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Clinical Results of Unilateral Dynamic Rod Application in the Short-Medium Period

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ABSTRACT

AIM: To evaluate the clinical results of patients who underwent unilateral dynamic rod stabilization after unilateral facet joint excision during spinal surgery.

MATERIAL and METHODS: Twenty patients who were diagnosed with degenerative spinal disease or spinal tumor, who were operated on using a unilateral approach, who underwent facet joint resection, and who were stabilized with a unilateral dynamic rod were examined. Visual analog scale (VAS) and Oswestry disability index (ODI) scores were used to clinically evaluate the cases during the preoperative and postoperative periods. Radiological examinations for sagittal alignment, segmental angle, and bone fusion were also conducted.

RESULTS: The mean preoperative VAS and ODI scores were 7.6 and 71.7, respectively, and the 12th postoperative month scores were 1.1 and 12.8, respectively. The mean segmental angle measurements were 22.1° in the preoperative period and 21.6° at the postoperative 12th month. No deterioration in sagittal alignment and no bone fusion were observed.

CONCLUSION: We can protect segmental movements and provide sufficient stability by applying unilateral dynamic rod stabilization after unilateral facetectomy. In addition, applying screws to one side can reduce operation time and cost as well as the possibility of complications.

KEYWORDS: Unilateral dynamic stabilization, Lumbar spine, Dynamic rod

INTRODUCTION

Facet joints enable the physiological movement of the spine and are important structures in the preservation of the spine natural alignment. They carry 16–25% of the compressive load biomechanically, and they provide resistance against shear and translation movements and torsional stiffness (2,46,47).

Facet joint integrity can be disrupted after traumatic injuries, during tumoral destruction or iatrogenically surgical treatment. During some surgical procedures, after laminectomy and total facetectomy are performed for adequate exploration and decompression (even if posterior ligaments are preserved), there is an increase in range of motion (ROM) during instability, flexion, and axial rotation in the functional segmental unit (FSU).

Unilateral facet joint resection may be required during the treatment of unilaterally affected bone tumors, spinal tumors that extend from the spinal canal to the paravertebral space, or degenerative spinal diseases, such as foraminal and extraforaminal disc hernia and lateral recess syndrome. However, increased axial rotation and extension movement have been reported after unilateral facetectomy, which may cause instability (49).

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Fusion operations with transpedicular screws and cages are widely used in the treatment of unstable spine segments. However, the resulting bone solid fusion has been shown to accelerate degenerative changes at adjacent moving levels over time (33,45). Various dynamic systems have been used to avoid this process, which is defined as adjacent segment disease (ASD), and to protect the movement in the FSU (11,35-37). Instead of using complex systems to treat iatrogenic instability caused by unilateral facetectomy and maintain segmental movement, FSU instability can be corrected by applying dynamic stabilization from one side (8).

The present study examines the clinical and radiological results of patients who underwent unilateral dynamic rod stabilization after unilateral facet joint excision during spinal surgery.

MATERIAL and METHODS

Ethics committee approval for our study numbered 128 was obtained from Ordu University on June 11, 2020.

Study Population

The study population included 20 patients (8 male, 12 female) with degenerative spinal disease or spinal tumor who underwent an operation in Ankara Numune Training and Research Hospital between 2013 and 2018 and were stabilized with unilateral dynamic rod after unilateral facet joint resection. The age distribution was 13–72 years old (mean=41.2). The follow-up duration was 12–60 months (mean=31.6). There were nine cases with degenerative diseases, such as foraminal/extraforaminal disc hernia or lateral recess syndrome due to facet hypertrophy. There were 11 cases of spinal tumor, nerve sheath tumor, or bone tumor of the vertebra. The diagnoses and applied surgical procedures are given in Table I.

Dynamic stabilization was applied in all cases since disc heights were preserved and osteodegenerative changes, such as osteofid formation, spondylolisthesis, and sequence defects, were not observed except for the defined lesion levels. Patients who underwent bilateral dynamic stabilization or rigid stabilization and had a follow-up time of less than one year were not included in the study.

Surgical Techniques

All operations were conducted in the prone position, and all patients were opened with a midline incision. The thoraco-lumbar fascia was opened unilaterally, and the paravertebral muscles were lateralized by blunt dissection. The pathology level was determined with the help of a C-arm, and unilateral facetectomy was performed regardless of whether hemi-laminectomy/total laminectomy was performed. All patients were treated with polyaxial transpedicular screws and then stabilized with dynamic rod. The layers were closed in an anatomical plan. The patients were mobilized on the first day of postop without using an orthosis.

Ten patients were operated on with titanium dynamic rods (Spine Master, Istanbul, Turkey) using single-level stabilization. The other 10 patients were operated on with polyetheretherketone (PEEK) rods (Osimplant, Istanbul, Turkey); single-level stabilization was used in three cases, two-level stabilization in five cases, and three-level stabilization in two cases. Pedicle screws are 5.5–6.5 mm in diameter and 40–45 mm in length. Dynamic rods have a diameter of 5.5–6.5 mm.

Evaluations

Visual analog scale (VAS) and Oswestry disability index (ODI) scores were used clinically evaluate the patients. Preoperative values and postoperative values at 3rd, 6th, and 12th month were evaluated, and the preoperative and postoperative 12-month scores were compared.

The radiological evaluation was conducted by measuring spinal alignments and segmental angles on direct radiographs and comparing the results for the preoperative and postoperative periods. A segmental angle can be calculated by measuring the angle between the lines from the upper endplate of the upper vertebrae and the lower endplate of the lower vertebrae of the stabilized segments (Figure 1).

Bone fusion and segmental instability were evaluated using computed tomography and dynamic radiographs. In addition, residual spinal tumors or spinal tumor recurrence were evaluated using contrasting magnetic resonance imaging (MRI) examinations.

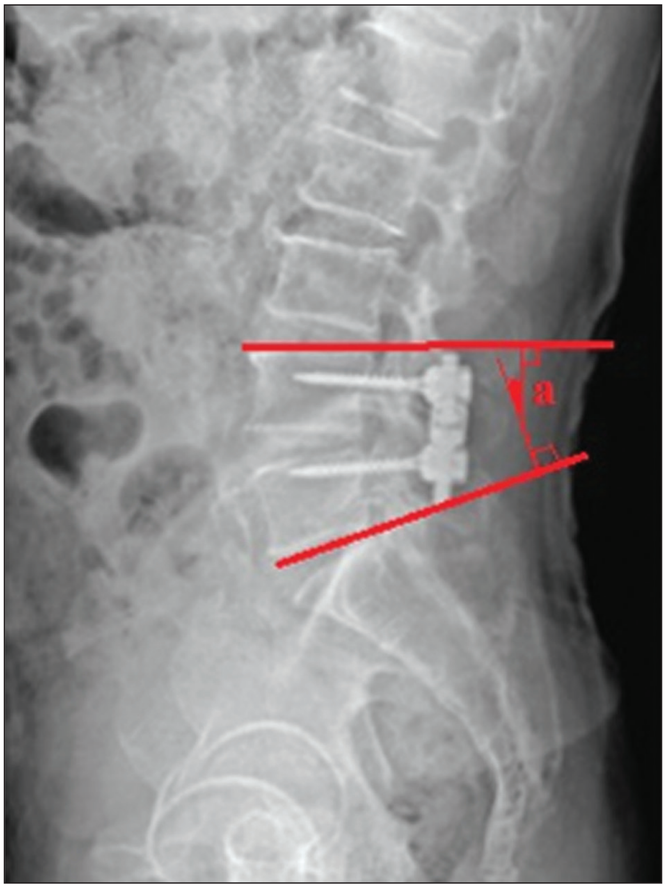

Figure 1: Calculation of segmental angle.

Table I: Diagnoses of the Cases and Surgical Interventions

Case	Age	Sex	Pathology	Surgical procedure	Segment
1	60	M	Right L4-5 Foraminal Disc Hernia	Right L4-5 Facetectomy, Discectomy	Right L4-5 Titanium Dynamic Rod
2	54	F	Left L3-4 Extraforaminal Disc Hernia	Left L3-4 Facetectomy, Discectomy	Left L3-4 Titanium Dynamic Rod
3	45	F	Right L4-5 Extraforaminal Disc Hernia	Right L4-5 Facetectomy, Discectomy	Right L4-5 Titanium Dynamic Rod
4	37	M	Left L4-5 Foraminal Disc Hernia	Left L4-5 Facetectomy, Discectomy	Left L4-5 Titanium Dynamic Rod
5	54	F	Left L4-5 Lateral Recess Syndrome	Left L4-5 Facetectomy	Left L4-5 Titanium Dynamic Rod
6	38	F	Left L4-5 Foraminal Disc Hernia	Left L4-5 Facetectomy, Discectomy	Left L4-5 Titanium Dynamic Rod
7	46	F	Left L4-5 Lateral Recess Syndrome	Left L4-5 Facetectomy	Left L4-5 Titanium Dynamic Rod
8	38	M	Left L2-3 Extraforaminal Disc Hernia	Left L2-3 Facetectomy, Discectomy	Left L2-3 Titanium Dynamic Rod
9	64	M	Left L4-5 Extraforaminal Disc Hernia	Left L4-5 Facetectomy, Discectomy	Left L4-5 Titanium Dynamic Rod
10	41	F	L1-2 Spinal Tumor, Meningioma	Left L1-2 Laminectomy, Facetectomy, Intradural Tumor Excision	Left L1-2 Titanium Dynamic Rod
11	13	F	L4 Vertebrae Aneurysmal Bone Cyst	Left L3-4, L4-5 Facetectomy, Tumor Excision	Left L3-4, L4-5 PEEK Rod
12	72	M	L3 Vertebral Bone Tumor, Osteoma	Right L2-3, L3-4 Facetectomy, Tumor Excision	Right L2-3, L3-4 PEEK Rod
13	48	F	T10-12 Cystic Spinal Tumor, Hydatid Cyst	T10-11-12 Laminectomy, Left T10-11, T11-12, T12-L1 Fasetectomy, Tumor Excision	Left T10-11, T11-12, T12-L1 PEEK Rod
14	24	M	T12-L1 Vertebrae Aneurysmal Bone Cyst	T12- L1 Laminectomy, Right T12- L1, L1-2 Facetectomy Tumor Excision	Right T12- L1, L1-2 PEEK Rod
15	46	F	Recurrent T10 Vertebral Mass, Hemangioma	T10-11 Laminectomy, Left T9-10, T10-11 Facetectomy Tumor Excision	Left T9-10, T10-11 PEEK Rod
16	28	M	T6-7 Vertebral Bone Tumor, Osteoblastoma	Left T 6-7-8 Laminectomy, Left T5-6, T6-7, T7-8 Facetectomy Tumor Excision	Left T 5-8 PEEK Rod
17	39	M	T10-11 Spinal Tumor, Schwannoma	T10-11 Laminectomy, Right T10-11, T11-12 Facetectomy, Tumor Excision	Right T10-11 T11-12 PEEK Rod
18	42	F	L3 Spinal Tumor, Schwannoma	Left L3-4 Laminectomy, Facetectomy, Tumor Excision	Left L3-4 PEEK Rod
19	19	F	L5 Spinal Tumor, Schwannoma	Right L5 Laminectomy, L5- S1 Facetectomy + Spinal Tumor Excision	Right L5-S1 PEEK Rod
20	15	F	T9 Spinal Tumor, Schwannoma	Left T9-10 Laminectomy T9- 10 Facetectomy, Tumor Excision	Left T9-10 PEEK Rod

***M:** Male, **F:** Female.*

Case Examples

Case 9: A 64-year-old male presented with complaints of back and left leg pain. In the lumbar MRI examination, an extraforaminal disc hernia was detected in the left L4-5 distance. The patient was operated on, and a left L4-5 facetectomy and a sequestered disc discectomy were performed. Left L4-5 transpedicular polyaxial screws and dynamic rod stabilization were applied for segmental instability (Figure 2A, B). The patient was discharged 24 hours after the operation and did not have neurological deficits in the postoperative period.

Case 16: A 28-year-old male with back pain was found to have a T5-6 vertebral mass. After examination, the mass was excised during an operation. Dynamic stabilization was performed with a left T5-8 transpedicular screws and a PEEK cage. During the pathological examination, the mass was determined to be an osteoblastoma (Figure 3A, B).

Statistical Analysis

The data was analyzed using IBM Statistical Package for the Social Sciences (SPSS) for Windows (V24). Continuous variables were expressed as means and standard deviations (SD), and the rate of change and categorical variables were expressed as frequencies (n) and percentages (%). Statistical analysis of all data was performed using the paired sample t-test. Continuous variables were presented as mean differences, and the threshold for statistical significance was set to $p<0.05$.

RESULTS

All patients were evaluated the 3rd, 6th, and 12th postoperative months, and the clinical and radiological assessments were recorded.

Clinical Assessment

The mean VAS and ODI scores decreased significantly from 7.6 and 71.7, respectively, in the preoperative period to 1.1 and 12.8, respectively, during the 12-month postoperative evaluation period. The decreases were statistically significant ($p=0.000$) (Table II).

Radiological Assessment

No bone fusion or adjacent segment disease findings were

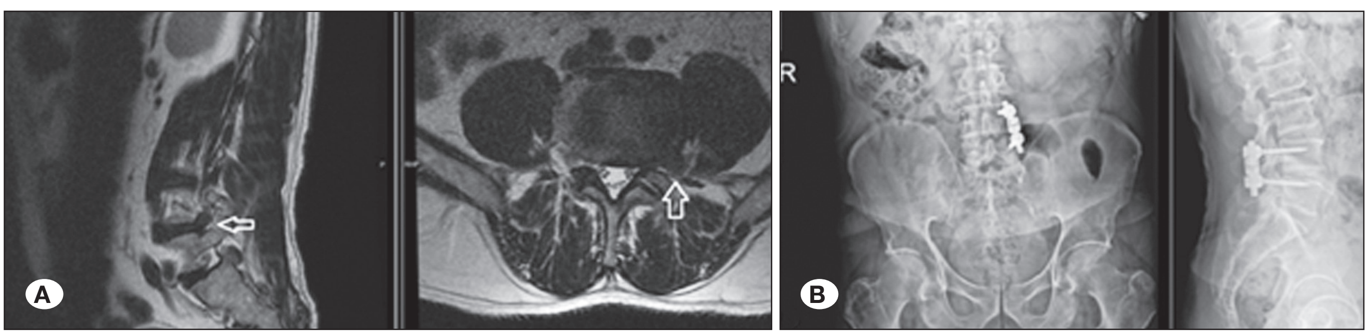

Figure 2: A) In lumbar MR examination, an extraforaminal disc hernia is seen in the left L4-5 distance (left: sagittal, right: axial). **B)** Image of dynamic stabilization material on anteroposterior (left) and lateral (right) radiographs taken in the postoperative period.

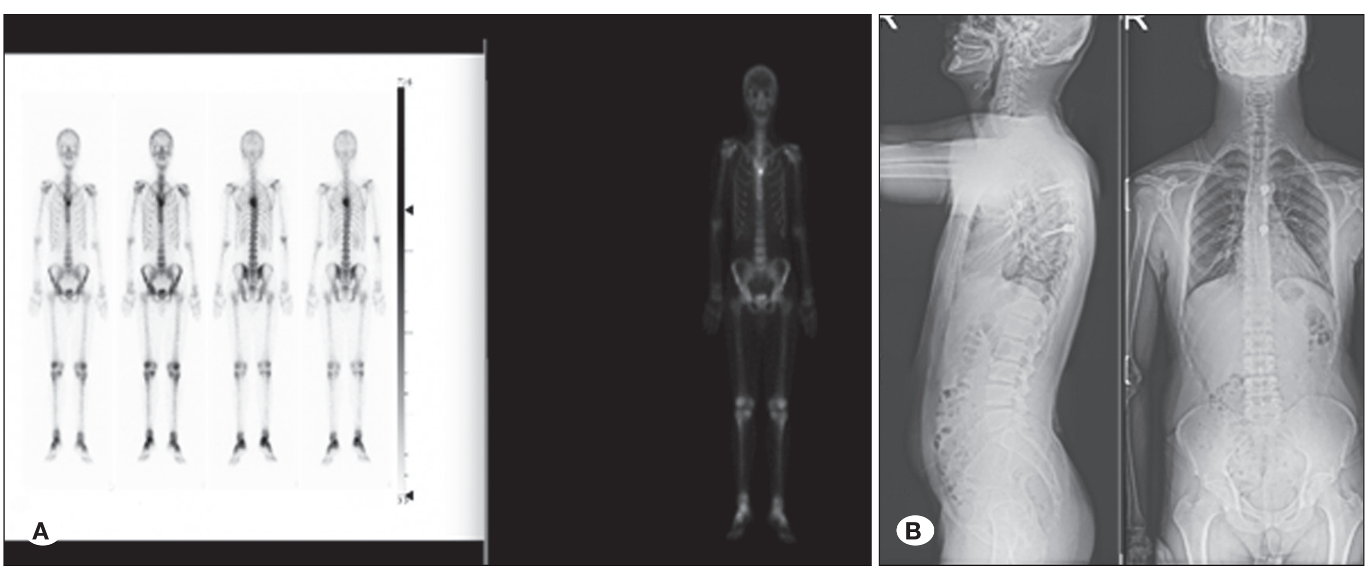

Figure 3: Preoperative and postoperative images of case 16; **A)** image of thoracic 5-6 involvement in preoperative whole body bone scintigraphy, **B)** Dynamic stabilization view with left T5-8 PEEK rod on postoperative direct radiography (left: lateral, right: anteroposterior).

detected radiologically at the 12th postoperative month. The mean segmental angle measurements were 22.1° in the preoperative period and 21.6° at the 12th postoperative month; this decrease was not statistically significant (p=0.18). During the follow-up period, there was no deterioration in sagittal alignment, and no bone fusion was observed.

The mean ODI, VAS, and segmental angle values and the paired sample test results (p-values) are given in Table III.

Complications

None of the patients needed reoperation in the postoperative period due to screw malposition, wound infection, or pseudomeningocele. During the postoperative period, there where no complication related to the PEEK rod or the dynamic route.

In three cases, which each involved an operation for a schwannoma, a sensory deficit compatible with the lesion level was observed. No reduction in motor function was observed in any of the patients during the postoperative period.

DISCUSSION

Facet joints are structures involved in the movement of the spine, load distribution, and stabilization. The upper facet is

Table II: ODI, VAS and Segmental Angle Values at Preoperative and Postoperative 12th Month

	Preoperative			Postoperative (12th month)		
Case	**VAS**	**ODI**	**Segmental Angle**	**VAS**	**ODI**	**Segmental Angle**
1	9	74	22	0	6	20
2	10	82	8	0	8	7
3	10	78	15	1	4	17
4	8	72	17	2	12	17
5	7	68	24	2	14	23
6	8	70	26	2	20	25
7	7	62	23	1	16	20
8	7	66	18	2	18	16
9	9	80	21	1	12	18
10	7	70	10	1	14	10
11	6	68	12	2	20	12
12	8	72	24	1	12	24
13	7	70	28	2	20	28
14	7	80	23	1	14	23
15	7	70	28	1	14	26
16	8	78	35	0	4	38
17	7	68	25	1	14	23
18	6	66	16	0	8	16
19	6	68	26	1	14	26
20	8	72	40	1	12	42

Table III: Preoperative and Postoperative (12th month) ODI, VAS and Segmental Angle Mean Scores

	Preoperative	Postoperative (12th month)	p
ODI	71.7	12.8	**0.000**
VAS	7.6	1.1	**0.000**
Segmental Angle	22.1	21.6	0.180

responsible for carrying the joint load, and the lower facet distributes the joint load. Facet joints in sagittal orientation in the lumbar region allow flexion and extension while limiting axial rotation movement.

The range of motion in the lumbar region is 12-17° in flexion-extension movement, 7-9° in lateral bending, and 3° in each segment in axial rotation (32). Many studies have shown the biomechanical importance of facet joints in the spine. Voronov et al. reported in their cadaver study that there was an increase in angular ROM in all directions after laminectomy and bilateral facetectomy. This increase reported that from 15.3° to 18.7° in flexion-extension, from 8.2° to 9.3° in lateral bending, from 3.7° to 5.9° in axial rotation movement (43). Tender et al. in the cadaver study, it was reported that after unilateral facetectomy applied to the L5-S1 segment, ipsilateral axial rotation increased 1.4° and axial ROM increased 3° (41). In a study of the lumbar spine of sheep, Karakoyun et al. observed that spinal segments that underwent unilateral facetectomy were not as stable as those of the control group that did not undergo facetectomy (19). In an in vitro experiment on fresh human lumbar spine segments, Abumi et al. reported an increase in flexion movement after medial facetectomy and an increase in axial rotation after unilateral facetectomy (1). Similarly, Zeng et al. reported that axial rotation and extension movement increased after unilateral facetectomy and may lead to instability (49). Meanwhile, Zander et al. reported that a stability difference only occurred in flexion movement in bilateral laminectomy with hemilaminectomy, while axial rotation increased after total facetectomy and laminectomy (48). Another study showed that, even if the posterior ligaments are preserved, instability occurs in the FSU after total facetectomy (11).

Due to the importance of facet joint functions, neurosurgeons tend to protect the joint. In spinal stenosis cases, it was reported that biomechanical instability and kinematics changed less when facet-sparing laminectomy was performed instead of total facetectomy (12). Kato et al. reported that stabilization can be preserved in osteoplastic laminectomy that preserves the spinous process and the facet joint (20). However, facet joint resection may be inevitable for the treatment of foraminal or extraforaminal disc hernias, foraminal stenoses due to facet hypertrophy, intradural or extradural spinal cord tumors in the appropriate lateralization, and lateralized tumors in the spine. Facet joint resection may be the cause of instability even if it is unilateral (49).

Meanwhile, Natarjan et al. reported that abnormal movements occurring after facetectomy may require fusion (31). In addition to the bilateral transpedicular fusion treatment, some patients have been fused with a unilateral pedicle screws or instability after unilateral facetectomy (14,42,47). Molinari et al. in their systematic review, similar fusion rates were reported in unilateral and bilateral rigid stabilization applications (29). Likewise, Işık et al. they reported that there was no difference between ASD rates and fusion rates (18). It has also been reported that the risk of developing ASD in the neighboring segment increases after fusion operations due to intradiscal pressure increase, which may change the ROM and the sagittal alignment (5,17). In comparison, with rigid stabilization techniques, segmental motion can be preserved by applying dynamic stabilization; thus, fusion-related ASD risk can be reduced (8).

McAfee et al. applied the total posterior arthroplasty system (TPAS) after bilateral laminectomy and facetectomy to patients with spinal stenosis and spondylolisthesis due to facet arthropathy and achieved multiaxial stability in flexion, extension, rotation, and lateral bending motions; their radiological and functional results were good at the 12-month follow-up (26). Anekstein et al. reported that clinical improvement and radiological stability were maintained during the 7-year follow-up of 10 patients who underwent TPAS (4). Meanwhile, Phillips et al. reported that the ROM and the quality of the operated segment were restored by applying a total facet arthroplasty system and that the ROM in adjacent segments showed near-normal improvement (36). Although other methods assume the role of the facet joint, such as the dynamic stabilization system (DSS, Paradigm Spine) and Stabilimax ZN. Applied Spine, USA) (35,37), the clinical applications of these systems are challenging and complex (34).

Instead of such complex systems, it may be sufficient to stabilize FSU movements with a unilateral dynamic rod (34). According to Bozkus et al., sufficient stability can be created by using a unilateral dynamic screw or a dynamic rod instead of a fusion treatment and the instability that develops with facetectomy (8). Ozer et al. reported that unilateral stabilization with a dynamic screw and a dynamic rod was applied in a series of 10 cases for the treatment of disc hernias at the foraminal level; the functional movements of the facet joint were preserved (34). In our study, in addition to foraminal and extraforaminal disc hernias, sufficient stability and segmental movement were maintained in patients with unilaterally approached spinal cord tumors.

Bisceglia et al. in his literature review evaluating the 15-year survey of solitary fibrous tumors of the central nervous system, he reported that meningeoma, schwannoma and neurofibroma are generally good prognosis tumors (6). In addition, in these tumors, recurrence can be expected in case of subtotal resection or atypia, metastasis and tumor-related deaths are rarely observed (6). Most intradural extramedullary tumors in the thoracic and lumbar regions (e.g., schwannoma) result from the dorsal root ganglion. A limited laminectomy, which usually protects the facet joints, may be sufficient to remove these lesions. However, aggressive facetectomies may be required in foraminal extradural lesions. Moreover, it may be necessary to perform transpedicular, lateral extracavitary, or costotransversectomy in the thoracic wall and mediastinal lesions (23,30). Ando et al. performed a single-stage posterolateral approach and bilateral rigid stabilization for instability that may occur after the excision of thoracic dumbbell tumors in 16 cases series (3). Four of our cases were diagnosed as shcwannoma and 1 case as menengioma. No recurrence was observed in the clinical follow-up and follow-up of these cases. Aneurysmal bone cyst is a benign lesion that can involve almost all bones and it is rarely observed to undergo malignant transformation (15). Mankin et al. In his series of aneurysmal bone cysts of 150 cases, he reported that spinal involvement was present in 11 cases and that the main problem in treatment was local recurrence in 20% of the cases (25). Two of our cases were operated for aneurysmal bone cysts and no recurrence was observed in these cases during the follow-up. Osteoblastomas are lesions with aggressive behavior due to extensive uncontrollable recurrences compared to osteoid osteomas (44). Osteoblastomas are benign locally aggressive pirmer bone tumors that are frequently observed in the 2nd and 3rd decade of life (7). In their series of 360 cases of osteoblastoma, Lukas et al. reported that although most lesions were well circumscribed, there were findings suggestive of malignancy in 12% of cases (24). Enneking classification is widely used in muscle and skeletal system tumors (13). In this classification, the histological type of the tumor, the location of the tumor and the presence or absence of distant metastasis are evaluated. According to this classification, stage 1 lesions are defined as latent, stage 2 lesions as locally active, and stage 3 lesions as locally aggressive lesions. Harrop et al. reported that the recurrence rate after subtotal resection was 10-15% in stage 2 tumors and 50% in stage 3 tumors (16). Therefore, he recommended comprehensive intralesional curettage for stage 1-2 lesions and extensive resection for stage 3 tumors (16). Dynamic stabilization was performed with a PEEK rod after extensive surgical resection in our 2 patients who were diagnosed with osteoma and osteoblastoma by pathological examination. Although the follow-up periods of these patients were short, no recurrence or distant metastasis was observed. Hydatid cyst occurs due to echinococcus granulosus parasite and spinal involvement is rarely seen (9). If cyst rupture occurred before resection, it may require reoperation accordingly (9). In our case, hypertonic saline was used during the operation and albendazole treatment was started in the postoperative period. In this case, reoperation was not required during the follow-up.

Meanwhile, surgical stabilization was performed on the patients in the present study to remove the facet joint(s) during vertebral mass and dumbbell tumor excision. In our cases, which were stabilized with a dynamic rod, decreases in the ODI and VAS values were observed in the postoperative period. In addition, there was no deterioration in sagittal alignment during the postoperative period. No clinical study involving a comparison of unilateral dynamic rods and rigid rods has been found in the literature.

Studies have shown that the risk of ASD can be reduced by preventing deterioration of the posterior elements (5,17). The unilateral approach was used in the surgical treatment of our cases. The risk of ASD can be reduced by preserving the opposite side paravertebral muscles, facet joint, lamina, and ligamentum flavum. However, the follow-up time in our series was not long enough to provide results in terms of ASD development.

Today, a unilateral approach is used in the surgical treatment of many diseases affecting the spine and the spinal cord, and this trend is gradually increasing. Decompression procedures, especially for lumbar spinal stenosis, are almost routinely performed on one side. Cavusoglu et al. reported that adequate decompression can be achieved by applying bilateral decompression with a unilateral approach for lumbar spinal stenosis cases (10). Similarly, decompression of the cervical narrow canal can be performed from one side (27,38). In a study on spondylolisthesis, a degenerative disease, patients who underwent transpedicular screw and minimally invasive transforaminal lumbar interbody fusion with a unilateral approach for the treatment of meyerding stage 1-2 spondylolisthesis had similar clinical results in their 12-month follow-up compared to bilateral cases (39). Mobbs et al. and KrishnanKutty et al. reported that intradural lesions with appropriate lateralization can be removed by unilateral hemilaminectomy (21,28).There are even presentations stating that intramedullary tumors can be removed from one side via the dorsal root entry zone (22,40). By using a unilateral approach, anatomical integrity is preserved as much as possible, and the potential for instability is reduced. Thus, hospital stay durations can be shortened, and treatment costs can be reduced (10,21). Since it was approached unilaterally, there was less blood loss during the operation, the operation time was shortened, and the cost was reduced; since the screw application was unilateral, the risk of screw-related complications was also reduced.

This study has some limitations. Its retrospective nature and the relatively low number of cases could decrease its scientific value. In addition, as our follow-up time was not long enough, evaluations could not be made in terms of ASD or fusion that may develop later. Therefore, prospective, large-scale, multicenter clinical trials are needed to further confirm our results.

CONCLUSION

By applying unilateral dynamic rod stabilization after unilateral facetectomy, we can protect segmental movements and provide sufficient stability. In addition, applying screws to just one side can reduce operation time and cost as well as the possibility of complications.

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