23,13	4,12	-1,22	0,24
	Group 2	8	28,63	12,06		
PJK	Group1	8	10,13	4,91	-0,26	0,80
	Group 2	8	11,00	8,23		
Lumbar Lordosis	Group1	8	99,13	180,95	0,85	0,41
	Group 2	8	44,63	9,18		
SVA	Group1	8	-34,50	40,31	-2,16	0,06
	Group 2	8	17,38	28,72		
LAV Translation	Group1	8	27,13	8,32	-1,12	0,28
	Group 2	8	33,13	12,64		
SRS-22	Group1	8	3,89	0,37	-0,53	0,60
	Group 2	8	3,99	0,43		
UIV Tilt	Group1	8	3,38	1,51	0,79	0,44
	Group 2	8	3,63	1,19		
UIV Disc	Group1	8	2,25	0,89	-1,14	0,27
	Group 2	8	2,00	1,31		
L3 Tilt	Group1	8	5,00	2,45	-0,89	0,39
	Group 2	8	4,13	1,96		
L3 Disc	Group1	8	2,13	0,64	-1,99	0,07
	Group 2	8	3,25	2,71		
L4 Tilt	Group1	8	5,25	2,71	0,59	0,56
	Group 2	8	6,63	3,42		
L4 Disc	Group1	8	1,75	0,89	-0,71	0,49
	Group 2	8	3,38	2,13		
LEV Lumbar Level	Group1	8	3,00	0,00	-2,05	0,06
	Group 2	8	3,38	0,52		

Table-3. Investigation of differences in last follow-up control measurements according to groups

Measurement	Group	n	Mean	s.d	Mann U z	P
Major TL Curve	**Group1**	**8**	**6,13**	**0,85**	**-2,86**	**0,01***
	Group 2	**8**	**7,25**	**0,76**		
Minor Thoracic Curve	**Group1**	**8**	**5,63**	**5,37**	**-4,61**	**0,01***
	Group 2	**8**	**8,75**	**11,31**		
Apical Rotation	Group1	8	1,13	0,35	-1,62	0,13
	Group 2	8	1,00	0,00		
TAV Translation	**Group1**	**8**	**15,13**	**6,85**	**-2,60**	**0,02***
	Group 2	**8**	**32,25**	**15,50**		
Lumbar Coronal Balance	Group1	8	27,50	14,13	-0,67	0,51
	Group 2	8	36,13	5,17		
Truncal Shift	Group1	8	4,50	2,56	-1,43	0,17
	Group 2	8	12,25	8,03		
Thoracic Kyphosis	Group1	8	31,63	10,06	-0,42	0,70
	Group 2	8	33,13	11,43		
PJK	Group1	8	13,88	7,49	-1,66	0,12
	Group 2	8	17,13	11,43		
Lumbar Lordosis	Group1	8	41,38	10,13	-1,61	0,13
	Group 2	8	49,25	11,78		
SVA	**Group1**	**8**	**-46,60**	**30,69**	**-2,84**	**0,01***
	Group 2	**8**	**-36,00**	**29,70**		
LAV Translation	Group1	8	25,63	11,15	0,03	0,98
	Group 2	8	34,13	9,23		
SRS-22	Group1	8	4,12	0,40	0,56	0,58
	Group 2	8	4,11	0,55		
UIV Tilt	Group1	8	3,38	1,77	-1,65	0,12
	Group 2	8	3,50	2,45		
UIV Disc	Group1	8	2,25	0,89	0,55	0,59
	Group 2	8	2,13	1,55		
L3 Tilt	Group1	8	4,88	2,85	0,20	0,85
	Group 2	8	4,00	3,34		
L3 Disc	Group1	8	2,63	2,00	0,56	0,58
	Group 2	8	4,00	3,78		
L4 Tilt	Group1	8	4,00	1,85	-0,91	0,38
	Group 2	8	6,88	1,81		
L4 Disc	**Group1**	**8**	**2,13**	**1,36**	**-3,14**	**0,01***
	Group 2	**8**	**3,50**	**1,93**		

DISCUSSION

Our aim in Lenke type 5C curves is to obtain a more mobile spine with coronal and sagittal balance, by fusion of smaller number of segments. Thus, selective posterior spinal fusion applications are becoming more popular.

Okada et al have divided 29 patients with Lenke type 5C curves on whom they had performed selective posterior fusion in two groups retrospectively. In 10 patients, UIV was left at UEV level, and it was left one level below in 19 patients. In follow-up, significant differences were found in Cobb angle of major curve, correction rate of curvature, operation duration and blood loss, while SRS-22 scores, Coronal and sagittal balances were similar. The authors have concluded that an approach one segment shorter may be an alternative treatment to classic approach in which UEV level is the UIV level, while they admit limitations of their study as small sample size, short follow-up duration and its retrospective nature [5]. In our study, UIV level was UEV in 13 patient's, and UEV was 1 level lower in 3 patients. These 3 patients were from Group 1, with normal coronal balance; thus, we believe that there is no significant relationship between coronal imbalance and UIV level.

When the medical literature is examined, LIV level was more extensively investigated than UIV level on coronal balance in Lenke type 5C curvatures. Li et al have retrospectively examined 27 patients with Lenke type 5C curvature on whom they had performed surgery. A difference of 15 mm was considered significant for coronal imbalance and coronal imbalance was found in 4 patients during 2 years of follow-up. LIV level was L3 in 18 patients, L4 in 8 patients, and L5 in one patient. They have found pre-operative coronal imbalance, pre-operative LIV tilt and post-operative LIV tilt to be effective on post-operative coronal imbalance. If the pre-operative LIV tilt is 25° or more or if it does not fall below 8° post-operatively, these patients may have coronal imbalance[2]. We considered 15 mm as threshold for coronal imbalance. Pre-operative TAV translation and coronal balance measurements were higher in Group 2 in comparison with Group 1, but including these parameters, there were no significant pre-operative differences.

In a study by Wang et al in patients with Lenke type 5C curvatures for LIV selection, there were important results and suggestions. But the fact that 10 of the 30 patients in this study were treated with anterior spinal fusion is an important limitation. 20 mm was considered threshold for coronal imbalance and coronal imbalance was found in 4 patients in 2 years of follow-up. Pre-operative LIV and CSVL distance and LIV +1 vertebra tilt, lumbar Cobb angle, lumbar AV-CSVL distance during 2 years of follow-up were significantly effective in general and on thoracic balance. Additionally, pre-operative LIV level selection was shown to be significantly effective on correction and balance in 2 years of follow-up [6]. They did not find significant increases in major TL/L curvatures in 2 years of follow-up of Lenke 5C curvatures, which is in concordance with our study.

LIV tilt was found to be the most important factor for coronal balance in the study by Li et al, while LIV vertebral tilt higher than 25° and LIV translation over 28 mm were found to be significantly effective on coronal balance in the study by Wang et al [2,6].

In our study, LIV level was 1 level above LEV level in 2 patients, LIV level was at LEV level in 12 patients and LIV level was 1 level below LEV level in 2 patients. When the LIV tilt angles of our patients were compared with the literature, they were found to be similar **(Table-4).** Significant differences were found between pre-operative measurement and early post-operative measurement or last control measurements, while measurements at early post-operative period and last control measurement were similar. We couldn't confirm significance of 25° as a criteria for pre-operative LIV tilt angle in our study. When we examined the last control results of 4 patients with LIV tilt angle higher than 25°, coronal imbalance was not present in 3 of them, with only one with coronal imbalance.

Lee et al have investigated 229 patients with Lenke 3C, 5C, 6C types with major TL/L curvatures. They have divided these patients in two non-equal groups, and compared stopping instrumentation at L3 level distally and L4 level. Instrumentation was stopped at L3 level in 196 patients and L4 level in 33 patients. In this study, 82 patients had Lenke 5C curvature, 73 of which was in L3 and 9 was in L4 groups. While all patients had undergone posterior instrumentation, threshold for coronal balance was considered as 20 mm. Decompensation had developed in post-operative follow-up in 12 patients. While 9 of these patients were from L3 group, when the ratios were compared, ratio of patients with coronal imbalance was twice as higher, but without statistical significance. An insignificant difference was found between the two groups in terms of adjacent disc disease, and no significant differences were seen between staying at L3 level or extending to L4 level in any aspects, including SRS-22 results. After this, the L3 group was divided in two sub-groups, one with LEV level at L3 or higher and the other at L4 and below. In this study also, a significant difference was not observed. For this reason, they have recommended leaving a longer mobile segment by staying at L3 level in patients with major TL/L curvatures [7]. In our study, we had 13 patients in whom LIV level was at L3 and 3 patients at L4. One of these 3 patients was in the group with normal coronal balance, and 2 were in the other group. In analysis on these patients, no significant differences were found.

Sun et al have evaluated the results in 37 patients with TL/L curvatures whom they had operated LIV level according to LEV level. In 3 patients with major TL/L Cobb angle between 30° - 60° who had undergone posterior spinal instrumentation, level was LEV -1, in 22 patients level was LEV and in 12 LEV +1 **(Table-5).** In these patients with similar preoperative demographic characteristics, those in whom LIV level was LEV and LEV+1 were compared. Pre-operative LIV Translation was significantly lower in LEV +1 group; and LIV disc angle was significantly lower in LEV group. Except for these two parameters, all of the other parameters of these two groups were similar. In the post-operative evaluation, one patient from each group showed coronal imbalance (>20 mm) and these patients were not consistent with criteria described by Li et al and Wang et al. For this reason, the authors reported that these criteria should not be included into the guidelines. In post-operative measurements, significant difference was found only in LIV translation, and this was attributed to similar pre-operative differences. They have concluded that fusion one level lower in curvatures with major TL/L Curve Cobb Angle between 30º - 60º does not contribute significantly to curvature restoration, and that this may only be significant in patients with curvatures higher than 60º [(8)].

Liu et al had operated 40 patients with Lenke type 5C curve and they have later investigated the importance of UIV or LIV levels and other parameters in coronal balance in these patients. In conclusion, these authors recommend that when pre-operative UIV translation is over 25 mm UIV level should be one step upper, and when pre-operative LIV tilt angle is over 25° LIV level should be one step lower. During follow-up period, the most important parameter on coronal balance was also reported to be UIV tilt [(9)]. But we did not observe a significant difference between pre-operative LIV tilt angle and UIV tilt in our study.

Ando et al. have done a retrospective study in order to determine the parameters for prediction of distal adjacent disc disorder when LIV level is taken as L3 in 16 patients with Lenke 5C curvature. In this study, they have applied ASF in 5 patients, and PSF in others with L3 accepted as LIV level. After that, in follow-up of patients L3 vertebra tilt, L4 vertebra tilt and L3/4 Disc Angle more than 10 degrees were considered as DAD+. Seven patients were found to be DAD+. When DAD+ and DAD- patients were compared, a significant difference was found between LEV levels; which was L4 in most of DAD+ patients, and L3 in the other group, and that the difference was significant. There was no significant difference between these patients in terms of SRS-22 clinical results, coronal and sagittal balances. When the L3/4, L4/5 Disc angles of these patients were measured, those that were on pre-operative convex side were considered as negative, and those on pre-operative concave side were considered as positive. They report that patients with pre-operative negative L3/4 Disc angles had a higher risk of Coronal imbalance (**Figure 3**). In their study on coronal balance, they have reported that translation of standing pre-operative LIV and LIV+1 levels, and translation of L3/4 disc angle and LIV +1 levels at traction x-rays were found to be significant. [(10)]. When we evaluate our patients in terms of the direction of disc angles, 6 were found to have pre-operative negative disc angles. On the other hand, the fact that half of these patients had coronal imbalance and the other half had normal coronal balance, implicates absence of such a relationship.

In summary, pre-operative coronal balance, TAV translation and LEV levels were better in Group I patients, albeit insignificantly. Later, coronal balance and truncal shift at SRS-22 measurements and early post-operative x-rays were significantly better in Group 1 patients, and TAV translation, lumbar coronal balance, L3/4 disc angle and L4/5 disc angles were also better in Group 1 patients, but insignificantly. A significant difference in favor of Group 1 was observed at major TL/L curve and thoracic curve angles at last control. L4/5 disc angle measurements were significantly different at last control between measurements of 2 groups, while no differences were observed between patients with LIV level L3 and L4, in terms of being effective on L4/5 disc.

Limitations of our study include small sample size in comparison to other studies in the literature, and the fact that not all patients had completed their second year at their last control.

In conclusion, use of pre-operative LEV level in determination of LIV level in order to prevent more mobile segments while obtaining coronal and sagittal balance in patients will be beneficial.

Table-4. LIV Tilt Angle Change

	Preoperative	Early Postoperative	Last Control
Li et al.[2]	18 ± 5.6	5 ± 3.2	5 ± 3.1
Wang et al.[6]	25.9 ± 9.4	8.0 ± 5.9	8.5 ± 8.4
Present Study	19.4 ± 5.8	4.6 ± 2.2	4.6 ± 3

Table-5. LIV – LEV relationship in the medical literature

Study	LIV = LEV-1	LIV = LEV	LIV = LEV+1	Total Patients
Li et al.[2]	12	10	5	27
Sun et al.[8]	3	22	12	37
Our study	2	12	2	16

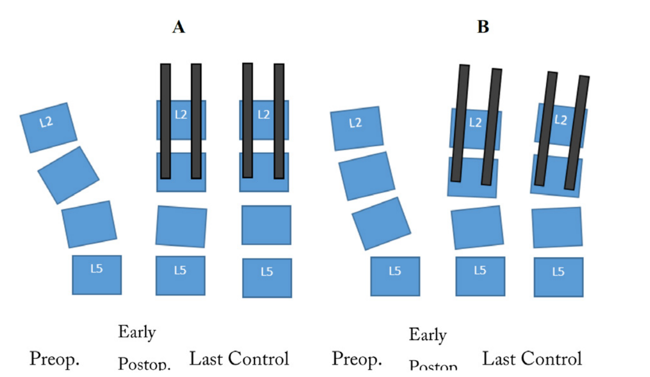

Figure-3. Schematic presentation of Positive Disc Angle **(A)** and negative Disc angle **(B)** in pre-operative, early post-operative and last follow up control x-rays.

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ORIGINAL ARTICLE

ANALYZING THE PREOPERATIVE AND POSTOPERATIVE SPINOPELVIC PARAMETERS IN LENKE TYPE 3 AND TYPE 6 ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS

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ABSTRACT

Objective: To analyze the pre and postoperative changes of sagittal spinopelvic parameters in Lenke type 3 and 6 AIS patients.

Methods: Thirty-two Lenke 3 and 6 AIS patients evaluated retrospectively. Thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt angles were measured on preoperative and last follow-up standing full-length lateral radiographs. Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

Results: There were 27 females and 5 males. Mean age was 14 years, mean follow-up was 37 months. Mean preoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 38.3°±13.9°, 51.9°±9.4°, 49°±8.5°, 34.5°±6.2°, and 14.4°±6.9°, respectively. Mean postoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 26.4°±6.6°, 46.1°±7°, 49.7°±8.5°, 34.1°±5.7°, and 15.5°±6.7°, respectively. Preoperative and last follow-up thoracic kyphosis and lumbar lordosis comparison showed that there is a significant difference, however there is no difference in comparison preoperative and last follow-up pelvic incidence, sacral slope and pelvic tilt.

Conclusion: Lenke type 3 and 6 AIS are double structural curves and fusing the thoracal and lumbar region may change the spinopelvic parameters thus compensatory mechanisms should not be corrupted during the surgery.

Key words: adolescent idiopathic scoliosis; Lenke type 3; Lenke type 6; sagittal balance, spinopelvic parameters

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a 3-dimensional deformity of the spine with an incidence of 1-3 % and an etiology that is not well yet understood. Treatment depends on age, curve type, curve size and other several factors. Several classification systems have been proposed to better understand different curve types in AIS. In 2001, Lenke[8] introduced a new classification for AIS with the aim to account for all types of curves and this classification system guides selection of fusion levels. The recommended fusion is to fuse the structural curves and leave unfused the nonstructural curves.

Recent studies have shown the importance of the sagittal spinal and pelvic alignments for the treatment of spinal pathologies[13]. Duval-Beaupe`re[3] described the relationship between the pelvis and lumbar lordosis. They introduced the pelvic incidence (PI) angle, which is an anatomical parameter characteristic of the pelvic shape of each individual, unaffected by the orientation of the pelvis. Many authors [1,5,7,12] showed that there are correlations between the adjacent pelvic and spinal sagittal parameters: PI and sacral slope (SS), PI and pelvic tilt (PT), PI and lumbar lordosis (LL), SS and LL and finally LL and thoracic kyphosis (TK). PI is the only parameter that is anatomically fixed and it determines all spine and pelvis balances. PI determines SS and PT. SS, which is also the distal part of the lordosis, determines LL. In turn, LL balances with TK. This upward successive influence provides the spino-pelvic balance of the upright position.

Lenke type 3 curves are double major curves with a major main thoracic and a structural thoracolumbar or lumbar curve. Type 6 curves are major thoracolumbar or lumbar and structural main thoracic curves. The importance of these two curves is the necessity of the fuse the two structural thoracic and thoracolumbar/lumbar curves [(9)], however this may cause decompensation of spinopelvic alignment due to restriction of mobile segments close to spinopelvic region.

Thus, we aimed to analyze the pre and postoperative changes of sagittal spinopelvic parameters in Lenke type 3 and 6 AIS patients.

MATERIAL - METHODS

A retrospective study of Lenke type 3 and 6 AIS patients treated at a single institution between 2008-2013 by a single surgeon was conducted. Inclusion criteria included: 1) a diagnosis of Lenke type 3 and 6 AIS, 2) patients treated with posterior pedicle screw only instrumentation, 3) no previous spine surgery 4) full sets of preoperative and last follow-up standing full-length AP and lateral radiographs. Patients who had previous spinal surgery, suffered from congenital deformities, hybrid constructs, anterior surgery and osteotomy were excluded. Those whose radiographs did not meet standards were also excluded in order to discard measurement error.

All surgical procedures were performed by the same attending senior spinal surgeon. Segmental pedicle screws with 6.0-mm titanium rod were used in all patients. All patients received standard posterior surgery. After facetectomies within the fusion levels, pedicle screws were placed. The lowest instrumented vertebrae (LIV) was chosen according to the stable vertebra theory, which is the first-touched vertebra by the central sacral vertical line and also lateral side-bending radiographs prior to surgery. Several surgical maneuvers were used in combination, including rod-rotation, apical vertebral derotation, convex compression, and concave distraction.

The Surgimap software (New York, New York, USA) was used to measure the sagittal spinal and pelvic parameters. Standing full-length lateral radiographs before surgery and at the last follow-up measured by the author who did not attend the surgeries. In the lateral standing radiographs, five sagittal parameters were measured: thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). The LL was measured as the Cobb angle between the upper endplate of the L1 and S1. The TK was measured as the Cobb angle between the upper endplate of the T5 and T12. The PI, PT, and SS were measured as the angle between the vertical line of the sacral plate and the line connecting the midpoint of the sacral plate to the mid-point of the bilateral femoral head center, the angle between the plumb line and the line connecting the midpoint of the sacral plate with the midpoint of the bilateral femoral head center, and the angle between the sacral plate and the horizontal line, respectively. Measurement values were analyzed with SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

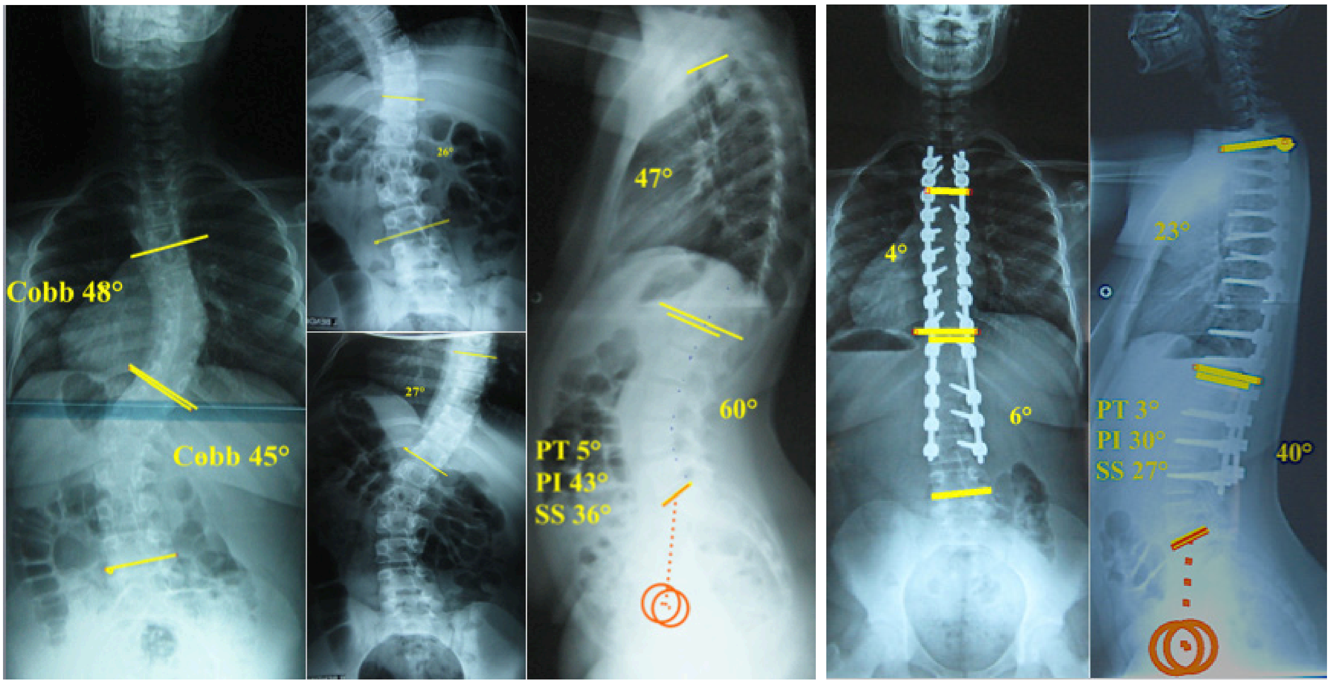

Figure-1. Preoperative and postoperative photos of a 16 year-old Lenke type 3 patient

RESULTS

A total of 218 AIS patients in the database were assessed and finally 32 patients (27 females, 5 males) with mean ages 14.7 ± 2.36 were included in the study who met all the criteria. Twenty-two patients were Lenke type 3 and 10 patients were Lenke type 6. The mean follow-up was 37.3 ± 7.2 months. Lower instrumented vertebra (LIV) was L3 in twenty- three patients and L4 in 9 patients. Mean preoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 38.3° ± 13.9°, 51.9° ± 9.4°, 49° ± 8.5°, 34.5° ± 6.2°, and 14.4° ± 6.9°, respectively. Mean postoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 26.4° ± 6.6°, 46.1° ± 7°, 49.7° ± 8.5°, 34.1° ± 5.7°, and 15.5° ± 6.7°, respectively.

Preoperative and last follow-up thoracic kyphosis and lumbar lordosis comparison showed that there is a significant difference ($p<0.05$), however there is no difference in comparison preoperative and last follow-up pelvic incidence, sacral slope and pelvic tilt. ($p=0.65$, $p=0.81$ and $p=0.38$).

DISCUSSION

After the introduction of the important effect of pelvic morphology in the regulation of an adequate sagittal balance by Duval-Beaupe`re et al [3], a great number of studies inverstigated the sagittal spinopelvic parameters in adults but little research has been devoted to examining this relationship on patients with AIS. Some authors have studied the spinal balance in adolescent idiopathic scoliosis (AIS) [2,10], but its relation to pelvic configuration is poorly defined in the literature.

In the literature, debate continues as to deviations on the pelvic parameters between patients with AIS who underwent posterior instrumentation surgery and those of the healthy population. Although some authors stated no difference between the two populations [6,14,16] , some authors [10-11] found the PI to be higher in patients with AIS compared to the normal population.

Farshad et al [4], investigate the spinopelvic parameters in different types of AIS curves, and found that the spinopelvic balance was not statistically distinguishable in different Lenke curve types. They found a slight difference of spinopelvic balance only in Lenke type 5 and 6 (major curve at the thoracolumbar/lumbar region) with a pelvis incidence of 44°, sacral slope of 34° and pelvic tilt of 10°, when compared with normal population values. In our study invastigating the Lenke tpye 3 and 6, those also have the structural lumbar curves, when compared with Farshad's study, we found a slight higher values in pelvic incidence, similar values in sacral slope and a slight higher values in pelvic tilt. However, when compared with normal population[11], pelvic incidence and sacral slope were similar but pelvic tilt was slightly higher.

There are explicit data in the literature regarding variances relevant to some spinopelvic parameters in patients with AIS following surgical management. For instance, La Maida et al. reported a statistically significant increase in pelvic tilt (PT) [6]. Similarly, Tanguay et al. obtained a significant relationship between lumbar lordosis (LL) and pelvic parameters below and within the fusion from the analysis of 60 patients with AIS following posterior spinal instrumentation and fusion surgery [14]. In contrast to the literature, in our data, PT following surgery showed no statistically significant difference, however, LL showed a statistically significant decrease.

Our study showed that pelvic parameters did not change significantly after the surgery. This indicates that the decrease in the thoracic kyphosis was compensated by the decrease in lumbar kyphosis and the spinopelvic compensatory mechanisms worked only in the spine and did not extend to the pelvic region. Furthermore, our results contradicts to the common opinion that AIS generally represents with thoracic hypokyphosis [8,15]. Mean thoracic kyphosis value for our patients was 38.3° and it changed to 26.4° postoperatively. While these pre-surgical values do not represent hypokyphosis, surgery seems to be further decreasing amount of kyphosis. This we believe may be a result of compensation to correction of lumbar lordosis or simple over correction by the surgeon.

Nevertheless, there are some limitations to our study as well. First, this is a retrospective study and it lacks randomization. The measurements were done by a computer-based software and there could be some measurement errors. Finally, we did not evaluate the costs and patient reported outcome parameters, for the reason that they are out of the scope of our aim.

CONCLUSION

Sagittal spinopelvic parameters are important in treating adolescent idiopathic scoliosis and must be taken into account before and after surgery. Lenke type 3 and 6 AIS are double structural curves and fusing the thoracic and lumbar region may change the spinopelvic parameters thus compensatory mechanisms should not be corrupted during the surgery.

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ORIGINAL ARTICLE

ANALYZING THE PREOPERATIVE AND POSTOPERATIVE SPINOPELVIC PARAMETERS IN LENKE TYPE 1 ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS

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ABSTRACT

Objective: To analyze the pre and postoperative changes of sagittal spinopelvic parameters in Lenke type 1AIS patients.

Methods: Thirty Lenke 1 AIS patients evaluated retrospectively. Thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt angles were measured on preoperative and last follow-up standing full-length lateral radiographs. Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

Results: There were 28 females and 2 males. Mean age was 13.4 years, mean follow-up was 38 months. Mean preoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 35.3°±11.9°, 50.8°±7.4°, 48.3°±8.5°, 33.4°±5.6°, and 15.5°±4.5°, respectively. Mean postoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 28.6°±4.6°, 46.3°±7.1°, °7.7±°34.3 ,°7.5±°49.5, and 7°.7±°15.2, respectively. Comparison of the preoperative and last follow-up thoracic kyphosis and lumbar lordosis showed that there is a significant difference statistically. However, there is no statistical difference between preoperative and last follow-up pelvic incidence, sacral slope and pelvic tilt.

Conclusion: Lenke type 1 AIS thoracic structural curve and fusing the thoracic and lumbar region may change the spinopelvic parameters thus compensatory mechanisms should not be corrupted during the surgery.

Key words: Adolescent idiopathic scoliosis; Lenke type 1, sagittal balance, spinopelvic parameters

Level of evidence: Retrospective clinical study, Level III

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a three planar deformity of the spine but etiology is not understood well. Treatment depends on several factors like age, curve type, curve size. Several classification systems have been identified to better understand different curve types in AIS. In 2001, Lenke [8] introduced a new classification for AIS with the aim to account for all types of curves and this classification system guides selection of fusion levels. The recommended treatment is fuse the structural curves when non-structural curvature leave unfused.

Many studies have shown the importance of the spinopelvic alignment for the treatment of spinal pathologies [14]. Duval-Beaupere[3] described the relationship between the pelvis and lumbar lordosis. They introduced the pelvic incidence (PI) angle that does not affected by the change of orientation of pelvis. Many authors [1,5,7,12,13] showed that there are correlations between the adjacent spinopelvic sagittal parameters: PI and sacral slope (SS), PI and pelvic tilt (PT), PI and lumbar lordosis (LL), SS and LL and finally LL and thoracic kyphosis (TK). PI is the only parameter that is anatomically fixed. PI determines SS and PT. SS, which is also the distal part of the lordosis, determines LL. In turn, LL balances with TK. This upward successive influence provides the spino-pelvic balance of the upright position.

Lenke type 1 curves are major thoracic curves with a major main thoracic and a nonstructural thoracolumbar or lumbar curve. The importance of these curve is the if fuse the too distal level unnecessarily [9], this may cause decompensation of spinopelvic alignment due to restriction of mobile segments close to spinopelvic region.

Thus, we aimed to analyze the pre and postoperative changes of sagittal spinopelvic parameters in Lenke type 1 AIS patients.

MATERIALS - METHODS

A retrospective study of Lenke type 1 AIS patients treated at a single institution the period of 2008-2013 by a single surgeon was conducted. Inclusion criteria included: 1) a diagnosis of Lenke type 1 AIS, 2) patients treated with posterior pedicle screw only instrumentation, 3) no previous spine surgery 4) full sets of preoperative and last follow-up standing full-length AP and lateral radiographs. Patients who had previous spinal surgery, suffered from congenital deformities, hybrid constructs, anterior surgery and osteotomy were excluded. Those whose radiographs did not meet standards were also excluded in order to discard measurement error.

The same attending senior spinal surgeon performed all surgical procedure. Segmental pedicle screws with 6.0-mm titanium rod were used in all patients. All patients received standard posterior surgery. After facetectomies within the fusion levels, pedicle screws were placed. The lowest instrumented vertebrae (LIV) was chosen according to the stable vertebra theory, which is the first-touched vertebra by the central sacral vertical line and lateral side-bending radiographs prior to surgery. Several surgical maneuvers were used in combination, including rod-rotation, apical vertebral derotation, convex compression, and concave distraction.

The Surgimap software (New York, New York, USA) was used to measure the sagittal spinal and pelvic parameters. Standing full-length lateral radiographs before surgery and at the last follow-up measured by the author who did not attend the surgeries. In the lateral standing radiographs, five sagittal parameters were measured: thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). The LL was measured as the Cobb angle between the upper endplate of the L1 and S1. The TK was measured as the Cobb angle between the upper endplate of the T5 and T12. The PI, PT, and SS were measured as the angle between the vertical line of the sacral plate and the line connecting the midpoint of the sacral plate to the mid-point of the bilateral femoral head center, the angle between the plumb line and the line connecting the midpoint of the sacral plate with the midpoint of the bilateral femoral head center, and the angle between the sacral plate and the horizontal line, respectively.

Measurement values were analyzed with SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov test was utilized to assess distribution of study parameters. Preoperative and postoperative results were compared with Wilcoxen Sum Rank test. $p<0.05$ considered as statistically significant.

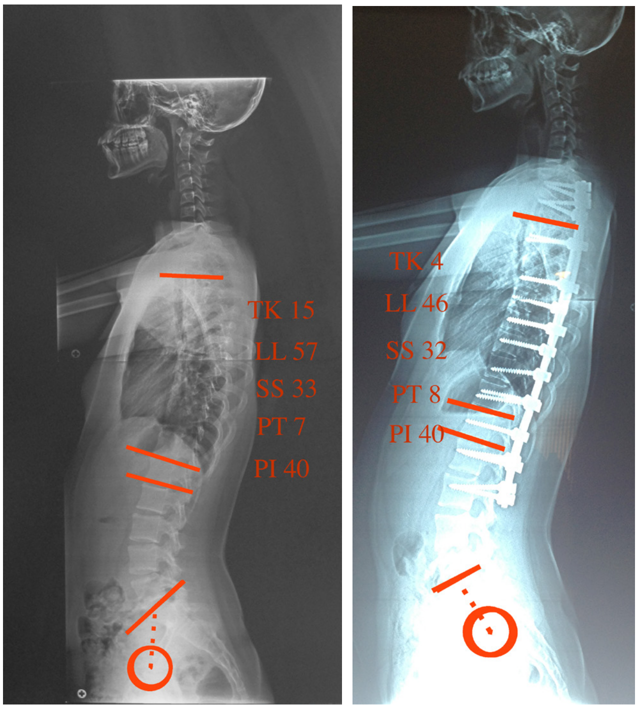

Figure-1. Preoperative and postoperative photos of a 15 year-old Lenke type 1 patient

RESULTS

Two-hundred-eighteen AIS patients in the database were assessed and finally 30 patients (28 females, 2 males) with mean ages 13.4 ± 2.21 were included in the study who met all the criteria. The mean follow-up was 38 ± 8.4 months. Lower instrumented vertebra (LIV) was L2 in 18 patients, L3 in 11 patients and L4 in one patient. Mean preoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 35.3° ± 11.9°, 50.8° ± 7.4°, 48.3° ± 8.5°, 33.4° ± 5.6°, and 15.5° ± 4.5, respectively. Mean postoperative thoracic kyphosis, lumbar lordosis, pelvic incidence, sacral slope and pelvic tilt were 28.6° ± 4.6°, 46.3° ± 7.1°, 49.5° ± 7.5°, 34.3° ± 7.7°, and 15.2° ± 7.7°, respectively.

Preoperative and last follow-up thoracic kyphosis and lumbar lordosis comparison showed that there is a significant difference ($p<0.05$), however there is no difference in comparison preoperative and last follow-up pelvic incidence, sacral slope and pelvic tilt. (p=0.81, p=0.28 and p=0.92).

DISCUSSION

After the explanation the relation between pelvic morphology spinal alignment by Duval-Beaupe`re et al [3], many studies investigated the sagittal spinopelvic parameters in adults but little research has been devoted to examining this relationship on patients with AIS. Very little studies focused on the spinal balance in adolescent idiopathic scoliosis (AIS) [2, 10], but its relation to pelvic configuration is not defined detailed in the literature.

In the literature, the findings of relation between spinopelvic parameters and pelvic orientation shows variability. Although some authors stated no difference between the two populations [6,13-14,17], some authors [10-11] found the PI to be higher in patients with AIS compared to the normal population.

Spinopelvic parameters investigated by Farshad et al [6] in different types of AIS curves, and found that the spinopelvic balance was not statistically distinguishable in different Lenke curve types. They found a slight difference of spinopelvic balance only in Lenke type 5 and 6 (major curve at the thoracolumbar/lumbar region) with a pelvis incidence of 44°, sacral slope of 34° and pelvic tilt of 10°, when compared with normal population values. In our study investigating the Lenke tpye 1, those also have the non-structural lumbar curves, when compared with other studies, we found a slight higher values in pelvic incidence, similar values in sacral slope and a slight higher values in pelvic tilt. However, when compared with normal population [11], pelvic incidence and sacral slope were similar but pelvic tilt was slightly higher.

In the literature regarding variances relevant to some spinopelvic parameters in patients with AIS following surgical management. La Maida et al. reported a statistically significant increase in pelvic tilt (PT) [6], similarly Tanguay et al. acquired significant relationship between lumbar lordosis (LL) and pelvic parameters below and within the fusion from the analysis of 60 patients with AIS following posterior spinal instrumentation and fusion surgery [15]. Different to the literature, in our data, PT following surgery showed no statistically significant difference, however, LL showed a statistically significant decrease.

Our study showed that pelvic parameters did not change significantly after the surgery. This indicates that the decrease in the thoracic kyphosis was compensated by the decrease in lumbar kyphosis and the spinopelvic compensatory mechanisms worked only in the spine and did not extend to the pelvic region. Additionally, in our study ,unlike the other studies about AIS, [8,16] mean thoracic kyphosis value for our patients was 35.3° and it changed to 28.6° postoperatively. While these pre-surgical values do not represent hypokyphosis, surgery seems to be further decreasing amount of kyphosis. This we believe may be a result of compensation to correction of lumbar lordosis or simple over correction by the surgeon.

Nevertheless, there are some limitations to our study as well. First, this is a retrospective study and it lacks randomization. The measurements were done by a computer-based software and there could be some measurement errors.

CONCLUSION

Sagittal spinopelvic parameters are important in treating adolescent idiopathic scoliosis and must be taken into account before and after surgery. Lenke type 1 AIS are major thoracic structural curve and fusing the thoracal and lumbar region may change the spinopelvic parameters thus compensatory mechanisms should not be corrupted during the surgery.

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Volume: 28, Issue: 4, October 2017 pp: 237-240 ORIGINAL ARTICLE

TRAUMATIC THORACIC AND LUMBAR SPINE FRACTURES

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ABSTRACT

Aim: To analyses the operated cases of traumatic thoracal and lumbar vertebral fracture cases.

Material and Method: Ninety-three patients who admitted to Adana Numune Training and Research Hospital Department of Neurosurgery between 2015-2017 years for traumatic thoracal and lumbar fractures inspected retrospectively. Data's were inspected from the patient's files and radiology PACS system. Decompression surgeries for these fractures were posterior instrumentation-fusion and laminectomy. Patients were evaluated with age, gender, type of trauma, level of trauma and neurological condition..

Results: A total of 93 patients were included in this study. The mean age of the participants was 43.1 ± 18.6 years, and 62.4 % of the population were males. Most frequent cause of admission was falling from height (60.2 %), which was followed by motor vehicle occupant trauma (20.4 %) and non-occupant motor vehicle trauma (12.9 %). Most frequently fractured vertebrae were L1 (40.9 %), T12 (21.5 %), and L2 (19.4 %). Types of the fractures were distributed as compression fracture (49.5 %), burst fracture (48.4 %), and dislocated fractures (2.2%). The comparisons of the general characteristics between males and females revealed that non-occupant and occupant motor vehicle traumas were significantly higher in men, and falling from height and osteoporosis were significantly higher in women ($p=0.008$). However, the age distribution ($p=0.544$) and the types of fractures ($p=0.480$) were similar in both sexes. The effect of surgery on findings in neurological examination was significant. When the outcomes in post-operative period were compared with the pre-operative findings, the patients were found to have significantly improved neurological outcomes ($p<0.001$).

Conclusion: Thoracic and lumbar fractures are frequently seen healthcare problems. Surgery or conservative treatment could be chosen according to fracture type. Surgery must be done urgently if neurological deficit is present. Our clinical results that similar to literature show us that early decompression-fusion surgery could give positive feedback to recovery of neurological deficits.

Key words: Thoracal vertebral fractures, thoracal trauma, spinal traumas

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Spinal fractures are usually the result of high-energy injuries and the incidence of these injuries increases by development of technology. Traffic accidents are seen 40 % to 45 % and voluntary or involuntary falls are 15 % to 30 % that includes suicides. Other injuries accounts for 15 % to 25 % as sport, work and leisure accidents [5]. Studies showed that, 230 of one million person have spinal fractures each year [7]. Spinal fractures can also see attending by 30 % cranial trauma, 16 % to 18 % thoracic trauma and 10 % abdominal trauma [8]. The most common spinal fractures are seen at thoracolumbar region because it is the transition zone between the relatively rigid thoracic and more flexible lumbar spine [4]. Neurologic deficit rate is 15 % to 30 % in this region [1].

MATERIAL AND METHOD

Ninety-three patients who admitted to Adana Numune Training and Research Hospital Department of Neurosurgery between 2015-2017 years for traumatic thoracal and lumbar fractures inspected retrospectively. Data's were inspected from the patients files and radiology PACS system. Decompression surgeries for these fractures were posterior instrumentation-fusion and laminectomy (Figure-1,2,3,4). Patients were evaluated with age, gender, type of trauma, level of trauma and neurological condition.

Figure-1. Preoperative thoracal fracture sagittal CT image

Figure-2. Preoperative thoracal fracture axial CT image

Figure-3. Postoperative thoracal fracture sagittal CT image

Figure-4. Postoperative thoracal fracture axial CT image

STATISTICAL ANALYSES

Numerical variables were presented as mean and standard deviation, and categorical variables were presented as frequency and percent. The comparisons between independent groups were conducted by Mann-Whitney U test for numerical variables, and

Chi-square test for categorical variables. Changes in neurological examinations over time were tested by Friedman non-parametric analysis of variances. A Type-I error level of 5 % was considered as statistical significance in all analyses. The SPSS 21 software (IBM Inc., Armonk, NY, USA) was used for the statistical analyses in this study.

RESULTS

A total of 93 patients were included in this study. The mean age of the participants was 43.1 ± 18.6 years, and 62.4 % of the population were males. Most frequent cause of admission was falling from height (60.2 %), which was followed by motor vehicle occupant trauma (20.4 %) and non-occupant motor vehicle trauma (12.9%). Most frequently fractured vertebrae were L1 (40.9 %), T12 (21.5 %), and L2 (19.4 %). Types of the fractures were distributed as compression fracture (49.5 %), burst fracture (48.4 %), and dislocated fractures (2.2 %). General characteristics of the patients were presented in Table-1.

The comparisons of the general characteristics between males and females revealed that non-occupant and occupant motor vehicle traumas were significantly higher in men, and falling from height and osteoporosis were significantly higher in women ($p=0.008$). However, the age distribution ($p=0.544$) and the types of fractures ($p=0.480$) were similar in both sexes (Table-2).

The effect of surgery on findings in neurological examination was significant. When the outcomes in post-operative period were compared with the pre-operative findings, the patients were found to have significantly improved neurological outcomes ($p<0.001$).

Table-1. General characteristics of patients

	Mean	Standard Deviation
Age (years)	43.1	18.6
	n	**%**
Gender		
Male	58	62.4
Female	35	37.6
Cause of admission		
Non-occupant motor vehicle trauma	12	12.9
Motor vehicle occupant trauma	19	20.4
Falling down from height	56	60.2
Contusion	4	4.3
Osteoporosis	2	2.2
Level of injury		
T2	1	1.1
T3	3	3.2
T4	4	4.3
T5	2	2.2
T6	3	3.2
T7	3	3.2
T8	4	4.3
T9	5	5.4
T10	5	5.4
T11	5	5.4
T12	20	21.5
L1	38	40.9
L2	18	19.4
L3	7	7.5
L4	7	7.5
L5	1	1.1
Type of fracture		
Compression fracture	46	49.5
Burst fracture	45	48.4
Fracture and dislocation	2	2.2

Table-2. General characteristics of patients according to gender

	Male		Female		p
	Mean	**SD**	**Mean**	**SD**	
Age (years)	42	18.3	44.8	19.2	0.544
	n	**%**	**n**	**%**	
Cause of admission					0.008
Non-occupant motor vehicle trauma	10	17.2	2	5.7	
Motor vehicle occupant trauma	15	25.9	4	11.4	
Falling down from height	29	50	27	77.1	
Contusion	4	6.9	-	-	
Osteoporosis	-	-	2	5.7	
Type of fracture					0.480
Burst fracture	26	44.8	19	54.3	
Compression fracture	30	51.7	16	45.7	
Fracture and dislocation	2	3.4	-	-	

DISCUSSION

Thoracolumbar fractures are more frequent in man (2/3) than in woman (1/3) and peak between the ages of 20 and 40 years [4]. Traumatic fractures occur at the thoracolumbar junction between 15 % and 30 % of, whereas 9 – 16 % occur in the thoracic spine [4]. Spinal cord injury occurs in 10 – 30 % of traumatic spinal fractures [6].

There is no consensus about timing and type of surgery about thoracal and lumbar fractures but stability of the vertebral column must be the focus of treatment [11]. There are many treatment options varying from conservative treatment to surgery for thoracolumbar fractures [2]. Early decompression (<12hour) resulted in better outcomes compared to both delayed decompression (>24hour) and conservative management in the literature [9]. The result of our study is supporting early decompression with better results.

Surgical options for thoracal and lumbar vertebral fractures are stabilization-fusion, vertebroplasty - kyphoplasty, laminectomy, discectomy and minimal invasive techniques like endoscopic and thoracoscopic approaches [10]. Thoracic and lumbar vertebral anatomy must be evaluated well before the surgery. Fusion is defined as a surgical technique used to join two or more vertebrae. The goal of internal fixation for fusion is to reconstruct the compromised columns within a spinal motion segment with non-biologic materials, affording temporary immobilization and stabilization until bony fusion can develop [11]. Bone graft is used in conjunction with the body's natural bone growth processes to fuse the vertebrae. Fusion with instrumentation utilizes stainless steel, titanium or non-metallic devices to stabilize the spine. Fixation is successful when a construct can withstand the wear and tear of stresses and strains until fusion occurs [10].

Thoracic and lumbar fractures are frequently seen healthcare problems. Surgery or conservative treatment could be chosen according to fracture type. Surgery must be done urgently if neurological deficit is present. Our clinical results that similar to literature show us that early decompression-fusion surgery could give positive feedback to recovery of neurological deficits.

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ORIGINAL ARTICLE

turkishspine

UNILATERAL APPROACH FOR HEMIVERTEBRECTOMY IN TREATMENT OF LUNG CANCER WITH VERTEBRA INVASION

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ABSTRACT

Purpose: The aim of the study is to show the results of hemivertebrectomy with only unilateral approach in treatment of lung cancer with vertebra invasion

Material and Method: Ten patients with an average age of 59 (49-65) years with lung cancer with thoracal vertebra invasion were operated between 2008 and 2015. Biopsy was performed in all patients for diagnosis. The diagnosis of the patients was, non-small cell carcinoma in seven patients, squamous cell carcinoma in two patients and adenocarcinoma in one patient. Chemotherapy and 60 GyRT radiotherapy were given before surgery. Unilateral thoracal spine exposure was used for vertebra resection after limited laminectomy and root sacrification.

Results: In patients who undergone vertebral resection, the resected segments were between T2 and T5. Mean resected vertebrae count was 3 (2-4) and mean corpus resection extent was 40.5% (30-69). Mean follow-up duration of the patient was 24 months (8-84) .1 year survival rates of the patients included were 70%, while 5-year survival rates were 10 %.

Conclusion: In treatment of lung cancer with spine invasion, it is possible to achieve clear surgical margins. Due to lack of the enough strength to prevent deformity from unharmed anatomic structure, strong instrumentations are necessary.

Keywords: Lung Cancer; Hemivertebrectomy; Enbloc resection

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

In tumor surgery, achieving a wide resection with clear margins is the main goal. In NSCLC treatment, an intra-lesion or incomplete tumor resection is associated with a poor prognosis [4]. While spine involvement in NSCLC patients with was considered a poor prognostic factor and a contraindication to surgery, surgical treatment is now possible with combined surgical procedures involving vertebral resections[3,5-6,8-9,11-12]. A review by Collaud et al. reported 3, 5, 10 year survival rates of 57 %, 43 %, and 27 %, when vertebral resection was included in the procedure [1]. The osteotomy can be partial, semi or total, depending on the extent of the invasion in the vertebrae[3,6,12]. Although bilateral instrumentation is often advised for stabilization after vertebrectomy, there are also studies against it [3,9-10]. In this study, we aim to present our cases of NSCLC with vertebral invasion, who were treated with partial vertebrectomy without rigid fixation using a unilateral posterior spine approach.

PATIENTS AND METHOD

We reviewed 10 patients undergoing concomitant lung and vertebral resection for NSLC tumor between 2008 and 2015. Patients with no distant metastasis, pathological mediastinal lymph node involvement and spine involvement were not included. Pre-op evaluations of the patients consisted of routine Thorax X-rays, Thin-slice CT and thorax and spinal MRI with IV contrast in order to determine the extent of the spine invasion (Figure-1).

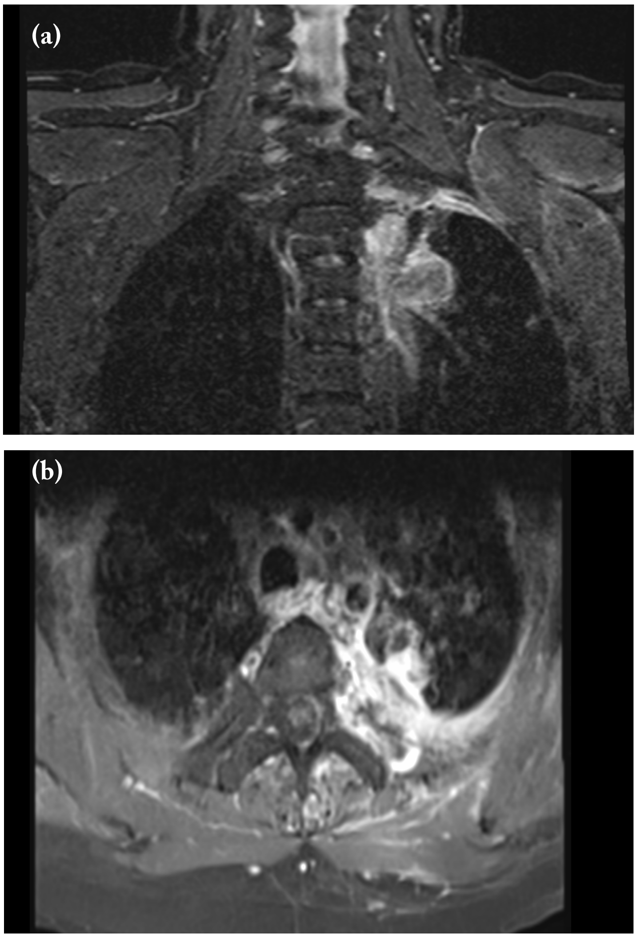

Figure-1. The MRG evaluataion of the patient with lung cancer invading spine. Coronal **(a)** and axial **(b)** T2 weighted MRG showed vertebral invasion of the upper thoracic mass.

PET-CT scans were performed to assess the distant metastases. Patient with medullary invasion or more than 20 % invasion in the vertebral corpus in their MRI scans and patients who have had more than 4 vertebral resections were excluded.

All patients who were included received chemotherapy and radiotherapy prior to surgery. Surgical planning was done after 60 Gy of radiotherapy. All patients were operated in a standard manner by the same spinal and thoracic surgery teams. Prior to the operation patients had lymph node biopsy under mediastinoscopy done and surgery was performed if the invasion status was negative. As the first step in the operation spinal surgeons performed a longitudinal incision 2 cm lateral to the midline from C7-T6 with the patient in the prone position and the paravertebral muscles were separated from the posterior bony structures subperiostally with cautery. After fluoroscopic check, laminectomy was performed just lateral to the spinous processes with a high-speed Burr. Laminectomy area was expanded using a Kerrison Rounger to reach the roots. The roots were cut after ligation with 3/0 suture.

After the roots were cut medulla spinals were retracted medially and oblique osteotomies in the axial plane were performed. Osteotomy was advanced to just before the anterior cortex without a complete osteotomy trying to mimic a green-stick fracture. After the osteotomy the newly achieved movement in the osteotomy line was tested with 2 wide osteotomies and the posterior approach was concluded after bleeding control.

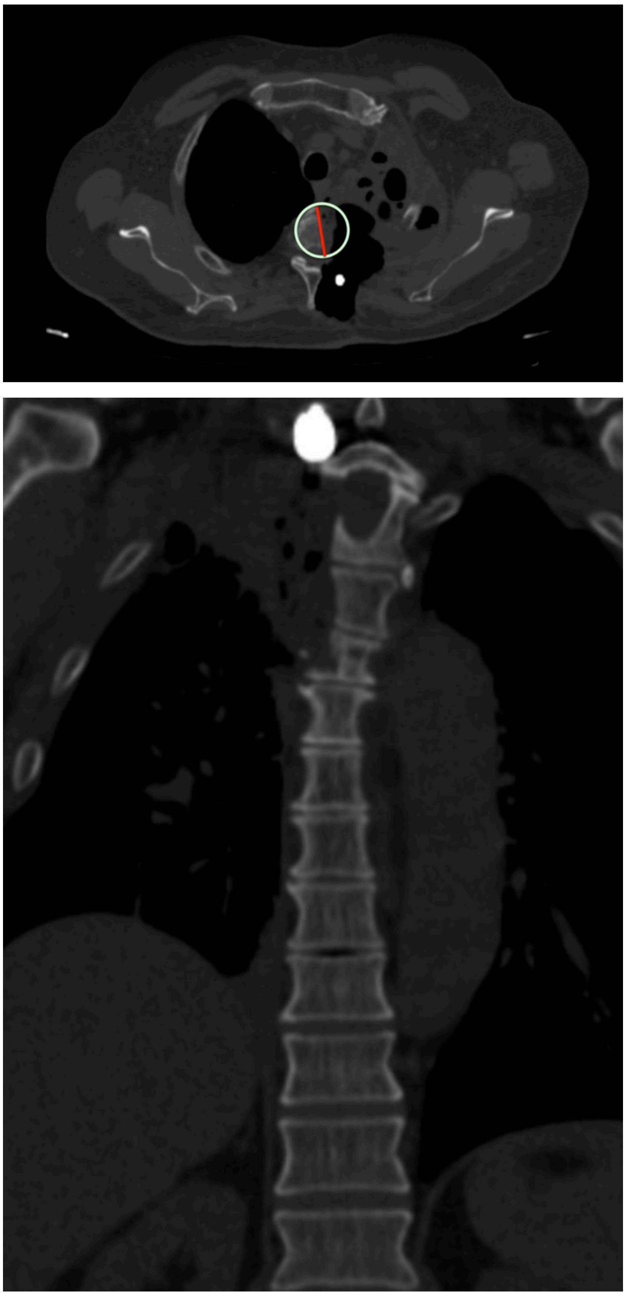

Figure-2. Postoperative CT showed amount of resection. Green circle show vertebra enlargement and red arrow show the oblique osteotomy line.

During the posterior approach the contralateral paravertebral muscles and the spinous process were left intact including the associated subcutaneous tissues to protect the stability. In the second stage of the surgery the thoracic surgery team performed thoracotomy on the patients in lateral decubitus position continuing the existing posterior incision and performed lung superior pole resection including the costae.

RESULTS

Average age of the patients included in the study was 59 (49-65) and all patients were male. The diagnosis of the patients was non-small cell carcinoma in seven patients, squamous cell carcinoma in two patients and adenocarcinoma in one patient.

In patients who undergone vertebral resection, the resected segments were between T2 and T5. Mean resected vertebrae count was 3 (2-4) and mean corpus resection extent was 40.5 % (30-69) (Figure-2).
In all patients' lamina and facet, joints of the contralateral side were preserved including spinous processes.

Mean follow-up duration of the patient was 24 months (8 - 84) 1 year survival rates of the patients included were 70 %, while 5-year survival rates were 10 %. Histopathological investigation showed clear surgical margins and none of the patients had local recurrence however two of 10 patients had distant metastasis (Table-1).

One-year survival rates of the patients included were 70 %, while 5-year survival rates were 10 %.

During the follow-up revision, surgery due to instability was not needed for any patient. 2 patients developed compression fractures due to osteoporosis during follow-up. The patient with a 70% compression fracture in the anterior column of T5 developed kyphosis in the upper thoracal vertebra (Figure-3).

Other patient had compression fracture of T4 involving 50% of anterior column however it did not cause any instability. In the follow-up of patients who had undergone unilateral approach, thoracic curves with an average Cobb angle of 11^0 (6^0-16^0).

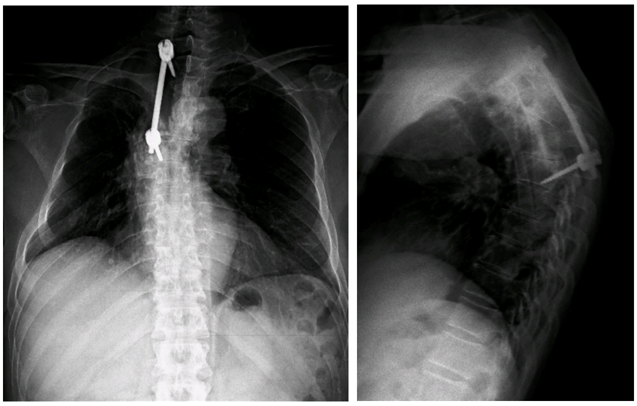

Figure-3. N.B., 61 years old man with lung cancer. The postoperative CT showed T5 compression fracture that have more resected and osteoporotic vertebra corpus. There is no neurological problem or pain related the kyphosis.

Table-1. The distribution of the patients.

Patients	Gender	Diagnosis	Age	Radiotherapy	Resection Level	Resection Segment	Resection Ratio	Complication	Follow-up	Scoliotic curve
AA	Male	N-SCC	65	60 GyRT	T2-T5	4	40,00 %	None	10	10
EE	Male	N-SCC	49	60 GyRT	T3-T6	4	36,00 %	Drainage	84	13
MH	Male	N-SCC	61	60 GyRT	T2-T3	2	50,00 %	None	14	8
VP	Male	SCC	61	60 GyRT	T2-T3	2	33,00 %	None	18	12
NB	Male	N-SCC	61	60 GyRT	T3-T5	3	42,00 %	Drainage/T5 fx (anterior 70 %)	16	6
CŞ	Male	N-SCC	58	60 GyRT	T2-T4	3	30,00 %	None	12	16
ÖH	Male	SCC	68	60 GyRT	T2-T4	3	32,00 %	None	8	10
EG	Male	N-SCC	57	60 GyRT	T2-T4	3	49,00 %	None	57	11
MB	Male	N-SCC	60	60 GyRT	T2-T4	3	36,00 %	None/T4 fx (anterior 50 %)	14	15
İÖ	Male	Adenoca	53	60 GyRT	T2-T4	3	34,00 %	Drainage	13	7

DISCUSSION

While vertebral invasion was considered a poor prognostic factor in NSCLC patients, with combined surgical treatments 3 year survival rates were reported around 57 % [1-6,8-9,11-12]. According to Grunnenwald et al, with new advances in chemotherapy, distant metastasis can now be taken under control and surgical treatment can lead to better results than radiotherapy [7]. The main parameter determining the success of the surgery is achieving a tumor-free margin. In a study, Collaud et al have reported 5-year survival rates of 80 % in cases treated with wide resection, whereas 35 % in cases treated without wide resection [1].

Surgical resections are routinely performed as 3 (57 %) or 4 (23 %) levels in the upper thoracic region. Vertebral resections are 70 % of the time just posterior approach and hemivertebrectomy following laminectomy, while they can also be partial without a laminectomy [2]. In our study, the average number of vertebral segments upon which hemivertebrectomy was performed was found to be 3.2. While the immediate mortality rate of these operations are reported between 17 and 40 %, in our study the mortality rate was found to be 0 %. In our study, three of 10 patients had prolonged wound drainage and collections and therefore required prolonged hospital stay. This was similar to the case series with 2-phase surgeries.

After en bloc surgical resection, all patients were found to have tumor free margins under histopathological evaluation.

While different surgical treatments are reported, surgical approaches are also different. Yokomise et al have reported achieving wide resection using a single incision (posterolateral thoracotomy) and position [12]. They did not suggest an adjunct procedure involving the spine; however, Mazel and Grunenwald suggested 2-phased surgical approach. During the posterior approach they suggest bilateral mobilization of the paravertebral muscles and posterior instrumentation [6,9]. Fadel et al similarly recommend performing vertebral stabilization after partial vertebral resection [3]. In the literature, it has been reported in series by Grunenwald and Fadel that following spinal instrumentation mechanical failure can develop [2-3,6-7,9-10]. Yokomise et al on the other hand did not report spinal instability development even though spinal instrumentation was not performed [12].

In our study, partial vertebrectomies were performed using a unilateral paravertebral approach. Because the contralateral paravertebral region and spinous processes are unharmed, posterior ligamentous complex and some anterior longitudinal ligament are preserved. İnitially we believe that because these structures are intact, osteotomy is stable in itself. However, the results of our patients showed that, this type of surgery also unharmed posterior structure have not enough stability to prevent kyphosis due to compression fracture at the weakest vertebrae and deformity. Hence the posterior structure not have enough strength to prevent further deformity, the strong posterior instrumentation are needed after this kind of surgery

Hemivertebrectomy in cases of lung cancers with vertebral invasions using a posterior unilateral approach achieves a clear surgical margin. Due to lack of the enough strength to prevent deformity from unharmed anatomic structure, strong instrumentations are necessary.

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ORIGINAL ARTICLE

SPINAL TUMORS

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ABSTRACT

Aim: Our aim is to evaluate patients whom operated for spinal tumor according to symptoms, pathology, level of tumor, grade of tumor and demographic data's.

Material and Method: We inspected patients whom operated for spinal tumor for the last five years retrospectively. Data collected from the patient files and radiology PACS system. Spinal tumors inspected according to symptoms, pathology, level of tumor, grade of tumor and demographic data of patients.

Results: A total of 37 patients were included in this study. The mean age of the participants was 50.8 ± 15.7 years, and 54.1 % of the population were males. Most frequent complaints were weakness in legs (24.3 %), low back pain (35.1 %), arm/leg pain (35.1 %), and gait disturbance (16.2 %). Accordingly, most frequent pathological diagnoses were meningioma (29.7 %), schwannoma (27 %), and ependymomas (10.8 %); most frequent disease grade was 1 (76.7 %), and most frequent sites of localization were L2 and L3 (21.6 % each). Accordingly, only age was significantly higher in men than women (p=0,029), and remaining characteristics of patients were similar between genders (p>0.05 for all).

Conclusion: Total resection of spinal tumors improve recovery of neurological deficits, reduce symptoms and give a chance for oncological treatment modalities.

Key words: Spinal tumors, spinal mass, spinal malignancies

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Spinal tumors are classified as extradural, intramedullary and intradural-extramedullary. Primary spinal tumors make up less than 5 % of spinal column tumors, but these lesions offer spinal oncologists the opportunity to induce a surgical cure [2]. Surgical treatment is palliative in patients with metastatic disease. Skeletal metastases are a frequent issue because 10 % of patients with cancer will develop symptomatic spinal metastases; of these, 50 % will require treatment due to pain or neurological deficit [1,5,9]. The most common solid primary tumors to metastasize to the spine are those in the breast, lung, prostate, and colon [4].

Preserving neurological function must be the goal of spinal tumor surgery and surgical decompression of neurological elements and stabilization of the spinal column are the key points of surgery. Timing of surgery is also important because spinal cord or nerve compressions could result with deficit so that early and complete spinal cord decompression and spinal column stabilization must be done to preserve or restore ambulation and continence, reduce pain and maximize quality of life [4,6,8,10].

In our study we try to analyse the spinal tumors operated in our clinic for 5 years.

MATERIAL AND METHOD

We inspected patients whom operated for spinal tumor for the last five years retrospectively. Data collected from the patient files and radiology PACS system (Figure-1,2,3,4).

Spinal tumors inspected according to symptoms, pathology, level of tumor, grade of tumor and dermographic data of patients.

Figure-1. Preoperative lumbar spinal tumor sagittal MRI image

Figure-2. Preoperative lumbar spinal tumor axial MRI image

Figure-3. Postoperative lumbar spinal tumor sagittal MRI image

Figure-4. Postoperative lumbar spinal tumor sagittal MRI image

STATISTICAL ANALYSES

Numerical variables were presented as mean and standard deviation, and categorical variables were presented as frequency and percent. The comparisons between independent groups were conducted by Mann-Whitney U test for numerical variables, and Chi-square test for categorical variables. A Type-I error level of 5% was considered as statistical significance in all analyses. The SPSS 21 software (IBM Inc., Armonk, NY, USA) was used for the statistical analyses in this study.

RESULTS

A total of 37 patients were included in this study. The mean age of the participants was 50.8 ± 15.7 years, and 54.1 % of the population were males. Most frequent complaints were weakness in legs (24.3 %), low back pain (35.1 %), arm/leg pain (35.1 %), and gait disturbance (16.2 %). The general characteristics of patients are presented in Table-1.

Clinical characteristics of patients are presented in Table-2. Accordingly, most frequent pathological diagnoses were meningioma (29.7 %), schwannoma (27 %), and ependymoma (10.8 %); most frequent disease grade was 1 (76.7 %), and most frequent sites of localization were L2 and L3 (21.6 % each).

The comparisons of general and clinical characteristics of patients are presented in Table-3 and Table-4, respectively. Accordingly, only age was significantly higher in men than women (p=0,029), and remaining characteristics of patients were similar between genders (p>0.05 for all).

Table-1. General characteristics of patient

	Mean	Standard Deviation
Age (year)	50.8	15.7
	n	%
Cinsiyet		
Erkek	20	54.1
Kadın	17	45.9
Complaint		
Weakness in legs	9	24.3
Low back pain	13	35.1
Gait disturbance	6	16.2
Arm/Leg pain	13	35.1

Table-2. Clinical characteristics of patients

	n	%
Pathology		
Adenocarcinoma metastasis	2	5.4
Dermoid tumor	1	2.7
Ependymoma	4	10.8
Epidermoid tumor	2	5.4
Hemangioperisitoma	1	2.7
Carcinoma metastasis	1	2.7
Lymphoma	2	5.4
Melanocytoma	1	2.7
Meningioma	11	29.7
Myxopapillary ependymoma	1	2.7
Paraganglioma	1	2.7
Schwannoma	10	27
Grade		
0	2	6.7
1	23	76.7
2	4	13.3
3	1	3.3
Localization		
C1	1	2.7
C2	4	10.8
C3	3	8.1
C4	1	2.7
C5	1	2.7
T1	1	2.7
T2	3	8.1
T4	2	5.4
T5	4	10.8
T6	3	8.1
T7	2	5.4
T8	3	8.1
T9	3	8.1
T10	1	2.7
T11	3	8.1
T12	5	13.5
L1	5	13.5
L2	8	21.6
L3	8	21.6
L4	1	2.7
L5	1	2.7
S1	1	2.7

Table-3. General characteristics of patients according to gender

	Male		Female		p
	Mean	SD	Mean	SD	
Age (year)	46.5	13.3	55.8	17.2	0.029
	n	**%**	**n**	**%**	
Complaint					
Weakness in legs	5	25	4	23.5	1.000
Low back pain	7	35	6	35.3	1.000
Gait disturbance	2	10	4	23.5	0.383
Arm/Leg pain	7	35	6	35.3	0.383

Table-4. Clinical characteristics of patients according to gender

	Male		Female		p
	n	%	n	%	
Pathology					0.389
Adenocarcinoma metastasis	2	10	-	-	
Dermoid tumor	1	5	-	-	
Ependymoma	3	15	1	5.9	
Epidermoid tumor	1	5	1	5.9	
Hemangioperisitoma	1	5	-	-	
Carcinoma metastasis	1	5	-	-	
Lymphoma	1	5	1	5.9	
Melanocytoma	-	-	1	5.9	
Meningioma	3	15	8	47.1	
Myxopapillary ependymoma	1	5	-	-	
Paraganglioma	-	-	1	5.9	
Schwannoma	6	30	4	23.5	
Grade					0.645
0	1	6.7	1	6.7	
1	10	66.7	13	86.7	
2	3	20	1	6.7	
3	1	6.7	-	-	
Localization					
C1	1	5	-	-	
C2	3	15	1	5.9	
C3	2	10	1	5.9	
C4	1	5	-	-	
C5	1	5	-	-	
T1	1	5	-	-	
T2	2	10	1	5.9	
T4	1	5	1	5.9	
T5	2	10	2	11.8	
T6	2	10	1	5.9	
T7	2	10	-	-	
T8	2	10	1	5.9	
T9	2	10	1	5.9	
T10	1	5	-	-	
T11	-	-	3	17.6	
T12	4	20	1	5.9	
L1	4	20	1	5.9	
L2	3	15	5	29.4	
L3	3	15	5	29.4	
L4	1	5	-	-	
L5	-	-	1	5.9	
S1	-	-	1	5.9	

DISCUSSION

Spinal tumors are classified as extradural, intramedullary and intradural extramedullary tumors. Extradural tumors are metastatic, multiple myeloma, condrosarcoma, chordoma, aneurismal bone cyst, osteoid osteoma, osteoblastom, osteochondrom, hemanjioma, granuloma and giant cell tumor. Intramedullary tumors are astrocytoma, epandimoma and hemanjioblastoma. Intradural-extramedullary tumors are meningioma, neuronoma and neurofibroma. Symptoms of spinal cord lesions include bilateral motor and sensory symptoms not involving the head and face, often with other upper motor neuron symptoms consistent with a myelopathic syndrome [(7)].

Radiographic evaluation is necessary to determine the location and extent of tumor involvement and may help to differentiate between lesions. A role still exists for plain radiographs in evaluation as they can illustrate bony erosions or evaluate for scoliosis. Magnetic resonance imaging with contrast agent is the gold standart fot detecting spinal tumors.

Management of primary and metastatic tumors is quite complex and requires a multidisciplinary understanding of tumor type, location, extension, and overall preoperative and neurological conditions [(11)]. Precise and timely diagnosis with a history, physical examination, imaging, and biopsy are critical first steps. Preoperative planning for en bloc surgical resection of spinal tumors is necessary for improved patient outcomes as well as to minimize any intraoperative and postoperative complications such as cerebrospinal fluid leakage, infection and reconstruction failure.

Biologics and immunotherapy are the new advances in cancer treatment over the past decade, such improving patient outcomes and consequently life expectancy. The most common sites for metastases in the general population with cancer are the liver and lungs, followed by bone [(3)]. Considering bone metastases, the majority will affect the spine. Primary spine tumors are rare neoplasms that can lead to significant patient morbidity and mortality [(7)]. Intramedullary spinal cord tumors are the rarest of these neoplasms and can potentially lead to severe neurologic deterioration, decreased function, poor quality of life, or death [(10)].

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ORIGINAL ARTICLE

turkishspine

TARLOV CYST

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ABSTRACT

Aim: Our aim is to analyse Tarlov cysts according to their size, localization and bone destruction.

Material and Method: We inspected the lumbar magnetic resonance imaging (MRI) datas of 68 patients for one year from the radiology database retrospectively. We excluded the patients with lumbar malignities such as tumors and developmental anomalies.

Results: The mean age of the participants was 52.2±13.7 years, and 72.1% of the population were females. Most frequently involved vertebrae were S2. Ratio is 26.5% of the patients with multiple Tarlov cysts. Mean diameter of the cysts was 11.8±7.7 mm. Destruction was present in 44.1% of the cases. When the characteristics of patients were compared between males and females mean age (p=0.262), cyst size (p=0.307), distribution of involved vertebrae (p>0.05 for all levels), number of cysts (p=0.063), and destruction pattern (p=0.195) were all-similar between genders.

***Conclusion*:** Tarlov cysts are usually asymptomatic and are found incidentally during radiodiagnostic examinations so that they do not treated with surgery till compression symptoms occur.

Key words: Tarlov cyst, sacral perineural cyst, sacral spinal cyst

Level of Evidence: Retrospective clinical study, Level III

INTRODUCTION

Sacral perineural cysts were first described by Tarlov in 1938 as an incidental finding at autopsy and were later classified as Type II meningeal cysts by Nabors et al. [5,10]. They are lesions of the nerve root on the extradural components in the sacral region. The cysts arise at the junction of the dorsal ganglion and the posterior nerve root and develop between the endoneurium and perineurium [3].

The prevalence of sacral perineural cysts has been estimated to be approximately 1.5 to 4.6 % (4). Most of the cysts are asymptomatic and are found incidentally during radiodiagnostic examinations for other reasons. Approximately 1 % of Tarlov cysts size increase and cause symptoms related to local compression [2]. Pathogenesis of these cysts is unclear and there is no consensus on the optimal treatment modality.

MATERIAL AND METHOD

We inspected the lumbar magnetic resonance imaging (MRI) datas of the patients for one year from the radiology database retrospectively (Figure-1,2).

We excluded the patients with lumbar malignities such as tumors and developmental anomalies. We evaluated 68 patients with Tarlov cysts and analyse according to their size, localization and bone destruction.

Statistical Analyze

Numerical variables were presented as mean and standard deviation, and categorical variables were presented as frequency and percent. The comparisons between independent groups were conducted by Mann-Whitney U test for numerical variables, and Chi-square test for categorical variables. A Type-I

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error level of 5% was considered as statistical significance in all analyses. The SPSS 21 software (IBM Inc., Armonk, NY, USA) was used for the statistical analyses in this study.

Figure-1. Sagittal T2-MRI image of level S2-3 Tarlov cyst.

Figure-2. Axial T2-MRI image of level S2-3 Tarlov cyst.

RESULTS

A total of 68 patients were included in this study. The mean age of the participants was 52.2 ± 13.7 years, and 72.1 % of the population were females. Most frequently involved vertebrae were S2 (76.5 %), S3 (38.2 %), and S1 (25 %). 26.5 % of the patients had multiple Tarlov cysts. Mean diameter of the cysts was 11.8 ± 7.7 mm. Destruction was present in 44.1 % of the cases. General characteristics of the patients were presented in Table-1.

When the characteristics of patients were compared between males and females (Table-2) mean age ($p=0.262$), cyst size ($p=0.307$), distribution of involved vertebrae ($p>0.05$ for all levels), number of cysts ($p=0.063$), and destruction pattern ($p=0.195$) were all similar between genders.

Table-1. General characteristics of patients

	Mean	Standard Deviation
Age (years)	52.2	13.7
Size (mm)	11.8	7.7
	n	**%**
Gender		
Male	19	27.9
Female	49	72.1
Level		
L5	1	1.5
S1	17	25
S2	52	76.5
S3	26	38.2
S4	4	5.9
Count		
Multiple	18	26.5
Single	50	73.5
Destruction		
(+)	30	44.1
(-)	38	55.9

Table-2. General characteristics of patients according to gender

	Male		Female		p
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	
Age (years)	54.8	11.8	51.1	14.3	0.262
Size (mm)	10.3	5.5	12.3	8.3	0.307
	n	**%**	**n**	**%**	
Level					
L5	-	-	1	2	1.000
S1	4	21.1	13	26.5	0.761
S2	17	89.5	35	71.4	0.201
S3	6	31.6	20	40.8	0.482
S4	-	-	4	8.2	0.570
Count					0.063
Multiple	2	10.5	16	32.7	
Single	17	89.5	33	67.3	
Destruction					0.195
(+)	6	31.6	24	49	
(-)	13	68.4	25	51	

DISCUSSION

Tarlov cysts often arise between the endoneurium and perineurium and occur on the extradural components of sacrococcygeal nerve roots at the junction of dorsal root ganglion and posterior nerve roots [3]. The cysts are usually multiple extending around the circumference of the nerve, and can enlarge to compress neighboring nerve roots and cause significant bone erosions. We found 44.1 % bone erosions in our study.

The pathophysiology of Tarlov cysts remains unclear, but several hypotheses have been proposed, including inflammation within the nerve root cysts followed by inoculation of fluid, developmental or congenital origin, arachnoidal proliferation along and around the exiting sacral nerve root, and breakage of venous drainage in the perineuria and epineurium secondary to hemosiderin deposition after trauma [1,5-6,8]. The most accepted theory to explain the progression in the size of the cyst is the so-called ball-valve mechanism, in which cerebrospinal fluid enters the cyst with systolic pulsation but is unable to exit through the same portal during diastole [2].

MRI and Computed tomography (CT) myelography are useful radiodiagnostic tools for Tarlov cysts but the final diagnosis is histopathological diagnosis because the cyst walls contain peripheral nerve fibers and ganglionic cells covered with meningeal epithelium. Tarlov cysts were seen clearly by T1- and T2-weighted MRI sequences; the cysts were seen as fluid filled spaces with the CSF signal at a given MRI sequence as a low signal on T1-weighted images and a high signal on T2-weighed images [9]. MRI is quite useful for surgical planning because the absence of interference from bone, enhanced resolution of tissue density, useful in studying sacral perineural cysts and their relationship to the surrounding structures could be clearly demonstrated.

Symptoms with local compression of Tarlov cysts are local low back sacrococcygeal pain, sciatic pain, leg weakness and numbness, bowel and bladder dysfunction, and sexual impotence [1]. Symptoms can change with changes of the posture and increased CSF pressure with coughing, Valsalva maneuvers, standing, lifting and climbing stairs.

Tarlov cysts are usually asymptomatic and are found incidentally during radiodiagnostic examinations so that they do not treated with surgery until compression symptoms occur.

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F18-FDG PET-CT IN DIAGNOSING, TREATING AND MONITORING SPINAL INFECTIONS*

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ABSTRACT

Spinal infections are important problems that occur due to various factors, show different pathological processes, cause pain, spinal compression and neurological deficit, and lead to high morbidity and mortality. Scanning methods provide great facilities in the diagnosis and monitoring of these infections. MRI is quite sensitive in evaluating spinal infections. However, they may remain incapable in certain cases. Nuclear medicine imaging techniques can be used in the cases where MRI remains incapable. Three patients that have presented to our clinic with the prediagnosis of infection were evaluated by F18-FDG PET-CT and 3-phase bone scintigraphy-SPECT-CT to make definite diagnosis and for treatment monitoring. By means of these cases, we demonstrated that PET-CT, which is an adjuvant method to MRI, can be used in making diagnosis as well as in evaluating the extent of infection, residual disease, response to treatment and duration of treatment in spinal infections where MRI remains incapable.

Keywords: Spine infection, F18-FDG PET-CT, Diagnosis, medical treatment

Level of evidence: Case series, Level IV.

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INTRODUCTION

Spinal infections are important problems that occur due to various agents, show different pathological processes, cause pain, spinal compression and neurological deficit, and lead to high morbidity and mortality. Spinal infections have increased in number with the increasing number of spinal interventions, antibiotic-resistant bacteria strains, and immunocompromised patients. The diagnosis is delayed in many patients as the onset of the disease is insidious and infection-specific signs are absent in the beginning. Delayed diagnosis results in permanent neurological deficit, even death [4].

Technological advancements in imaging methods have provided substantial convenience in identifying the focus of infection and in making diagnosis. Furthermore, evaluation of the extent of infection, as well as prognosis, residual disease and treatment response, is among the other required qualifications of imaging methods [19].

MRI is quite sensitive in diagnosing spinal infections. However, it is difficult to make differential diagnosis using radiological diagnostic methods in early stage bone and soft tissue infections where morphological changes have not occurred yet or in baseline chronic infection that has been exposed to anatomical changes due to trauma or surgery. Radiological methods may not be beneficial in prosthetic infections because of metal artifact. MRI may remain incapable in assessing residual disease and response to treatment. At this stage, nuclear medicine imaging methods make contribution to the diagnosis of spinal infections. Owing to the recently developed hybrid imaging methods and PET agents, the nuclear medicine gains increasing importance in assessing infection and inflammation as well as many diseases[3,6,7,23].

Radiopharmaceuticals (RF), which are being used in nuclear medicine to assess infection and inflammation, localize the infection by means of pathophysiological events such as increased tissue perfusion, increased capillary permeability, and leukocyte migration, which occur in case of inflammation, usually independent from the structural changes and etiological factors. Thus, they allow the diagnosis of infection by visualizing inflammation at early phase before the development of structural changes. Nuclear medicine imaging methods are able to perform not only regional imaging but also whole body imaging without need for additional radiation dose (excluding hybrid imaging with CT) or cost.Along with the availability of hybrid imaging methods in the recent years such as SPECT-CT, PET-CT and PET-MRI, pathophysiological data from SPECT and PET and morphological data from CT and MRI have been obtained at the same time and this has started a new period in the evaluation of inflammation and infection as well as many diseases[1,9,16,19].

CASE REPORTS

CASE REPORT-1

A 63-year-old female patient, who had undergone L4-L5 vertebra surgery 13 years ago with laminectomy of L4, presented with low back pain. MRI demonstrated postoperative changes in L4-5 vertebra and lesions consistent with spondylodiscitis in T5-6 and T6-7 vertebras. Pre-diagnosing with spondylodiscitis /metastasis, she was evaluated by 3-phase bone scintigraphy SPECT- CT and F18-FDG PET-CT before treatment and by F18-FDG PET-CT after treatment. Bone scintigraphy failed to demonstrate blood supply and blood pool phase of T5-T7 vertebras clearly because of massive cardiac activity. During bone phase of whole body and SPECT/CT images, increased activity uptake was observed in the lower end plate of T5 vertebra and upper end plate of T6 vertebra and T7 vertebra. PET-CT demonstrated lytic sclerotic changes with massive FDG uptake (SUVmax: 11.1, late SUVmax: 12.6) in T5-T7 vertebras and the discs supporting the pre-diagnosis of spondylodiscitis, as well as images of orthopedic instruments at the level of L3-L5 vertebras and mildly increased FDG uptake suggesting postoperative changes on the posterior surface around the instruments. Brucella infection was detected in the patient (Brucella agglutination test coombs: 1/320). She treated with streptomycin, rifampicin and tetracycline. She was evaluated by PET-CT on the 3rd month after treatment for Brucella; mildly increased FDG uptake (SUV max: 3.6 late SUVmax: 4.2) with remarkable metabolic response to treatment was observed in the T5-6 and T6-7 intervertebral space and in the T6 vertebra (Figure 1A,1B-2A,2B). Antibiotic treatment stopped at 3 months.

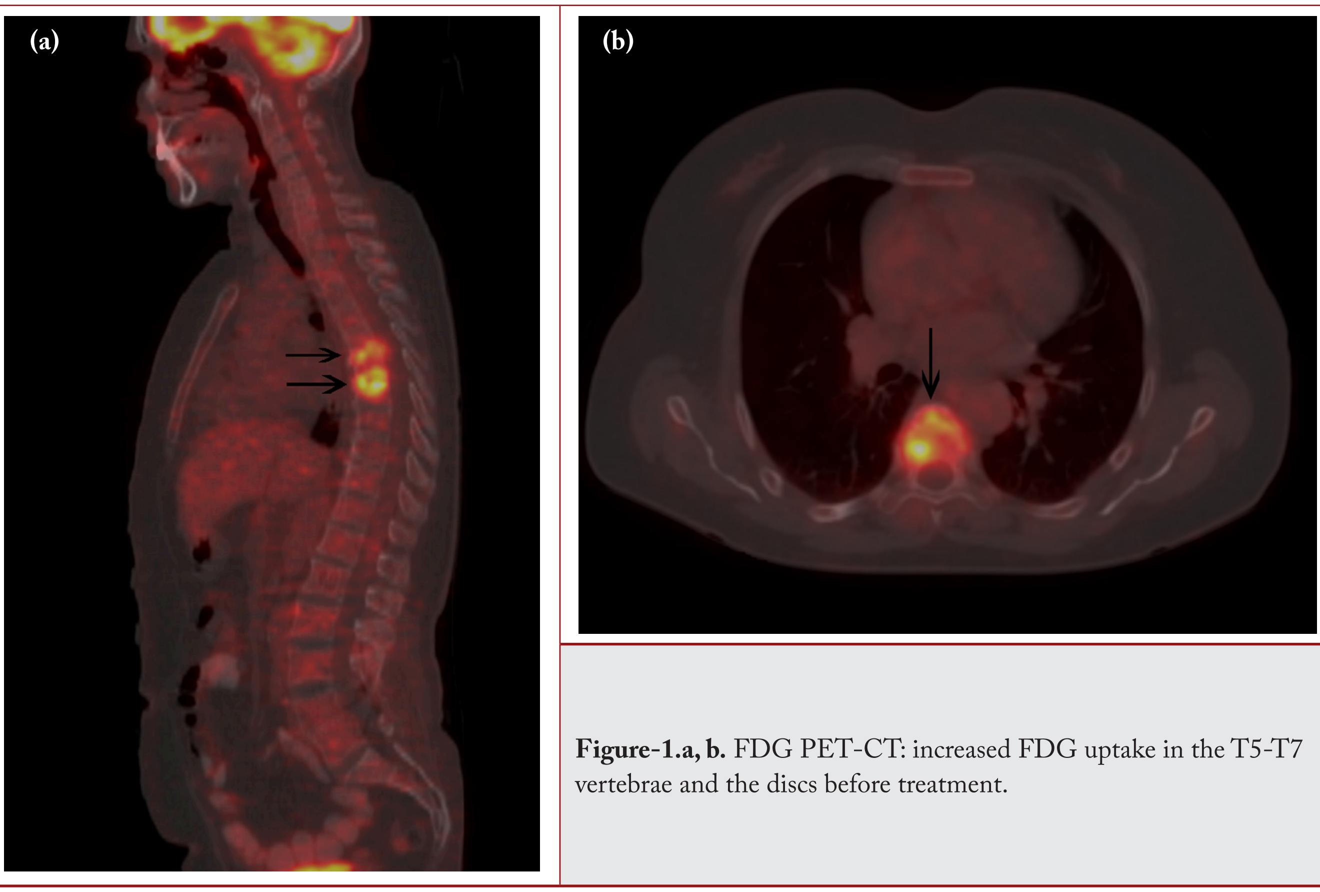

Figure-1.a, b. FDG PET-CT: increased FDG uptake in the T5-T7 vertebrae and the discs before treatment.

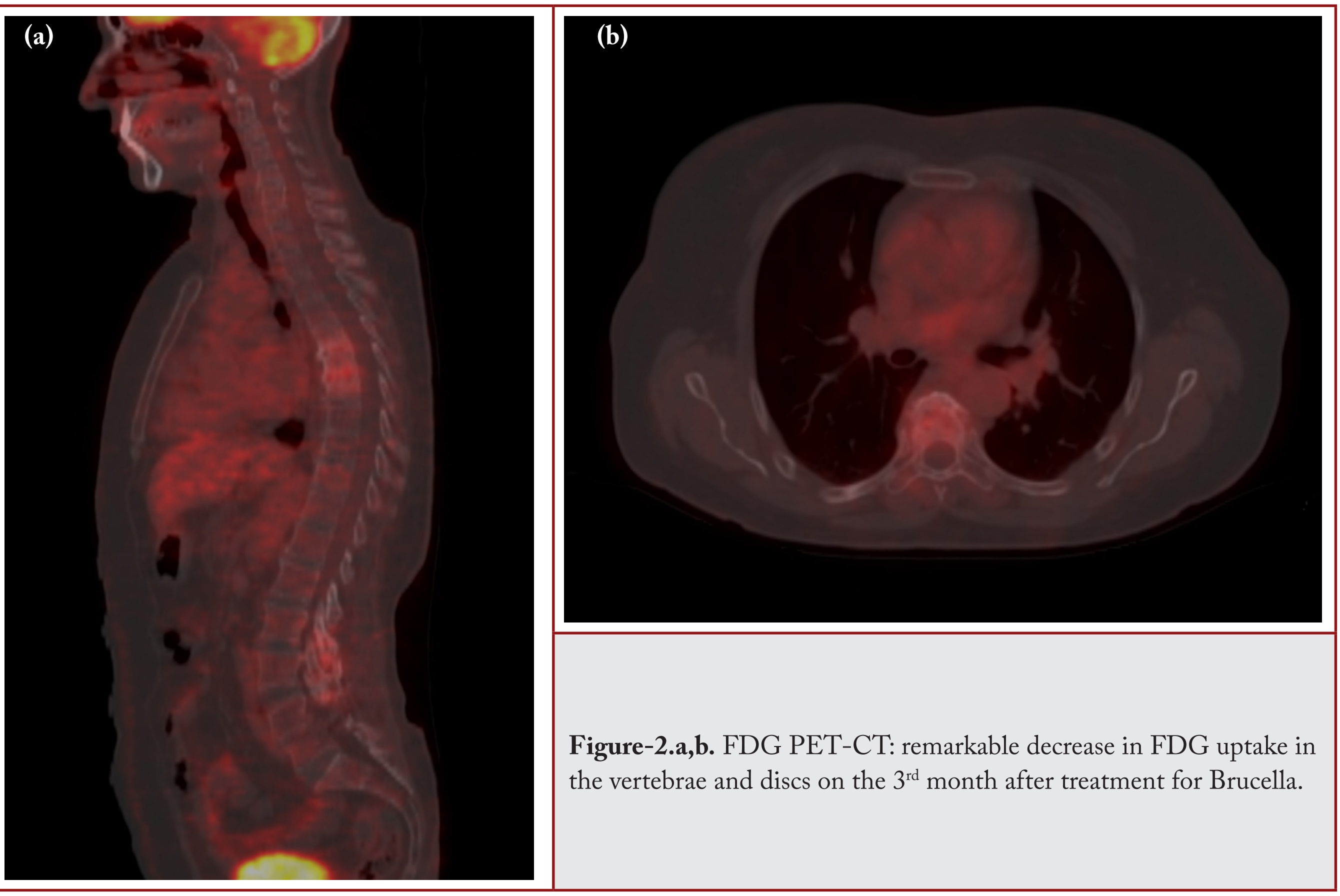

Figure-2.a,b. FDG PET-CT: remarkable decrease in FDG uptake in the vertebrae and discs on the 3rd month after treatment for Brucella.

CASE REPORT-2

A 66-year-old female patient presented with back pain and fever. She was evaluated by CT, and a lesion was detected in the T9-10 vertebras. Pre-diagnosing with malignancy, 3-phase bone scintigraphy/SPECT-CT and F18-FDG PET-CT were performed. Bone scintigraphy demonstrated hyperemia at the level of T9-T10 vertebra, whereas bone phase of SPECT-CT demonstrated diffusely increased activity uptake in the T9-T10 vertebras accompanied by soft tissue component. PET-CT revealed a lesion in theT9-10 vertebras with massive FDG uptake (SUVmax: 12.3) destructing the vertebras, which was accompanied by paravertebral soft tissue component. Spondylodiscitis could not be distinguished from malignancy. MRI primarily suggested spondylodiscitis. Histopathological evaluation was recommended; true-cut biopsy results were consistent with active chronic inflammation. Staphylococcus aureus was grown in the culture. She had medical treatment with cefazolin and ciprofloxacin.

CASE REPORT-3:

A 61-year-old female patient with diabetes mellitus and chronic renal failure, who have been receiving hemodialysis via intravenous catheter, underwent MRI for low back pain. MRI revealed spondylodiscitis in the T11-T12 and L1-L2 vertebras and also findings suggesting paravertebral abscess at the level of T11-T12 vertebra. Pre-diagnosing with spondylodiscitis, she was evaluated by three-phase bone scintigraphy/SPECT-CT and F18-FDG PET-CT. Bone scintigraphy demonstrated mild hyperemia at the level of T12 vertebra, SPECT-CT demonstrated loss of height in the T12 vertebra, destruction of vertebra corpus, increased RF uptake and concomitant soft tissue thickening at the corpus neighborhood, and increased RF uptake between T11 and L2 vertebras accompanied by soft tissue component suggesting spondylodiscitis and in L5-S1 vertebras primarily suggesting degenerative/arthritic changes. PET-CT demonstrated lytic-sclerotic hypermetabolic lesions (SUVmax: 7.4, late SUVmax: 9.5) betweenT11 and L2 vertebras accompanied by soft tissue components. Evaluating these findings together with clinical and laboratory findings, primarily spondylodiscitis was considered. Enterococcus faecalis was grown in blood culture. She had medical treatment with teicoplanin and ciprofloxacin.

DISCUSSION

Spinal infections have increased in number along with increasing number of spinal interventions, antibiotic-resistant bacteria strains and immunosuppressive patients[4]. One of the presented cases was an immunosuppressive patient with Diabetes mellitus and chronic renal failure.

Among imaging methods, MRI is still valid in assessing spinal infections as was in the present cases. Many studies have demonstrated that F18-FDG PET-CT is an adjuvant and complementary method in spinal infections[12,15].The studies have also revealed that F18-FDG PET-CT is effective in acute and chronic osteomyelitis, even in chronic osteomyelitis treated with antibiotics, spondylodiscitis, spondylodiscitis accompanied by soft tissue involvement, in discriminating modic changes from pyogenic spondylodiscitis, in discriminating degenerative from infectious end plate pathologies, in diagnosing infection in the patients with metallic implant and prosthesis, and in discriminating pyogenic from tuberculosis spondylitis. In a meta-analysis comparing different imaging methods in chronic osteomyelitis, F18-FDG PET was determined to be not only the most sensitive method but also the method with the highest specificity. The sensitivity of F18-FDG PET, bone scintigraphy and signed leukocyte scintigraphy was found to be 96%, 76% and 84%, respectively and the specificity was found to be 91%, 84% and 60%, respectively. Accordingly, it was concluded that it is the method with the highest diagnostic accuracy in detecting or excluding chronic osteomyelitis particularly in the axial bones[22]. F18-FDG PET-CT is used to evaluate response to treatment and residual disease via SUV measurement not only in the oncological diseases but also in the infectious and inflammatory diseases; thereby, it is superior to MRI and scintigraphy methods. The use of F18-FDG PET-CT in detecting biopsy point in the infection area is another advantage [8,11,22]. In our study, F18-FDG PET-CT helped us in determining biopsy point in two cases.

In addition to the visual evaluation, PET-CT also enables evaluation by standardized uptake value (SUV), which is a quantitative parameter calculated using PET imaging. SUV value is used to evaluate benign, infectious or inflammatory diseases as well as malignant disease. Although a SUV value of 2.5 is traditionally considered as the threshold value in discriminating benign from malignant lesion, it is known that SUV value lower than 2.5 can be measured in certain types of cancer or extremely high SUV value can be measured in certain infectious pathologies[2,17]. In our cases with proven infection, all had SUV value was over 7.

Double phase imaging can be performed to discriminate benign from malignant pathology and to enhance diagnostic specificity. Standard imaging is performed nearly 4-60 min after IV injection. In double-phase imaging, the 2nd imaging is performed 90-270 min after injection. In substantial proportion of the studies, increased SUV values were determined in the majority of (80-90%) malignant lesions during late imaging after RF injection, whereas increased SUV values were determined in the majority of benign lesions. This situation appears to be more valid in evaluating inactive and chronic infections. Unfortunately, increased SUV value can be detected during late imaging in some active granulomatous and infectious lesions as is in the malignant diseases, which hinders correct interpretation of double-phase imaging[2,17]. Double-phase imaging was performed in two of the present cases and increased late SUV values were determined.

Scintigraphy methods are being used for years in the spinal infections. It was determined that FDG-PET-CT is an excellent alternative to the scintigraphy methods in visualizing infection and inflammation. Some advantages of F-18-FDG PET-CT have made it preferred in detecting infection and inflammation.F-18 has convenient physical characteristics and convenient kinetics as it is rapidly collected in the lesion. Since it has short half-life, the patient receives lesser dose of radiation. Completion of the method in two hours owing to its physical characteristics is a critical advantage in terms of early outcome and patient comfort. In addition, PET devices have better resolution and contrast than scintigraphy devices. PET or PET-CT, as well as scintigraphy methods, enables whole body scanning and therefore is able to detect multifocal infections. In contrast to CT and MRI, artifacts due to metallic implants do not inhibit F18-FDG uptake in PET. CT enhances the advantage of PET as it provides anatomical detail. It is able to discriminate aseptic from septic inflammation. It can be used in elder and immunosuppressed patients. It is non-invasive with good interpreter consistency. It is easy to discriminate inflammatory cell from infiltrated bone marrow since FDG uptake is low in normal bone marrow. FDG uptake in bone can rapidly return to the normal after 3-4 months of trauma or surgery, which is another superiority to the bone scintigraphy. It has high sensitivity in chronic infections. One of the disadvantages of F18-FDG PET-CT is not being specific to infection and inflammation. Suspicious foci adjacent to the organs with physiologically high F18-FDG uptake might be reported as false negative or false positive [7,15,21]. In Case 2, the discrimination of infection from malignant pathology could not be made and therefore, biopsy was taken.

F18-FDG PET-CT is an adjuvant method to MRI with high negative predictive value and high sensitivity in evaluating spinal infections. Regardless of combining with CT, the sensitivity and specificity of F18-FDG PET in musculoskeletal infections are 95 % and 75-99 %, respectively. F18-FDG PET-CT has high negative predictive value and high sensitivity [12,15].Studies have demonstrated that F18-FDG PET-CT is superior to MRI in evaluating low-grade spondylitis or discitis and end plate anomalies, in detecting multiple infectious foci and directing for minimal invasive surgery, and in determining duration of antibiotic therapy [5,10,13,15,20].

Spondylodiscitis is a serious disease with high risk and cost and requires long-term antibiotic therapy. F18-FDG PET-CT is the second line method after MRI with similar accuracy in directing the cases where MRI is not convenient or diagnostic. Its specificity is higher than MRI in evaluation and in terminating the treatment [18].

Nanni et al. evaluated 34 spondylodiscitis patients by PET before and 2-4 weeks after treatment and concluded that 34 % decrease in SUV value on interim PET is the strong predictor of complete treatment response and is more effective than CRP for follow-up[14]. In the present study, the case with Brucella spondylodiscitis was evaluated by PET before and on the 3rd month of treatment for Brucella, and 68 % decrease was determined in SUV value.

Although there is high number of studies demonstrating that F18-FDG PET and PET-CT have high sensitivity and diagnostic accuracy, they have been conducted in a limited number of patients. Meta-analyses with larger sample size are required to identify clinical use and cost-effectivity [22].

In conclusion, F18-FDG PET-CT is a method adjuvant to MRI in diagnosing spinal infections and in evaluating extent of the disease, treatment response and duration of treatment where MRI remains incapable.

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CASE REPORT

LUMBAR INTRADURAL DISC HERNIATION WITH CAUDA EQUINA SYNDROME

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ABSTRACT

Intradural disc herniation (IDH) are very rare entities with an incidence of 0.2–2.2% among all cases of herniated discs. The incidence of cauda equine syndrome in IDH is higher than in extradural herniation. Preoperative diagnosis is challenging because of variable clinical and radiological variations. We presented a recurrent lumbar discopathy case operated for intradural disc herniation with cauda equina syndrome. Intradural disc herniation must be remembered cases with cauda equina especially in recurrent lumbar disc cases and differential diagnosis must kept in mind.

Key words: Intradural disc herniation, cauda equina syndrome, recurrent disc herniation

Level of Evidence: Case report, Level IV.

INTRODUCTION

Intradural disc herniation (IDH) are very rare entities with an incidence of 0.2–2.2% among all cases of herniated discs(9). Dandy reported the first IDH case in 1942[3]. The incidence of cauda equine syndrome in IDH is higher than in extradural herniation[1]. Preoperative diagnosis is challenging because of variable clinical and radiological variations. We reporetd a recurrent lumbar discopathy case operated for intradural disc herniation presented with cauda equina syndrome.

CASE REPORT

Sixty-three years old woman applied to our outpatient clinic with severe back pain, left leg pain, urinary and gaita incontinence. She could not even walk because of the pain. She had been operated for L3-4 disc herniation 5 years ago. In neurological examination she had 3/5 bilateral lower extremities muscle strength, and bilateral paresthesia. Anal sphincter muscle tonus was relaxed.

Lumbar magnetic resonance imaging (MRI) suggested immediately. L3-4 disc herniation had been visualized in sagittal and axial images (Figure-1,2).

Figure-1. Preoperative MRI sagittal T2 image

Operation suggested urgently. Patient accepted the operation. After preperation for the operation, she had been operated from the old incision. L3-4 left hemi-partial laminectomy extended under microscope. Dura was stickled to lateral side with fibrosis. Intradural mass appeared after fibrotic tissues cleaned from the dura. Dural incision made on the midline of dura. Rootlets carefully dissected with microdissectors from the disc fragment and then the fragment pulled out respectively(Figure-3).

Intervertebral disc space checked for residual fragments. After homeostasis dura and the other layers sutured properly. Fibrin glue used to prevent liquor fistula.

Postoperative second day the patient could be able to walk herself with urinary catheter and had no gaita incontinence. She is still followed up with urinary catheter.

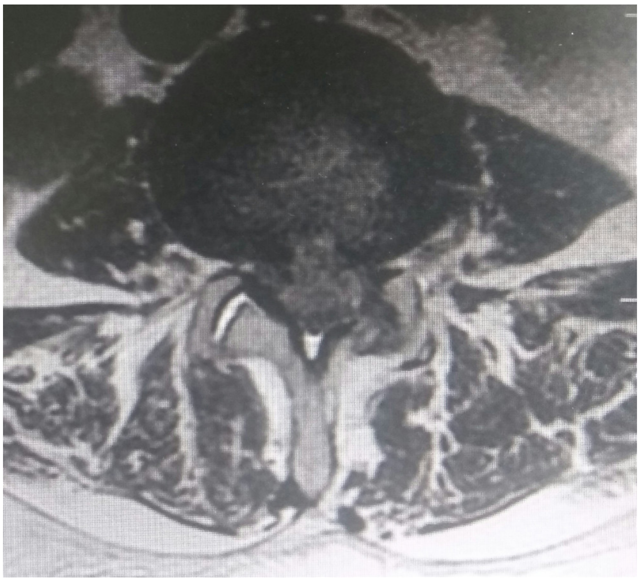

Figure-2. Preoperative sagittal MRI axial image

Figure-3. Intradural disc fragment

DISCUSSION

The pathogenesis of IDH is still controversial, but it may involve dural adhesion between the posterior longitudinal ligament and intervertebral disc annulus, which may be caused by postoperative scarring; and vulnerability of the dura to iatrogenic or congenital factors such as dural thickness and epidural adhesion with the longitudinal ligament [8]. Our cases' pathology is seemed to be as a result of the first operations' complication.

Öztürk et al. found that 92 % of all IDH cases occur in the lumbar region, with only 5% occurring in the thoracic region and 3% in the cervical region [11]. IDH is most common at the L4–L5 level because the dura mater and ventral posterior longitudinal ligament are anatomically closest at this level; also lumbar disc herniation frequently occurs at L4–L5 [2,4]. Our cases' level was L3-L4, which seemed to be rare.

There are no differences in symptoms between extradural disc herniation and IDH, most cases are acute, and typical symptoms include severe leg pain and chronic low back pain [7]. However, there is a higher incidence of cauda equina syndrome in IDH than in extradural herniation [4]. Our case presented with cauda equina syndrome with walking difficulty and severe back pain.

MRI is the gold standard for neuroimaging studies. Ring enhancement on gadolinium-enhanced MRI is the typical IDH imaging features, which is required for differential diagnosis of herniated discs from tumors such as schwannoma and meningioma [10]. Ring enhancement is caused by chronic granulation tissue and peripheral neovascularization [6]. In IDH, air images with the seqestrium in the intradural space or spinal canal are sometimes seen on CT, at six times the frequency observed in normal disc herniation [5].

We presented a recurrent lumbar discopathy case operated for intradural disc herniation with cauda equina syndrome. Intradural disc herniation must be remembered cases with cauda equina especially in recurrent lumbar disc cases and differential diagnosis must kept in mind.

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SACRAL FRACTURES AND LUMBOSACRAL DISLOCATION

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ABSTRACT

Sacrum fractures are injuries with a high rate of mortality and risk of neurological damage usually associated with pelvis fractures and rarely observed as isolated fractures. Since it occurs as a result of high energy trauma, concomitant injuries should be suspected. Full examination including a detailed neurological and radiological examination is required in order to determine treatment modality.

Proper classification of sacral fractures may facilitate determination of optimum treatment modality. Due to the complex nature of the injuries surgical therapeutic options are still being debated. Surgical therapeutic option consisting from decompression of neural structures along with stabilization of the fractures should be considered in patients with neurological deficit, severe soft tissue damage and lumbosacral instability. Percutanous iliosacral screw placement, fixation of posterior sacral tension band and lumbopelvic or triangular fixation techniques are preferred methods.

In this paper, the authors aim to share information in the literature along with their experience about anatomy of sacrum and pelvic regions and common sacral fractures, classification of sacral fractures and current therapeutic strategies.

Key words: sacral fructures; lumbopelvic fixation; triangular fixation; trauma.

Level of Evidence: Review article, Level V

INTRODUCTION

Almost 75% of patients referring to hospital with sacrum fracture don't have any neurological sign; thus, these patients may be overlooked during their first referral and their treatment may be inadequate. In young patients, they may occur because of high-energy trauma; but in osteoporotic older patients, sacral fractures occur more often because of low energy trauma. Recently sacral insufficiency fractures following long segment instrumentation applications are more common. To prevent lower extremity muscle weakness and neurological sequels such as urinary, rectal and sexual dysfunction, anatomy of sacrum should be fully appreciated and injury mechanisms and therapeutic options along with types of treatment should be very well known. The objective in management of sacrum fractures is to recover structure and neurological functions at their best; thus, both nerve decompression and reconstruction of skeletal system should be very well understood.

ANATOMY (4)

Sacrum consists of usually 5 vertebrae fused with each other and has a kyphotic appearence. Spinal canal diameter and size of vertebral body decrease from cranial to caudal. Sacral kyphosis varies between 10°-90° and is usually about 45°–60°. Central kyphosis determines sacral inclination angle. In case there is transitional vertebra, number of sacral segments may vary. Transverse processes of sacral vertebras may form a joint or fusion at ala of sacrum and articulates with ilium at lateral via sacroiliac joint. Between vertebral bodies and sacral ala there are 4 sacral neural foramina at anterior and posterior. Upper half of S_1 vertebra and 1st and 2nd sacral foraminal cortex at anterior and sacral laminae are locations where the bone density is highest.

Sacral ala itself contains spongious bone and density decreases with advancing age. Structural continuity of sacrum depends on surrounding ligaments. Thick and well developed ligaments at both sides attach to sacroiliac joints and ligaments at the most caudal region binds lumbar vertebra to pelvis. Lumbosacral plexus (L_4-S_1) and sakral plexus (S_2-S_4) are the neural structures directly affected from sacral injuries. L_5 nerve root extends distally from the lateral of sacral ala. At anterior of foramina the distance covered by sacral nerve roots is relatively the shortest at S_1 level and larger at S_4 level. Observations on cadaver dissection have revealed that S_1 and S_2 nerve roots occupy 1/3-1/4 of the foraminal distance anteriorly and S_3 and S_4 nerve roots occupies 1/6 of the foraminal distance anteriorly. Dural sac usually terminates at S_2 level. Sensorial branches of cluneal nerves arise from dorsal sacral foramina. Sacral angulation, translocation and direct compression of sacral spinal canal and ventral foramina may negatively influence function of sacral nerve roots or nerve recovery.

Biomechanically sacrum serves in transfer of the load arising from the vertebral column to both hip joints via sacroiliac joints. In supporting the vertebral column and in terms of ambulation first two sacral vertebras are very important.

EVALUATION OF THE PATIENT [4,9]

Initial assessment

Sacral fracture is usually caused by high-energy forces; thus, emergency resuscitation maybe needed and in accordance with ATLS protocols life threatining conditions should be urgently targeted and cardiopulmonary and hemodynamic stability should be established. In patients with AP compression fracture at pelvis, application of external fixator or pelvic girdle during resusitation in order to reduce pelvic volume and establish pelvic stability may be useful.

Stability of pelvic ring should be assessed by applying gentle rotational force to iliac alae. In case there is signs of laceration, wound, sensitivity, swelling or crepitation over or around pelvis sacrum injury should be suspected. Particularly, bony prominence on sacrum at posterior and presence of subcutanous palpable fluid mass that is an indicator of dissociation of lumbosacral fascia should be looked for Morel-Lavelle lesion [22]. Surgical incision over this lesion should be avoided, because it may increase risk of infection and may delay soft tissue healing.

Rectal examination should be always done in assessment of patients with sacrum fracture. Lacerations in the perinael region should also be examined for excluding a latent open fracture. In females speculum examination should't be neglected. Thoracolumbar vertebra fracture may also be present in patients with sacral fracture. Thus, other parts of the vertbrea must be fully evaluated.

Neurological Evaluation

Early evaluation of neurological status is important in sacral fractures. However, in a significant proportion of patients the severity of the trauma may impede full neorological assessment. Neurological injuries associated with U-shaped sacrum fractures are often seen as cauda equina syndrome due to injury of lower nerve roots (S_2-S_5) and manifested as bladder dysfunction, decrease in rectal tonus and saddle anesthesia. S_2-S_5 nerve injuries may be easily missed, due to absence of marked motor or sensual disorder. Perianal sensation, anal sphincter tonus, if present voluntary perianal constriction and presence of bulbocavernous reflex arc should be assessed. In unresponsive patients, perianal somatosensorial stimulation potential and EMG of anal sphincter provides valuable information about sacral plexus damage. Another frequent occurrence is L_5 or S_1 nerve root injury. L_5 nerve root injury may be seen as injury of posterior pelvic ring as result of vertical shear injury and fracture of transverse process of L_5 vertebrae may accompany it. Absence of dorsal flexion in ankle is the clinical sign of L_5 nerve root injury. Detection of cauda equina injury or open sacrum fracture is relevant in terms of the outcome and priority of the treatment.

Radiolocial Evaluation

ATLS protocol regarding imaging in injuries with suspected sacral fractures includes pelvic AP radiograpgy. Pelvic AP radiography is not ideal for revealing sacral fractures because of inclination angle of sacrum, iliac wings and intestinal gas. This may be more prominent in patients without significant asymmetry. Only 30 % of all sacral fractures may be seen in pelvic AP radiography [12]. Irregularity in sacral foramina and sacral arcuate line is a strong indicator of sacral fracture along with kyphotic deformity of sacrum revealing 'paradoxical inlet' appearence in pelvic AP radiography. Inlet and outlet radiographies of pelvis should be performed, because it's essential for better imaging of sacrum in patients with suspected pelvic ring injury.

Lateral sacrum radiography is required in order to show transverse fracture line in U-shaped fractures. Bilateral transforaminal sacral fractures, irregularity of superior sacral foraminal lines and tranverse process fracture of L_5vertebra are among other radiological clues for U-shaped sacral fracture [11].

CT imaging of both pelvis and vertebrae is important in order to observe details of the complex injury and to decide for definitive treatment. Axial sections in 5 mm or less than 5 mm thickness is recommended. Acquisition of sagittal and coronal images is important in terms of angulation and translation of the fracture, narrowing of neural canal and detection of shape of sacral fracture. Sagittal images show slippage of S_1 vertebrae over S_2 anteriorly and narrowing of the canal. Coronal images shows extension of the fracture towards foramina very well. 3 dimensional images allow understanding of the shape of the fracture exactly while getting prepraed for the surgical treatment and planning for it.

In addition, MRI assists in showing compression or neural structures and fracture lines. It may also be useful in assessment of peri-sacral soft tissues. In the period after acute injury particularly combination of MRI and neurography may be helpful in detecting lumbosacral plexus injuries. Myelography was previously used in assessment of subjects with neurological deficit but currently it's not a preferred diagnostic modality. Cystomyography and measurement of post-micturation residual urine are recommended in patients with neurogenic bladder.

CLASSIFICATION [4,9]

Depending on its localization and shape sacral fracture may distort stability of pelvic ring, lumbosacral junction or only sacrum. Classification should mainly discern whether the injury is stable or instable. In assessment of pelvic trauma systemic injury load and associated soft tissue damage, presence of neurological deficiti and its severity, displacement of the fracture, presence of ligamentous injury along with bone injury are the factors thay should be considered. The widely accepted radiological threshold between stable-instable fractures in pelvic injuries is 1 cm or more displacement of the fracture fragments. However, this measurement doesn't show the actual displacement that has occurred during the injury.

Sacral fractures were first described in the literature in 1847. Since than, advances in imaging methods and increasing awareness about the fracture itself, classification of the fracture has begun. Medelman has classified sacral fractures in 3 main categories: longitudinal, oblique and horizontal. In 1945 Bonnin have suggested another classification based on injury mechanism. In 1977 Fountain et al. have published transverse sacral fractures of 6 subjects and classified these fractures as transverse or longitudinal. Pelvic area fractures are basically classified in 3 categories.

Classification system based on injuries disrupting the structural integrity of pelvic ring was suggested by Tile, Letournel et al (AO/ASIF group). Isler based his classification on disruption of integrity of lumbosacral junction and stability. Denis et al. suggested a practical classification for sacrum fractures. Roy-Camille has added a subclassification system for transverse sacrum fractures including spinal canal (Denis Zone III) to this classification. Denis and Roy-Camille classication are complemantary rather than being distinct classifications. Classifications of other groups such as Sabiston and Wing, Kaehr and Anderson are variations of the above mentioned classification systems but they're not comprehensive.

The most understandable and practical classification system for sacrum fractures is the 3-zone system described by Denis et al. in 1988. In their study based on retrospective evaluation of 236 patients they have classified sacrum fractures according to the most internal fracture line. Fractures lateral to sacral neuroforamina are described as zone I fractures; transforaminal fractures that are usally vertical and don't extend to spinal canal are described as zone II fractures and fractures extending up to the spinal canal are described as zone III fractures. This classification based on anatomic fundamentals includes most of the sacrum injuries within the classification system and also indicates associated neurological deficit [11]. This 3 types of injury also often indicates the injuries and mechanisms of injuries. Zone I extraforaminal ala fractures occur in 50% of patients and rate of neurological deficit is 5.9 % and this includes L_4-L_5 roots of sciatic nerve. In 34% of the patient's zone-II transforaminal injuries are observed and in 28% of these patients, there is neurological deficit that includes L_5, S_1, S_2 roots. In this retrospective study, the authors have detected zone III injuries affecting spinal canal in 16 % of the patients. In 57% of them there was neurological deficit that includes sacral roots. In 76 % of patients with affected sacral roots bowel, bladder and sexual dysfunction may occur.

In the classification of Denis, the classification system doesn't include displacement of the fracture or instability stemming from the injury. Zone I and zone II fractures are usually vertically oriented fractures and related with posterior elements of the pelvic ring. In general they are the injuries occur as a result of exposure of pelvic ring to lateral compression or external rotation and they're very instable due to their nature. Bilateral zone I or II fractures are infrequent and they may also be an indicator for zone III fractures. Denis et al. have described zone I and II fractures as minimally displaced, stable or displaced-instable.

Although zone I injuries mainly affects stability of posterior pelvic ring, some zone II fractures and most of the zone III fractures may affect both pelvic ring stability and lumbosacral stability.

Zone II sacrum fractures may be subclassified according to their effect on stability. According to classification system suggested by Isler in 1990, lumbosacral junction Isler type I fractures are stable, because longitudinal sacrum fracture extends to lumbosacral joint and the lateral of L_5-S_1 facet joint and thus stays within the stable component of sacrum[21]. If the longitudinal fracture extends to the L_5-S_1 facet joint or internal side of the joint, joint may dissociate from the sacrum totally either along with the stable sacrum fragment or by fragmentation and possibly lumbosacral instability occurs. This instable fracture type is noted in nearly 40% of the instable vertical sacrum fractures [29].

Zone III fractures consist of a wide spectrum of injuries with various fracture shapes and displacement charactestics; thus, subjective or descriptive classification system maybe useful in oral definition of multiplane sacral fractures and their virtual visualisation. Many injuries resulting with transverse sacral fractures have longitudinal or vertical components and are usually bilateral transforaminal fractures extending to lumbosacral junction and forms a type of fracture which is called as U-shaped fracture [19]. Conventional longitudinal fractures form H, Y or lambda shaped fractures and result with spinopelvic dissociation by dissociation of sacrum

Sacral fractures that includes central spinal canal (Denis zone III) were subclassified by Roy-Camille. These types of transverse fractures consisting of upper part of sacrum are in fact described for fractures caused by jumping from heights with suicidal intention; however, they may also be used for zone III injuries and for other trauma mechanisms. The relationship between the severity of the injury and probability of occurrence of neurological deficit may be predicted by using the system described by Roy-Camille [33]. Type 1 injuries includes simple flexion deformity of sacrum, type-2 injuries flexion and translation deformity and type 3 injuries complete translation of superior and inferior sacral segments. Strange-Vognsen and Lebech later added type 4 to this classification. Type 4 injuries are segmental fragmented sacral fractures without severe translation or angulation and it's suggested that they occur as a result of exposure of vertebrae directly to axial load while staying at neutral position. These 4 types are associated with the severity of the trauma and neurological deficit and may be useful for treatment plan of the patients. Although it's suggested that all of the fracture types occur as a result of axial loading, in type-1 and type-2 injuries flexion forces are also involved and it results with kyphotic angulation at transverse fracture line.

Lumbosacral injury classification system (LSICS) was suggested in 2012 in order to help surgical decision making in complex sacral fractures. LSICS is a scoring system based on the severity of injury in 3 categories (morphology, posterior ligamentous complex and neurological status). The score from these 3 categories changes between 1-10. If the total score is <4 usually conservative treatment is advised. When the total score is >4 surgical treatment is advised for sacral fractures. If the score is 4, then, the decision of treatment is left to the surgeon's opinion [25].

Lumbosacral junction trauma is considered as a different entity. These injuries may manifest as facet dislocations only or as complex lumbosacral fractures. Due to the strong ligaments supporting lumbosacral junction, substantially high degree of force is required to cause this type of fractures. In numerous case reports describing lumbosacral injuries, various injuries from facet fractures to lumbosacral dissociation were reported. These injuries are seen as unilateral or bilateral L_5-S_1 facet anterior, posterior and lateral dislocations. It was found that vertical sacrum fractures located at lateral of L_5-S_1 facet joint has no impact on lumbosacral stability. Injuries extending beyond L_5-S_1 facet joints, extra-articular fractures of lumbosacral joints and fractures extending from inside of L_5-S_1 joint to neural arc are complex and thus considered as instable.

AOSpine Sacrum classification is a new classification system and validation studies are still ongoing. It includes elements resembling to lower thoracal and thoracolomber classification systems. In this classification system, the fractures are categorized under three main subgroups. Type-A; lower sacrococygeal injuries, Type-B; posterior pelvic injuries and Type-C, Spinopelvic injuries. In type-A injuries posterior pelvis and spino-pelvic regions aren't affected but neroulogical deficit may accompany in high grade injuries. Type-2 injuries are unilateral longitudinal sacral fractures where ipsilateral S1 facet joint conserves its continuity with medial side of sacrum. These injuries have impact mainly on posterior pelvic stability and on spinopelvic stability though to a lesser extent. Type-B injuries are categorized into 3 subgrups according to the probablity of neurological deficit. Type-C injuries are injuries that result with spinopelvic instability and categorized into 4 subgroups. In this classification neurological condition of the patient is also considered in additon to fracture morphology. Finally, 4 different variables that may affect the treatment plan of sacral fractures are also taken into account in this classification (severe soft tissue injuries, metabolic bone disease, anterior pelvic ring injury, acetabulum injury or high energy injuries that may be associated with vascular injuries and changed anatomy of lumbosacral junction – anatomic or previous fusion).

NEUROLOGICAL INJURY

Sacral nerve injuries may occur as a result of different mechanisms and may manifest itself as mono-radiculopathy, numerous but unilateral radiculopathy and bilateral sacral nerve root involvement, partial or full fledged cauda equina syndrome [15,24] . Bilateral nerve root injuries at S4 or below may cause pain or motor deficits but don't cause bladder or bowel dysfunction [37]. Nerve root injuries may potentially recover and contusion, compression or traction caused by angulation or translation of fracture fragments or direct compression of bone fragments may all cause these injuries. Avulsion or cutting of nerves may cause irreversible neurological deficit. These may occur hours after the initial travuma or months after it as late injuries and their causes may be epidural hematoma, instability of fracture fragments or callus formation. In lower extremity neurological injuries muscle strength assessment for all muscle groups should be done by using 0-5 scoring. Gibbons et al. described a sacral neurological injury classification in order to detect the severity of the deficit (**Table-1**).

Table-1. Gibbons classification for Neurologic Deficits

Grade	Criteria
Grade 1	No neurologic deficit
Grade 2	Paresthesias / sensory changes only
Grade 3	Motor weakness or loss but bowel / bladder control intact
Grade 4	Motor and / or sensory deficits associated with loss of bowel / bladder control

LUMBOSACRAL DISLOCATIONS

This type of fracture dislocations were first described in the literature in 1940 by Watson-Jones. Since then, more than 100 cases have been published in the literature. Most of the reports were published as case reports or literature review [35].

Numerous and various injury mechanisms may lead to fracture dislocations of lumbosacral transitional vertebrae resulting with different grades of spondylolisthesis and may also lead to displacements towards various directions.

Fracture dislocation is rarely seen at L_{4-5} level [10].

Neurological Findings

Neurological findings may vary widely. In case reports with or without neuorological deficit the injuries may differ from the injury of a single nerve root to severe paraparesia or full fledged cauda equina syndrome. Full dislocations occurring posteriorly may cause avulsion of dural sac and nerve fibers and in anterior dislocations dural sac may be preserved from the injury if there is bilateral pedicle or pars interarticularis fracture. It has been observed that posterior dislocations may cause more severe neurological injuries [14]. Some authors have suggested that there is a correlation between the degree of slip and neurological deficit. In injuries with more than 33% slippage incomplete cauda equina injury was more common [18].

Radiological findings

In multiple injured patients, initial imaging should include AP and lateral radiographies of lumbar vertebrae. High quality imaging is required for proper diagnosis. In AP radiographies, as a finding of a rotational injury, it may be seen that spinous processes at inferior or superior of the lesion displaced laterally or vertebrae moves to the lateral. In sagittal images slippage, short segment kyphosis, increase in interspinous distance and narrowing of disc distance may be seen. Presence of transverse process fractures should lead to suspicion for presence of lumbosacral injury [27].

Particularly in patients with transvers process fracture and multiple injuries lumbosacral junction should be assessed by CT imaging. In the literature cases with late diagnosis are reported and in these cases there was persistant lumbosacral pain with or without pain spreading to legs [2]. Sagittal reconstruction allows a good assessment of bony structures and spinal canal diameter. However, if the examination is performed in the supine position slip in L_5 vertebrae may be less than expected.

In unconscious patients full body scanning by 3 dimensional CT is required in order to see probable injuries [16].

MRI imaging may not be readily performed in emergency conditions. It provides a good preoperative assessment in stable and neurologically intact patients. Presence of disc injury or narrowing of L_5 neural foramina by disc fragment may be shown by MRG very well and it may prevent worsening of neurological condition that may occur during reduction maneuvre. However, in presence of neurological deficit or cauda equina syndrome decompression surgery should be done even though MRI has not been performed [13].

Occasionally, fracture of spinous process of L_5 vertebra or promontorium may be seen [1].

CLASSIFICATION

Aihara et al. have described 5 types. [1]

Type-1. Unilateral facet dislocation with or without facet fracture

Type-2. Bilateral facet lock with or without facet fracture

Type-3. Unilateral facet dislocation with contralateral facet fracture

Type-4. Acute spondilytic olisthesis

Type-5. Fracture of vertebra body or pedicle with dislocation of body with or without injury of lamina and facet joints. Type 5 is similar to Hangman's type of fracture.

Vialle et al. have suggested a classification with 3 types and their subgroups[39].

Type -1. Full dislocation of facet joints without fracture

IA: Unilateral rotational dislocation

IB: Bilateral facet dislocation with dislocation to lateral, disc tear may be present

IC: Bilateral dislocation with anterior slippage

Type-2. Unilateral joint fracture dislocation, anterior slippage of L_5 vertebra, asymmetrical and intervertebral disc lesions may accompany injury

Type-3. Bilateral fracture dislocation with disc injury and olisthesis

IIIA: Bilateral facet fracture with dislocation or acute fractures of pars interarticularis

IIIB: Bilateral facet fracture with rotational displacement associated with anterior slippage of L_5 vertebra

In the classification systems of Magerl et al and Blauth et al. most of the lumbosacral dislocations are classfied as type B and type C lesions[7].

CLINICAL APPEARANCE

Traumatic lumbosacral dislocations may occur as a result of high-energy trauma and may rarely be seen as isolated injuries and pulmonary, vascular and head traumas that are frequently associated with these dislocations usually require emergency interventions. Due to high mortality related with these lesions actual frequency of lumbosacral dislocations may be lower than estimated[32]. Shen et al. have reported that 10% of lumbosacral fracture dislocations are overlooked initially[36].

In a few cases isolated trauma or associated mild lesions were reported. Anterior and posterior dislocations may occur as open fracture dislocations depending on the severity of the injury; thus they should be investigated. Hematoma, open wound, abrasion and scar tissue may be seen at lumbar region in direct trauma cases.

TREATMENT APPROACH

Until the publication of a surgically treated case in 1975 by Samberg, fracture dislocations were having being treated with closed reduction and often by trunk brace or bed rest. Both in children and adults successful outcomes were obtained by conservative therapy.

In most of the cases conservative therapy has resulted with late deformity associated with secondary worsening of neurological condition and progressive low back pain.

360° fusion is recommended in cases with intervertebral disc damage in whom posterior decompression of dural sac is required. On rotational injuries with unilateral lumbosacral facet dislocation posterior instrumentation and posterolateral fusion may be sufficient. Resection of facet joints may be needed to provide reduction. To obtain circumferential fusion it may be possible to combine PLIF and ALIF methods with posterior instrumentation[39].

TRAUMATIC SPINOPELVIC DISSOCIATION:

U-SHAPED FRACTURE OF SACRUM

Sacral fractures may cause pelvic instability; on the other hand, multi-planar and substantially displaced sacral fracture dislocations may end with spinopelvic instability or dissociation. Traumatic spinopelvic dissociation or sacral U-shaped fractures are characterized with bilateral sacral fracture dislocations and transverse sacral fractures that lead to mechanical dissociation of upper part of sacrum and vertebrae from the pelvis. Anatomically these fractures dissociate lumbar vertebrae together with upper central part of sacrum from both lower part of sacrum and pelvis at sacral ala region. The term traumatic spino-pelvic dissociation is coined by Bents et al. in order to differentiate this type of injury from lumbosacral fracture dislocations or bilateral sacro-iliac joint dislocations[6]. It occurs as a result of high-energy injuries associated with high frequency of neurological deficits and debate regarding its diagnosis-treatment is still ongoing.

Only 3-5% of sacrum fractures are transverse sacrum fractures. U-shaped sacrum fractures are much rarer and publications in the literature are mostly case reports and small-sized case series.

U-shaped fractures of sacrum occur as a result of high-energy injuries leading to severe axial load on vertebrae [5]. A frequently encountered injury mechanism is jumping from heights with suicidal intent [33]. Other frequent causes are falling from heights, motor vehicle accidents and crush injuries. Rarely gunshot wounds may cause sacral injuries. Frequently local soft tissue injuries, bleeding and other orthopaedic injuries with high mortality may be associated with sacral injuries[6, 33].

Fragmentation and displacement of fracture may cause injury of sacral nerve root and this may lead to neurological deficits varying from incomplete monoradiculopathies to full fledged cauda eqina syndrome affecting lower extremity functions as well as bowel and bladder functions.

Clinical evaluation

Diagnosis of traumatic spinopelvic dissociation may be overlooked or delayed due to difficulties in imaging of upper part of sacrum and associated severe injuries. [20] If left undiagnosed and untreated painful deformities or progressive neurological deficit may occur[34]. Late corrective surgery is more difficult and outcome is usually poor. Since it's an easily overlooked injury, when a patiens presents with sacrococygeal pain sacrum injury should be suspected[38].

TREATMENT OF SACRUM FRACTURES

Conservative treatment

This treatment option includes activity modifications, bed rest, brace or cast immobilizations, lumbosacral corset with unilateral or bilateral hip extensions or skeleton traction.

Conservative treatment of sacrum fractures was mandatory befor advancement of surgical techniques but currently it's only an option.

Convervative management may be considered in patients with unilateral minimally displaced sacrum fracture without neurological deficit. In patients experiencing lumbopelvic ligamentous injury with marked displacement outcome of conservative management is poor.

In clinically stable pelvic ring injuries rotational movement, sitting in wheel-chair or assisted walking may not be markedly uncomfortable. If conservative treatment is decided in patients with marked displacement 8-12 weeks of bed rest and traction should be applied and the process should continue by application of braces. Evaluation of the outcomes of convervative treatment in patients presenting with posterior displacemet of pelvis usually reveals malunion of bones and long period of bed rest may cause pain.

Particularly in multiple injured patients prolonged bed rest is not desired. Recent studies have shown that surgical stabilization of pelvic ring injuries in multiple injured patients allowed early mobilization of patients, decreased early mortality and resulted with good long term outcomes[5, 17, 19].

Timing of intervention

Non-pathological fractures of sacrum occur as a result of high-energy trauma. The priority of the doctor should be the survival of the patient. Reducing pelvic volume may be useful in patients with open-book type pelvis ring injury associated with hypovolemic shock. Reduction of pelvic volume may be provided by various methods such as anterior external fixator, pelvic clamp or a tight wrapping (ie., bed sheet) around pelvic ring

Damage control orthopaedics principles should be applied (transient fixation and later definitive treatment). [30]

While planning for further therapies counter-measures for probable active bleeding, maintaining hemodynamic stability and evaluating neurological deficits and associated soft tissue injuries should all be considered. Active perisacral bleeding may be controlled effectively by angiographic embolization. However, bleeding due to displaced pelvic ring fractures is usually venous and thus less responsive to intravascular hemostasis.

Open sacral fracture and rectum perforation or perineal tear or dorsal soft tissue injury dictate routine surgical debridment as soon as general condition of the patient permits. In patients with progressive neurological deficit due to sacral fracture or posterior pelvic ring injury early decompression and internal fixation should be planned. In patients with established neurological deficit due to sacral injury surgical decompression is controversial, since its proper timing and risk-benefit ratio is not clearly known. In patients with displaced sacral fracture emergency surgery brings high risk of marked blood loss and high potential of wound-site infection. Thin dorsal presacral tissue region which is consisted of muscle, fascia and skin is an area prone to contusion and injuries.

Wound-site infection rate is 25% after open reduction and internal fixation of pelvic ring fractures by an intervention with posterior approach. Furthermore, potential of cerebrospinal fluid leakage following traumatic dural tear may be added to this risk. If there is sacral root cut after the trauma, early sacral decompression surgery may be a vain effort. On the other hand, prolonged compression of the nerve roots reduces the probability of neurological recovery.

In patients with traumatic lumbosacral root compression, if decompression surgery is performed in a later period exceeding 2 or 3 weeks residual sympoms such as pain and dysesthesia may become permanent. Outcome of the late decompression of post-traumatic sacral root compression is poor. Also, open reduction and internal fixation of displaced pelvic or sacral fractures after 2 weeks are more difficult.

In sacral fracture patients without neurological deficit emergency surgical intervention and open reduction is rarely indicated. In displaced transverse sacral fractures with angulation sacral soft tissue at posterior may be injured. Complex soft tissue injury may be prevented by correcting angulation of the fracture by early surgical intervention. Except above mentioned emergency surgery indications, most of the patients with sacral fractures may be operated safely and effectively between 48 hours – 2 weeks interval.

DECOMPRESSION METHODS [9, 42]

Indications of decompression surgery in patients with sacral fracture associated with neurological deficits aren't fully described. As reported in various studies, neurological recovery after sacral fractures is indepedent from whether the treatment was conservative or surgical in nearly 80 % of patients. There is consensus over performing decompression in patients with Denis zone fractures associated with cauda equina syndrome [(23)]. However, treatment of neurological deficits except cauda eqina syndrome is controversial. There is data showing positive outcomes of nerve root decompression, but except cauda equina syndrome evidence favouring nerve root decompression relative to convervative treatment in terms of more positive clinical improvement is scarce. In many patients with sacral fracture associated with neurological deficist, at least partial recovery without decompression has been reported [(3,8, 43)]. In theory, while decompression alone may increase the probability of nerve recovery in sacral nerve root injuries, and need for large surgical dissection and it prolongs the surgical time needed for surgical stabilization. Nerve decompression may not be successful by only laminectomy or foraminectomy. Without fracture alignment and stabilization decompression of nerve roots may not be possible.

Dorsal laminectomy may provide decompression of neural foramina and sacral canal when employed together with reduction and stabilization of both transforaminal and transverse sacral fracture components. By dorsal approach to reach kyphotic and slipped upper part of sacrum may often be possible. Reduction may be applied by different methods. Impaction of superior and inferior parts of sacrum may be dissociated by placing an elevator to transverse fracture line. After obtaining mobility between fracture ends, reduction of upper part of sacrum may be possible by fixating with Shanz screw that is placed between S_1 and S_2 roots and later this screw may be used as a maneuver lever to correct the angulation at sagittal plane. When needed traumatic dural injuries should also be repaired.

Dorsal or ventral sacral approaches are both possible but for decompression dorsal approach is clinically more preferred technique.

Ilioinguinal or low transperitoneal approach may be considered in a limited patient group with Denis zone I fracture for neurolysis when neurological deficit as a result of L_5 root entrapment caused by anterior displacement of alar region and hypertrophic new bone formation occurs. However, there is inadequate date to decide for success rate of this method.

Post-traumatic sacral foraminal narrowing usually affects the first two foraminas and may be seen after Denis zone II fractures.

Nerve root damage at foramina may be an indicator of foramina fragmentation or these injuries may occur after reduction of pelvic ring fractures. Sacral decompression should be considered if 50 % or more narrowing of first or second sacral foramina associated with symptoms like siatalgia exists.

For open reduction and internal fixation or isolated sacral foraminotomies of sacroiliac fracture dislocations unilateral or bilateral parasagittal longitudinal approaches were described. Hemilaminotomy from the midline to L_5-S_1 space is preferred over parasagittal approaches for many reasons. Midline approach provides better approach to ventral sacral foramina and better orientation despite distorted anatomy after the trauma. While comprehensive lumbopelvic stabilization may be established by similar midline approach, to reach lumbar vertebrae may not be possible by parasagittal approach. Usually bilateral parasagittal approach is required for stabilization. With this bilateral approach dorsal soft tissues that have been already injured during the trauma may further be injured and this in turn may increase complication risk during wound healing.

Central decompression of sacral spinal canal may also be performed by removal of sacrum dorsal neural arc. Subsequently, sacral roots are followed and a wide blunt probe is advanced laterally until it passes around the nerve at ventral sacral foramina. If the displaced body of sacral vertebrae is in contact with sacral root or compresses it, decompression of the canal may be provided ventrally by fracture reduction or kyphectomy. Central kyphectomy may be performed after isolation of sacral roots following sacral laminectomy. After controlling bleeding caused by dense epidural venous plexus surrounding sacral nerve roots and veins are taken to lateral in order to facilitite visualization of ventral spinal canal and surrounding structures. Fracture ends are corrected with high-speed burr or osteotom.

SURGICAL STABILIZATION METHODS

With the advances in segmental fixation instruments and improvement in sacroiliac fixation methods reduction and stabilization ability of the surgeons have increased dramatically in pelvic ring injuries including sacrum. Before trying reduction and fixation of dorsal pelvic ring the need for ventral stabilization of pelvic ring should be assessed. In pelvic ring fractures anatomic reduction and stabilization of anterior part may be easier than posterior part. Intrumentation from the anterior may provide stabilization of posterior ring alone, but it may guide the surgeon for the intervention to the posterior. Instrumentation options that may be used in the anterior are external fixation, anterior plate and retrograde pubic screws.

Methods for stabilization of posterior of pelvic ring are posterior transiliac grooved compression rods, open posterior-tension band plate method or percutanous sacroiliac screw fixation methods.

Posterior fixation by sacral bar and posterior tension band plate method aren't effective in Denis zone III fractures with transverse component. Neutralization of rotational forces at sagittal plane may be beneficial.

Sacral ala plates may be used for stabilization of transverse fracture component. Its shortcoming is inability to neutralize severe loads exceeding lumbopelvic junction because of inadeaquate fixation of fragmented or osteopenic sacral ala region. This method may be used together with iliasacral screws in order to increase stability of longitudinal fracture components.

Percutanous iliasacral screw method is a minimally invasive surgical fixation method but it can't correct sacral angulation as a disadvantage. Advantages of percutanous method are reduction of soft tissue damage and provision of rigid stabilization at supine position in traumatic patients. Indications for percutanous internal fixation are zone I and zone II fractures where efficient reduction and effective c-arm use is possible.

Recently, CT-guided sacroiliac placement is described. This method is time-consuming, reduces the chance for using external reduction maneuvers and redundant for surgeons trained for c -arm guided screw placement method. Risks of the method are reduction loss and malpositioned fixation. In rare cases penetrating injury or nerve, vessel or intrapelvic injuries due to screw are reported. If there is associated foraminal fragmentation in patients with Denis zone II fractures, secondary foraminal entrapment may occur due to overcompression during screw placement. Anatomic limitations of percutanous sacroiliac placement are failure to provide closed reduction and presence of abnormal lumbosacral anatomy.

Nork et al. have reported succeseful implementation of percutanous iliosacral screws in U-shaped mimimally displaced sacral fractures without severe canal or foraminal narrowing [28]. Other authors have reported that this method is not convenient in treatment of more instable, displaced, comminuted and irreducible Roy- Camille type 2-4 injuries [34,40]. Limitations of iliosacral screw fixation are reduction in catching force of the screw due to comminution of S_1 vertebra body, inadequacy of single iliosacral screw to stabilize sagittal deformity, iatrogenic nerve injuries due to compression or dectruction of sagittal deformity. Using 2 full grooved screw is recommended to avoid compression of fragmented bone comminution. Percutanous iliosacral fixation method is convenient for non-fragmented and minimally displaced U-shaped sacrum fractures.

Previously, in internal fixation of zone III fractures with transverse fracture components bilateral alar plating described by Camille et al. was in limited use. However, due to collapse of fracture line and weak attachment of screws because of hypodense bone structure of ala adequate stabilization couldn't have been provided. Due to protrusion at posterior using conventional spinal instrumentation such as hook and screws in not convenient. Galveston type fixation method used in deformity surgery is not routinely used, since it's not biomechanically stable and inadaptable to trauma.

Recently two studies showing combined use of iliac screws with lumbar and sacral pedicle screw fixation system have been published. Luque rods are used in a method similar to screw pathway method of iliac component and by the help of 9 mm thick 130 mm long screws and rods tightened to L_5 and S_1 pedicle screws at superior. This method has superiority over sacroiliac fixation in terms of stability and has low profile.

In Roy-Camille 3-4 type zone III fractures the most stable internal fixation structure can be maintained by open fraction reduction following neural canal decompression, L_5 and if possible S_1 pedicle screw fixation, bilateral screw fixation and rod connection. Supportive sacroiliac screws may be placed after fracture reduction and before posterior lumbosacral fixation. In patients with lumbosacral fracture-dislocation segmental lumbosacral instrumentation using pedicle screws may be a therapeutic option. Advantages of this fixation method are absence of displacement and fixation loss despite aggressive decompression of sacral nerve decompression and causing no healing problems despite permission for early loading **(Figure-1).**

Triangular fixation is a relatively new method applied in treatment of vertically instable sacrum fractures. This fixation method is rigid; it allows early loading and decompression of neural structures[41]. In a cadaver study, translation and rotation stability after application of 2 transsacral screws were reported to be nearly as stable as triangular osteosynthesis [26] **(Figure-2).**

Recently, Rhee et al. have used newly designed segmental lumbopelvic fixation system in treatment of fragmented U-shaped fractures. In this sytem, iliac screws are tightened to rods via modular connectors and thus allows avoidance from 3 dimensional rod formation [31].

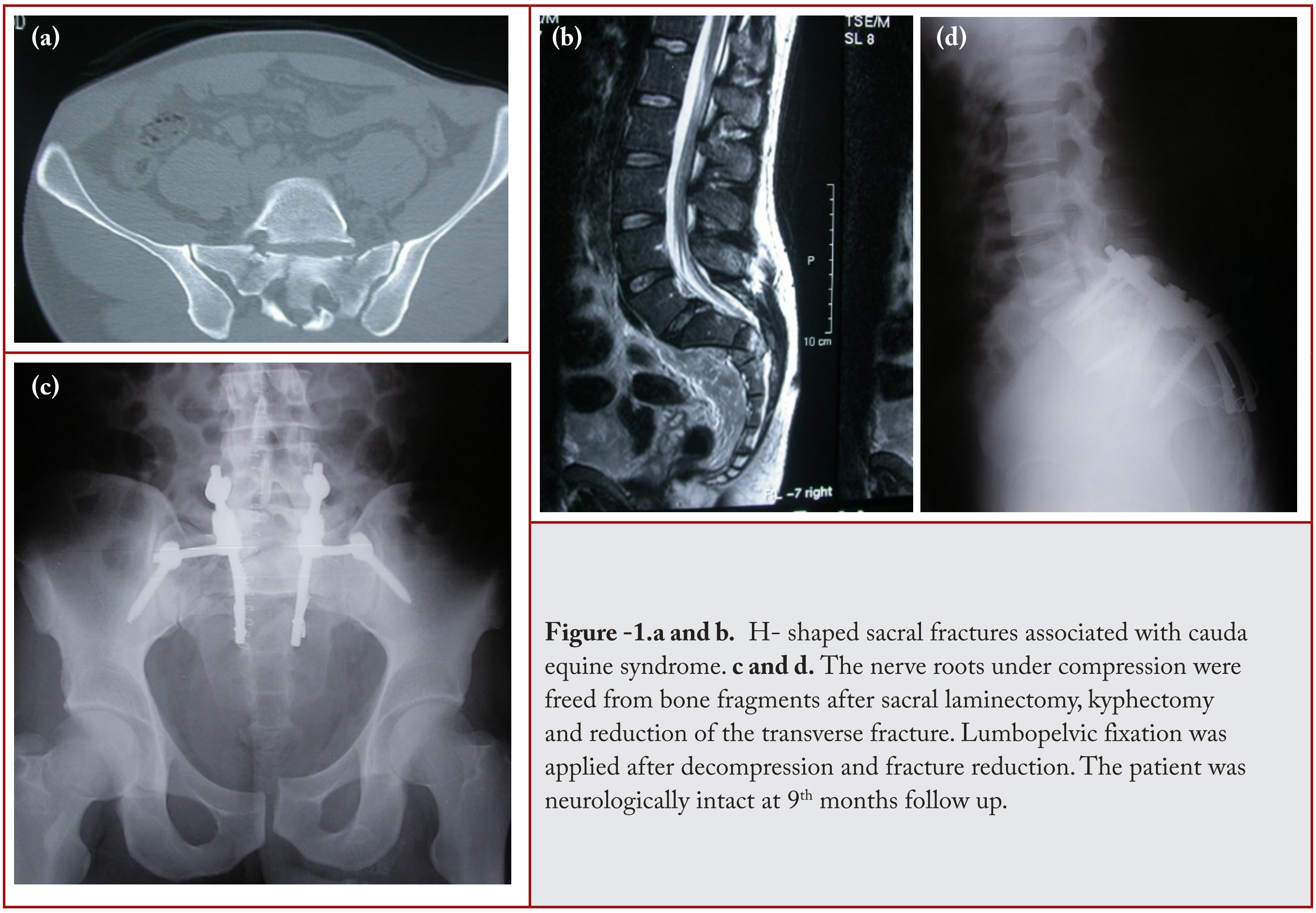

Figure -1.a and b. H- shaped sacral fractures associated with cauda equine syndrome. **c and d.** The nerve roots under compression were freed from bone fragments after sacral laminectomy, kyphectomy and reduction of the transverse fracture. Lumbopelvic fixation was applied after decompression and fracture reduction. The patient was neurologically intact at 9^{th} months follow up.

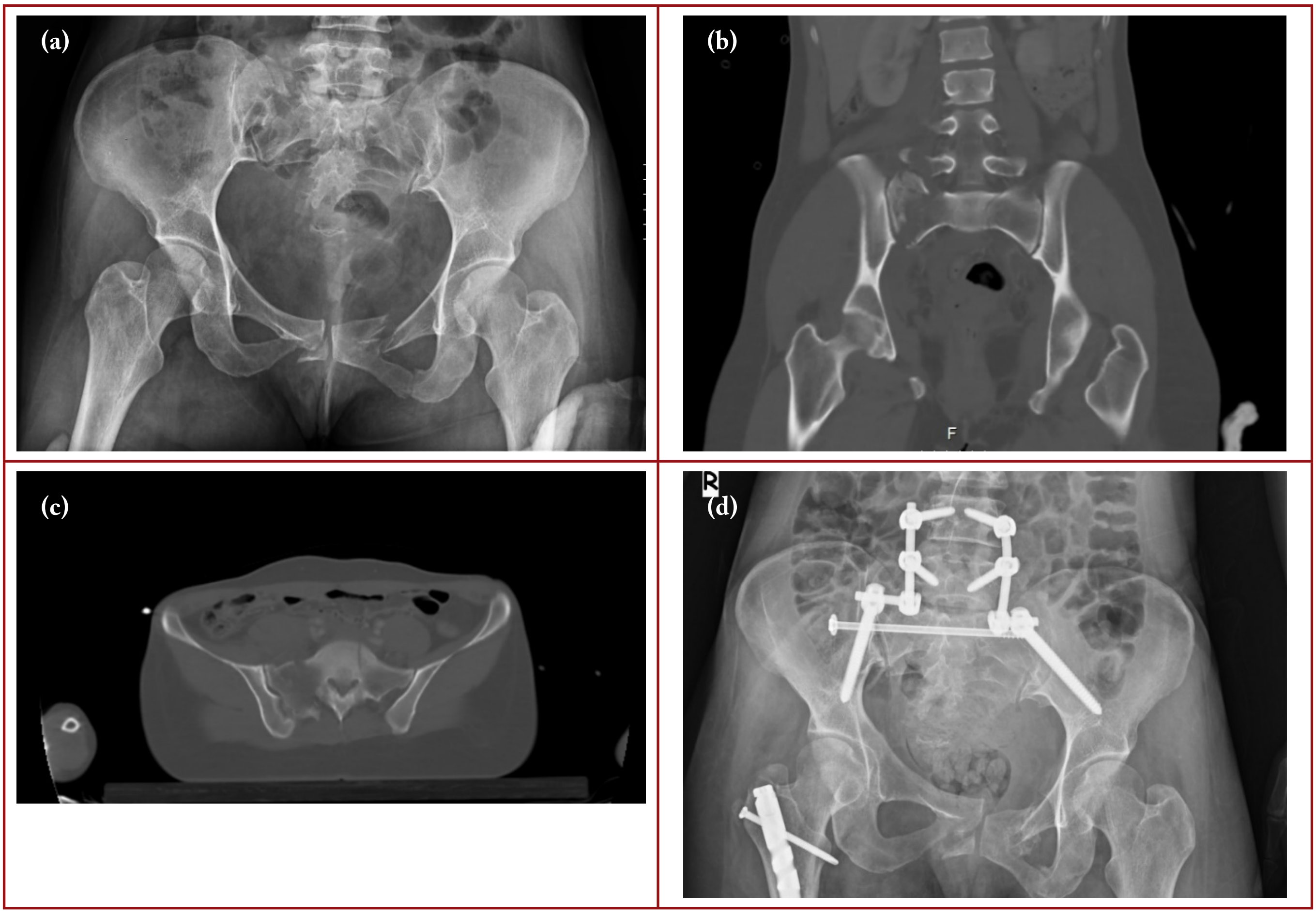

Figure – 2 a,b and c. Initial CT and x-ray images from illustrative case. Longitudinal fractures are noted in the right sacral ala and L5 transverse processes and in the left sacral body with involvement of the anterior pelvic ring. **d.** Post-operative radiograph demonstrating triangular osteosynthesis for bilateral sacral fractures.

RESULTS

The most important factor that has an impact on life quality of the patients is neurological deficit. In a significant proportion of patients due to the severity of associated injuries a proper neurological examination may not be performed. Thus, assessment of recovery or worsening of neurological condition may be difficult after surgical treatment of sacrum fractures. In sacral fractures manifested as spinopelvic instability neurological recovery is independent from whether the treatment was conservative or surgical in nearly 80% of patients. However, the type of the incident that caused the injury, the degree of recovery and criteria of assessment reduce the reliability and relevance of the reported recovery.

Vaccaro et al. have reported little chance of neurological recovery when bilateral nerve root cut-off or avulsion exist [38]. However, decompression and fracture reduction have substantial impact on recovery if the cause of nerve deficit is fracture fragments or nerve root compression due to angulation of fracture line, and early recovery may be observed. Schidhauer et. al have reported greater chance of recovery when neurological deficit is incomplete [34]. In their series recovery from bowel and bladder dysfunction was 85 % in patients with intact nerve root; however, in those with at least one sacral nerve root injury recovery rate was 36 %. It was shown that decompresion increased the rate of nerve recovery.

Proper reduction and fixation lead to nearly perfect bone union rates. Nork et al. have published succeseful outcome of sacroiliac screw treatment performed in 13 patients with non-fragmented minimally displaced Denis zone III fractures [28]. In a publication by Gribnau et al. regarding life quality of patients after U-shaped sacral fractures, in 8 patients treatment included percutaneous iliosacral fixation, transsacral plateosteosynthesis and transsacral plate or triangular osteosynthesis with or without plates. Following 36 months of follow up pain and mobility problems influenced general health status of the patients [17].

COMPLICATIONS

Complications associated with surgical treatment of sacrum fractures may be related with the wound-site such as hematoma, seroma and infection. Skin irritation caused by iliac screw may cause local pain and rarely decubitus ulcers and infection. This may cause severe problems particularly in patients with multitrauma and patients losing weight due to catabolic causes. Diet of these patients should be closely monitored. This problem may be solved by shaving of posterior iliac processes where iliac screws will be located by rounger or placing them more medially.

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Volume: 28, Issue: 4, October 2017 pp: 277-282 REVIEW ARTICLE

CLASSIFICATION OF METASTATIC SPINAL TUMORS

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ABSTRACT

The vertebral spine is the most common location for bone metastases. Its incidence has been increasing due to increasing expectation of life and the amount of elderly in our population. Around 70 % of cancer patients shows evidence of spinal metastasis and 10% of these lesions put pressure on the spinal cord. Prognostic indicators were defined for most beneficial surgical approach and indication for surgery. Metastatic tumor classifications were designed and several clinics have commenced to use them for treatment modality choice.

Key words: Metastatic spinal tumor, spinal tumor classification, spinal metastasis

Level of Evidence: Review article, Level V

INTRODUCTION

The vertebral spine is the most common location for bone metastases [27]. Its incidence has been increasing due to increasing expectation of life and the amount of elderly in our population [1]. Around 70 % of cancer patients shows evidence of spinal metastasis and 10 % of these lesions put pressure on the spinal cord [4]. The most common causes of spinal metastasis are cancers of the breast, lung, kidney, prostate, thyroid, colorectal, as well as melanomas, myelomas and lymphomas [28].

Parallel to the development in technology, the effective improvements in tumor surgery have also contributed to an increased quality of life. Before, decompressive surgery was performed and upon receiving bad results, radiotherapy was supported as the superior treatment option [7,18,25]. New technologies allow metastatic spinal tumor surgeries to stabilize better, to release the pressure on the spinal cord, and to decrease the pain. However, its effect on the prolongation of the average life expectancy is debatable. By anterior and anterolateral stabilization approach, the benefit of surgery plus post-operative radiotherapy instead of only radiotherapy has been proven by various studies [4,15].

Currently, surgical treatment modalities for metastatic tumors are dominating.

Prognostic indicators were defined for most beneficial surgical approach and indication. For patients whose life expectancy is over 3 month surgery is recommended. Other than, the life expectancy prediction by oncologists, additional factors such as, tumor spread and degree, preoperative life standard, postoperative expectations must be categorized and planned by surgeons [17]. For this reason, some classifications were designed and several clinics have commenced to use them.

SCORING SYSTEM FOR METASTATIC SPINAL TUMORS

It was tried to classify metastatic tumors according to symptomatic, anatomic and prognostic data and results of treatment strategies were obtained.

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Tomita prognosis score

Tomita analyzed several prognostic values and developed a prognostic scoring system based on 3 factors [23]. These factors are growth rate of a primary tumor, number of metastasis and internal organ metastasis. According to this system, data rated between 2 and 10 were considered as good prognosis, rates higher than 10 were considered as poor prognosis. Tomita created this system based on a retrospective study of 67 patients from 1987 and 1991. The primary tumor was identified and a relation between their kind and the survival rate was established, hence Tomita tried to respect the primary type of tumor in his classifications. According to this data, the survival rate of patients suffering from metastasis due to primary foci of the breast, prostate, thyroid, as well as myeloma presented to be longer compared to the other causes of spinal metastasis [23,29].

Tokuhashi prognosis score

Tokuhashi has created an evaluation system, based on 6 different parameters [20]. After observing the strong relation between the type of the primary cancer and the average survival rate, he restructured his scoring system [21]. The parameters include primary cancer type, existence of paralysis, Karnofsky performance status, number of extra spinal metastasis,vertebral corpus metastasis and internal organ metastasis. The grading system goes from 0-15, 0 representing the worst and 15 the best prognosis. The most important factor for the grading system is the primary cancer type; hence, thyroid, breast, and prostate cancer and carcinoid tumors receive 5 points, whereas lung cancer, osteosarcoma, gastric cancer, bladder cancer, esophagus cancer, and pancreas cancer receive 0 points. Tokuhashi et al. reported the prognostic factors not to be significant if alone but rather more meaningful when grouped [21].

As much as Tokuhashi's study supported the importance of paralysis, other studies did not find the pressure on the spinal cord caused by metastatic diseases or neurologic symptoms to be relevant regarding life span. Paralysis, which is due to compression of the tumor mass and the rapid growing of tumor mass, is also described as a parameter for a negative prognosis [16]. Zou et al report the Tokuhashi score to be successful in estimating short term survival rates, as well as the Tomita score to be meaningful regarding long term survival rates [29].

Harrington Spine Metastasis Scoring System

Harrington has established a classification system based on spinal instability and neurologic involvement, grading it with points going up to 5 [8]. According to Harrington, spinal instability, neurologic involvement, and mechanic pain are indications for surgical intervention. He stresses the superiority of surgery above radiotherapy. However, his scoring classification is not widely used due to different types of diseases being graded equally.

Anatomic Scoring System of Metastatic Spinal Tumors

Primary tumor progression is said to lead a major role in anatomical scoring of metastasis [19]. When planning a surgical intervention, more data is required concerning the anatomic location of the tumor.

CLASSIFICATIONS

Tomita Anatomical Surgery Classification

Tomita specified internal/external involvement and spreading of the vertebrae (metastasis) [22-23]. His classifications described the tumoral involvement of the vertebra starting from the corpus leading to the pedicules, the posterior columns, the extradural and paravertebral area, the neighboring vertebra, and finally to non-neighboring vertebrae. This scoring system allows for easily memorable tumor spreading as it follows a systematic description. However, the tumor may not always spread according to this course. Surgeons mostly face pathologies between type 4 and type 7 (Figure-1).

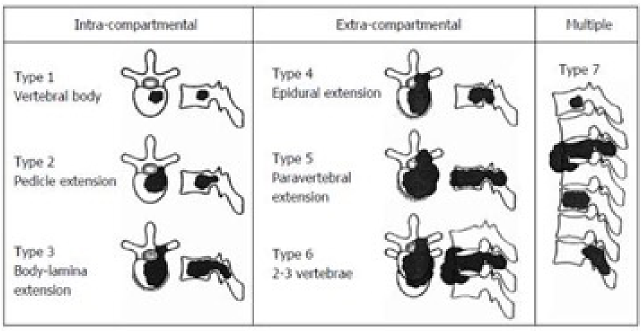

Figure-1. Tomita Anatomical Surgery Classification

McLain-Weinsteins Classification

The McLain-Weinstein classification divides the vertebral anatomy into 4 parts and 2 concentric levels [14]. Using this classification is very easy; however, it lacks detailed classifications in tumors of the third and fourth category.

Enneking Classification:

Enneking had classified primary long bone tumors and transcribed that classification to spinal tumors [6]. In this classification, benign tumoral involvement were described in 3 degrees, malignant tumor localizations in 4 levels, and metastatic high graded tumors in 2 levels. For this classification, histologic data and expansion of tumor throughout the body must be specified. Not being able to give a prognosis and involving extradural spreading and pressure signs when evaluating the patient are disadvantages of this classification (Figure-2) [6].

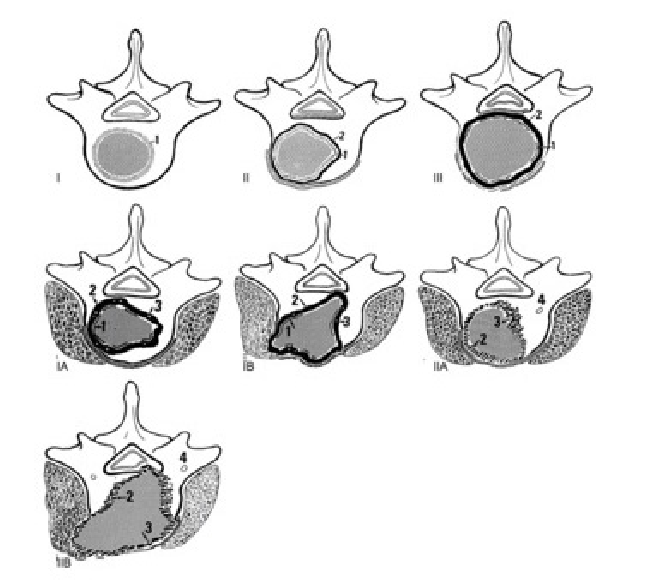

Figure-2. Enneking Classification

Weinstein-Boriani-Biagini (WBB) Classification

The WBB classification gives detailed information on the axial spreading of the tumor [2]. For this classification, a vertebra is viewed on axial cut, centering the spinal cord. The vertebra is then divided in a clock-wise manner and the areas involved are further broken down into sections. This classification is mostly chosen for surgical planning rather than prognosis establishment (Figure-3).

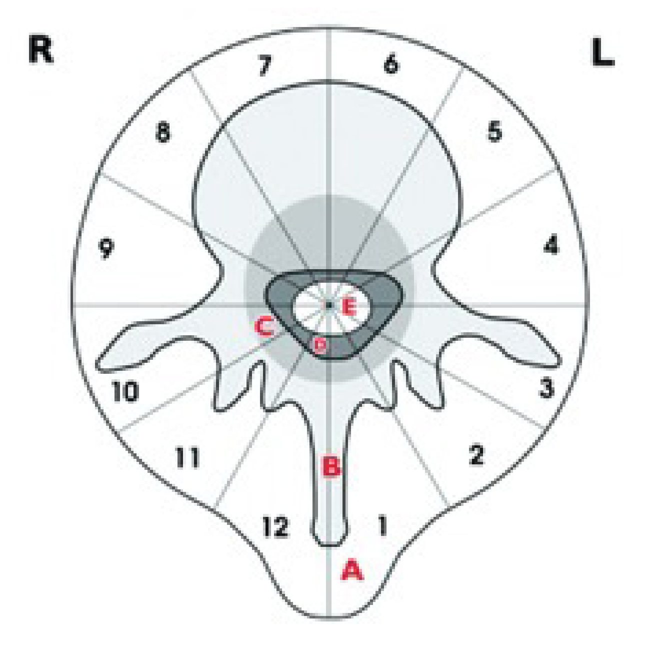

Figure-3. Weinstein-Boriani-Biagini Classification

Friedlander-Southwick Malignant Tumor Staging

As reported by the staging of Friedlander and Southwick, low grade tumors resting within the compartments present better prognosis comparing to higher graded tumors or tumors protruding outside of the compartment, which classified to show worse outcomes [27]. According to this staging, stage IA and IB require adjacent normal tissue to be removed with the entire tumor. In stage IIA, however, the entire removal of the compartment is advised. In case of a IIB lesion present in one extremity, radical amputation is advised, yet this normally used technique in other bone tumors can not be done in the spine due to following post-operative neurologic and stability issues. In this case, intralesional or marginal excisions may be advised.

USE OF CLASSIFICATIONS AND SURGICAL STRATEGIES

Although anatomic classifications are considered useful, Tomita and Tokuhashi classifications are the only long-term studies performed [20-22]. It is recommended to perform broad surgical resection on Tomita 2-3 scored patients, marginal or intralesion intervention for Tomita 4-5 scored patients, palliative surgery for Tomita 6-7 scored patients, supportive treatment for Tomita 8-10 scored patients [23].

The mean life expectancy of patients with good prognosis score and broad surgical resection was estimated to be 38,2 months, in patients with mild graded lesion approach mean life expectancy was estimated to be 21,5 months, and in patients with poor prognosis had only palliative treatment and stabilization, as their life expectancy was estimated to be 10,1 months according to Tomita et.al studies performed on 61 patients [22-23]. Due to these results, the Tomita classification was considered to be useful.

Tokuhashi on the other hand uses a different point of view, where patients with a good prognosis score of 12-15 were advised to undergo excisional surgery, intermediately well patients with a score of 9-11 to receive palliative surgery, and patients with a scoring of 8 or less to be given conservative treatment. His study on 118 patients revealed a statistically significant difference in the expected life span according to his classification and post-operative grading of life expectancy [20-21]. The obtained data was understood to aide in choosing surgical strategies and life span. Studies performed after the before mentioned model showed 80 % of the patients to be satisfied following surgical intervention as their treatment plan [5,26]. The best results were defined as the cessation of pain, nausea, fatigue, and anxiety. Long term results are expected to be obtained from polycentric studies, utilizing spinal metastasis prognosis, anatomic, and surgical classification [3-4,12,24].

The primary sources of the metastasis are of significant importance, as the primary cancers have very specific characteristics, which need to be evaluated. Breast cancer usually spreads its metastasis to the cervical and upper thoracal area, being sensitive to radiotherapy [17]. They respond well to hormone and chemotherapy. In these cases, surgery is recommended if spinal instability, increasing neurologic deficits, and excruciating pain are present [13]. Metastasis due to prostate cancer also respond well to hormone treatment and radiotherapy, but if surgery is recommended, aggressive excision must be considered given the patient's overall situation as their average life expectancy is staged as high [11,27].

Metastasis caused by lung cancer are different, as adenocancer may respond well to radiotherapy. However, as much as Small Cell type, accepted to be more of systemic disease, reacts favorably to radiotherapy, Squamous Cell type destroys the bone creating a breakdown and is resistant to radiotherapy [17]. In these patients, palliative surgery is only advised if excruciating pain or rapidly increasing neurologic deficits are present [9-10].

A complication risk of 20 %-30 % is estimated for spinal metastasis surgeries [27]. Considering these facts, surgeries must be planned carefully. All prognostic factors and classifications must be analyzed and evaluated in order not to decrease the quality of life of the patient.

Table-1. Tomita Prognosis Scoring Table

	1 POINT	2 POINTS	4 POINTS
Primary tumor	Slowly growing	Intermediate growing	Rapidly growing
Internal organ met.	-	Can be treated	Can not be treated
Bone metastasis	Single	Multiple	-

Table-2. Renewed Tokuhashi prognosis scoring system

	0	1	2	3	4	5
Karnofsky Performance (%)	10-40	50-70	80-100	-	-	-
Mets outside of spine	3 or more	1-2	0	-	-	-
Mets in spine	3 or more	2	1	-	-	-
Internal organ met.	Not removable	Removable	None	-	-	-
Primary cancer	Lung	Liver	Others	Kidney	Rectum	Breast
Palsy	Frankel A,B	Frankel C,D	Frankel E	-	-	-

Table-3. Harrington Spinal Metastasis Score

1	No neurologic involvement
2	Bone involvement, no instability or collapse
3	Neurologic involvement without bone involvement
4	Pain at vertebra or instability with collapse, no neurologic involvement
5	Pain at vertebra or instability with collapse and neurologic involvement

Table-4. McLain and Weinstein spine metastasis anatomic classification

1. AREA	From spinous process to pars and inferior facet
2. AREA	From superior facet to transverse process and pedicle
3. AREA	¾ anterior of vertebral body
4. AREA	¼ posterior of vertebral body
LEVEL A	Intraosetal
LEVEL B	Extraosteal
LEVEL C	Tumor spreading to non-neighboring area

Table-5. Friedlander-Southwick malignant tumor staging

GRADE	STAGE	METASTASIS	AREA	SURGERY
IA	Low	None	Intracompartmantal	Block excision
IB	Low	None	Extracompartmantal	
IIA	High	None	Intracompartmantal	Excision of tm with compartment
IIB	High	None	Extracompartmantal.	Intralesional
III	Mixed	Yes	Mixed	

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ABSTRACT

Prof. Dr. Can Solakoğlu was born in 1962 in İstanbul. He was the oldest son of his family. Since his father was an Officer, he had been in different locations in Turkey until he entered to Kuleli Military High School. After graduation from this school with an honor degree in 1980, he became a military Medical Student at Ataturk University in Erzurum, later he transferred to Gülhane Military Medical Faculty of Medicine in Ankara. After graduation in 1986, he served as a medical doctor for 2 years in Artvin and during this period, he was sent to Military Medical Center in San Antonia - Texas, USA for Public Heath in the field. Started his 4 years specialty in Orthopedics and Traumatology in 1990 in GATA. He worked as an Assistant Prof in 1995-1997, GATA Hospital, Ankara, Turkey.

He served as an Military Health Attaché at Turkish Embassy,Washington DC in 1997-2000.

He took his Associate Professor degree in Orthopaedics in 2004 at GATA Haydarpaşa Teaching Hospital, Istanbul, Turkey. His interest in spinal surgery turned to full contribution in this field and has opportunity of becoming a research fellow under the supervision of Ziya Gökaslan John Hopkins Hospital in Baltimore. He became professor at Maltepe University in 2012.

His interest of field and publication mainly focused on Spine and Arthroplasty surgery. He had 65 international, 30 national articles.

Key words: Prof. Dr. Can Solakoğlu, Spine surgery, GATA, Maltepe University

Level of Evidence: Biography, Level V

INTRODUCTION

Prof. Dr. Can Solakoğlu was born in 1962 in İstanbul. After graduation from Gülhane Military Faculty of Medicine (GATA) in Ankara. He started his specialty in orthopedics and traumatology in 1990-1994 in GATA. He worked as Assistant and then Associated Professor in Orthopaedics, GATA Hospitals. Then he retired and started to work in Maltepe University as a Professor and chief of the Orthopaedics and Traumatology Clinic **(Figure-1).**

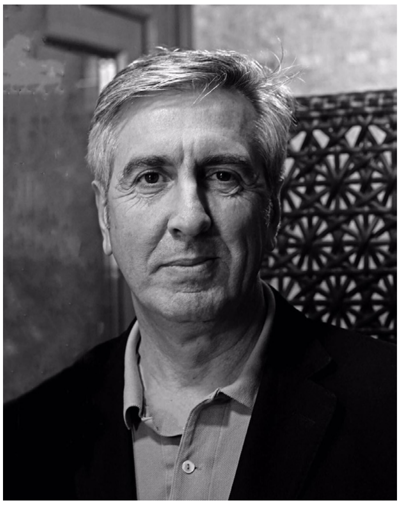

Figure-1. Prof. Can SOLAKOĞLU, M.D. (1962-2017).

Dr. Nurullah Ermiş:

First, I met him in a spine meeting. Our friendship started just as a colleague. I was working in public hospital and he was in GATA Haydarpaşa Hospital. One day he called me and asked me to work together in university hospital. I had many questions about university, payments and other things. He just said trust me and I approved. We started to make plans for our new clinic in his private office. In June 2011 we started. Before us, the clinic had nearly 10 surgery per month and 20 outpatients per day. 6 months later, we were doing 80 surgery and 500 patients in clinic. At that time we were not just a colleague and we were best friend each other.

We started to go Azarbeycan to do surgeries. Moreover, some foreign orthopedic residents came to our clinic as a research fellow.

It was a great honor for me to work with him nearly 6 years.

Things I learned from Can: "You can always smile. It makes you feel good and it brighten the day for others. It does not cost anything either. You can always take the fun part of life what you do. This doesn't cost you anything but make your and others' day brighter. Don't complain, find a solution. I never heard Can complain. He was too bust determining the next best next step."

Thank you Can Hoca…

One of his best friend from Kuleli Military High School, ***Prof. Dr. Melih Özel*** says;

Often we are given an honor that surpasses what we deserve. Writing about Can Solakoğlu is an honor for me. We were old friends, who have been together for over forty years. I can regale you with a lot of stories or amusing anecdotes about attending a game, watching TV, making field trips, working together in the same hospitals both here in Turkey and abroad. We did have those times together. Some of you probably only knew Can a short time. You know he did serve at the front. He never stayed at the rear and he served well everywhere he worked.

He was once the Dean of Maltepe University Medical School. He was the Chief of Orthopedics. In the past, he served in the Military at various Hospitals and Medical Schools and he served as the Military Medical Attaché at the Embassy of Turkey, Washington D, and USA. I had the privilege of serving with him in almost all of those settings. What he has left behind in all places he has worked was remarkable and unforgettable.

He was always full of energy and joy. He played volleyball and tennis; he was a very energetic fan of football and Galatasaray. He was very keen in finding the amusing parts of games and making fun of all these tools in life. The tragedy that separated him from us, hit unexpectedly and hard. He was a very careful motorcyclist. In addition, he died while he was doing one of the things he loved to do."

Prof. Dr. Kaan Erler:

I had first met him in 1976 at prep Scholl of Kuleli. It was the beginning of a 41 years journey of good friendship that we shared every moment of life not only socially but also scientifically. We both wanted to become a war pilot but we failed and changed our passion to medicine. He was a brilliant and hard-worker student. He was a good player of Volleyball team.

His learning curve in foreign language was superior to any other students. He graduated from the High Scholl with an Honor degree. We passed the entry exams of medical faculty and begun to Medical Faculty in 1980. We did not only study medicine but also got interested in playing tennis. We represented our faculty in all sportive organizations. Prof. SOLAKOĞLU was interested in scuba diving (Figure-2).

At the end of the six years, we graduated as a military medical doctor. He was assigned to Artvin where he spent 2 years as a doctor. During this period, he was sent to study Military Public Health in the field to San Antonia Military Medical Center in Texas for 3 months.

In 1989, I was accepted for GATA Orthopaedics Residency program. He said that "Orthopaedics is not suitable for me, I would prefer Plastic Surgery". Next year he was with me in Orthopaedics as mine junior assistant.

It was the beginning of a long academic carrier we walked together. We were completed our residency in one of the best training Hospital of the Country, GATA, produced a lot of academic papers (Figure-3).

He interested in Spinal Surgery and was trained under the supervision of Prof Dr. Mehmet Altınmakas who was a very well-known pioneer in Spinal Surgery (Figure-4).

In 1997, he passed all the exams including very hard English tests both written and verbal and he chosen for a Military Medical Attaché in Washington DC for three years. While he was there, he also visited different clinics of John Hopkins Hospital in Baltimore including Spinal Center.

He became Associate Prof in 2004 at Gülhane Haydarpaşa Training Hospital and became the Chief of Spinal Division where he performed surgeries and valuable academic researches until 2011 (Figure-5).

After this, he begun to work at the Department of Orthopaedics in Maltepe University, and got his Professor degree in Orthopaedics in 2012. He later was became the Dean of the Faculty for 3 years. All I can say that we lost a diamond, which is priceless (Figure-6).

Figure-2. Prof. Can SOLAKOĞLU was interested in scuba diving.

Figure-4. Prof. Can SOLAKOĞLU, in the operating theatre.

Figure-3. AAOS Meeting in Chicago in 2011.

Figure-5. Prof. Can SOLAKOĞLU, with Rauf Denktaş who was the president of the Republic of Northern Cyprus in GATA.

Figure-6. While Prof. Can SOLAKOĞLU was making a scientific presentation in the University of Maltepe.

LIFE STORY

He was born in 1962 in İstanbul. His father was military personnel. So he traveled a lot of city in turkey because of his father missions.

He was educated in Balıkesir for primary school. He wanted to be soldier like his father and started to Kuleli Military High School in 1976. He was hardworking; he decided to be a doctor in 1980 his faculty of medicine education started. When he finished at 1986 his first military mission started in Artvin Military Hospital.

Artvin was small place to do social events for his free time. There were some unused motorcycles in the military. Moreover, he started to drive. He was so happy when he drive but this hobby caused the end of his life in 2017.

In 1990, he was accepted in Orthopaedics and Traumatology Clinic for GATA, Ankara. After residency, he worked as an Assistant Professor until to 1997 in the same clinic.

He served Military Medical Attaché, Turkish Embassy, Washington DC in 1997-2000. Then he turn back to GATA and at 2004, he got Associated Professor title. In 2009 he went to John Hopkins Hospital, Baltimore USA for spine fellowship for one year. He worked in GATA Haydarpaşa Hospital until 2011 and retired.

He started to work in Maltepe university hospital as a chief of Orthopaedics and traumatology clinic. In 2013, he was assigned as a dean of faculty of medicine in Maltepe University and finished this job at 2016. In this time, he solved many problems about faculty. Education in English started and stem cell and gene laboratory placed.

His wife Dr. Gevher Solakoğlu and their handsome two sons were everything for him.

He was very social and liked traveling by motorcycle. At his last travel to Bulgaria, a traffic accident took him from us (Figure-7).

Figure-7. Prof. Can SOLAKOĞLU, with his motorcycle, which was his passion.

CONTRIBUTIONS TO SPINAL SURGERY

The contribution of the Prof. Solakoğlu was important for occurring of the GATA ecolé in the spinal surgery practice. He was the student of the Dr. Mehmet Altınmakas. Especially their new classification of the spinal tuberculosis and guidelines of the surgical treatment of the Pott's disease is the first classification in the literature [4].

He operated many patients with vertebral fracture and idiopathic scoliosis. He was interested in the patients with tethered cord. He reported that effects of untethered procedures on scoliotic curve in 2009 [3]. In 2009, he and his colleagues also presented that incidence of symptomatic re-tethering after surgical management of pediatric tethered cord syndrome with or without duraplasty [5].

The study of him about the changes of the pelvic incidence after resection of the sacral tumors was printed in 2011 [1]. On the other hand, his important contributions are studies on the sagittal plane. He reported that parameters of the sagittal plane in the two different groups of the patients with acondroplasia in 2012 [2]. He joined many international congress and reported many case and original articles in English and in Turkish in the main journals (Figure-8) [6].

He always hard worked in the Turkish Spine Society; he presented many oral presentation and panel speech in the International Congresses of the Turkish Spine Society. He shared his Knowles and experiences with his students and residents. As a result, he was a frontier of the Turkish Spinal Surgery.

Figure-8. Grand Canyon Excursion in 2013.

Figure-9. Prof. Can SOLAKOĞLU, in the wedding ceremony of his daughter.

Prof. Dr. İ. Teoman Benli, Editor of the JTSS:
He was a master and smart Orthopaedics surgeon and scientist.
He was also a polite and good man and good friend. Sleep in the lights.

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