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EFFECT OF RIGID AND HYBRID ROD ON THE DEVELOPMENT OF ADJACENT SEGMENT DISEASE AFTER LUMBAR SPINAL FUSION: OUR CLINICAL EXPERIENCE

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ABSTRACT

Objective: One of the most effective treatment methods for degenerative lumbar spine pathologies is fusion surgery. However, after fusion surgery, adjacent segment disease (ASD) status may occur. Our aim in this study was to evaluate the relationship between hybrid rod use and ASD and to contribute to the literature.

Materials and Methods: Patients who came to our clinic with various etiologies and underwent lumbar spinal fusion between January 2017 and June 2022 were examined in this study. Retrospective analysis was performed on factors, such as demographic characteristics of the patients, etiology, preoperative imaging, a type of rod used during surgery, development of ASD in the postoperative period, and reoperation.

Results: There were 53.5% (n=85) female cases and 46.5% (n=74) male cases. In all cases, the mean age was 59.5 years (38-69). In group A (n=72), which used a rigid rod, 54.2% (n=39) of the cases were female, and 45.8% (n=33) were male. There were 58 patients in this group who had three or fewer levels of fusion. Group B (n=87), which used a hybrid rod, had 52.9% (n=46) female cases, and 47.1% (n=41) premature cases. Radiographically, ASD was found in 48.6% (n=35) of group A patients. Because they were symptomatic, 45.7% (n=16) of these cases were reoperated. Radiographically, ASD was found in 25.3% (n=22) of group B patients. Because they were symptomatic, 18.2% (n=4) of these cases were reoperated. Patients with rigid rods were more likely to develop ASD, and they required more reoperations ($p<0.05$).

Conclusion: Patients who undergo degenerative lumbar region fusion surgeries with hybrid rods have less ASD. As more mobile instrumentation techniques are developed in the upper segments, the incidence of ASD in these fusion surgeries will decrease.

Keywords: Adjacent segment disease, hybrid rod, lumbar fusion, rigid rod

INTRODUCTION

Fusion surgery remains the gold standard treatment method for degenerative lumbar pathologies characterized by instability[1-5]. Instability, trauma, infection, tumor, collapse fracture, spinal canal stenosis, degenerative spondylolisthesis, scoliosis, degenerative disc disease, facet syndromes, and pseudoarthrosis are treated with spinal fusion[6,7].

Adjacent segment disease (ASD) can develop after lumbar spinal degenerative spine decompression and fusion surgery[8-12]. It is believed that biomechanical changes at the operated level and adjacent segments play a role in the onset of ASD after decompression surgery[13-18]. These biomechanical changes are attributed to factors, such as spinal column stress, excessive movement, increased intra-disc pressure, and posterior displacement of the axis of motion[19-23]. Age, sex, obesity, postmenopausal status, osteoporosis, spinal stenosis, pre-existing degenerated disc at the adjacent level, fusion length, rigid pedicle screw instrumentation, and injury to the facet joint of the adjacent segment are also blamed in the etiology[15,19,24,25]. The risk of ASD is generally highest in the upper adjacent region[26]. The annual rate of surgical intervention for ASD after fusion has been reported to be 3.9%, with a range of 25-35% after 10 yr[3].

This study aims to evaluate our data on ASD in patients who had spinal fusion with rigid and hybrid rods in our clinic to the literature.

MATERIALS AND METHODS

Patient Population

Patients who applied to our clinic with various etiologies and underwent lumbar spinal fusion between January 2017 and June 2022 were examined in this study. Factors, such as demographic characteristics of the patients, etiology, preoperative imaging, type of rod used during surgery, postoperative ASD development, and reoperation, were studied retrospectively.

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The study included patients aged 38-69 yr who underwent lumbar spinal fusion in our clinic. The studies excluded cases in which lumbar cage and interbody fusion material were used during lumbar spinal fusion.

From the patient files of 159 patients, factors, such as mean age, gender, operation level, ASD development, reoperation, and follow-up time after the first surgery were collected. The patients were divided into two groups for evaluation (A and B). The rigid rod was used by group A, and the hybrid rod was used by group B.

Approval was obtained for the study from University of Health Sciences Turkey, Gülhane Scientific Research Ethics Committee for in this retrospective study (decision no: 2021-238, date no: 20.05.2021).

Radiological Evaluation

Preoperative lumbar magnetic resonance imaging (MRI) and lumbar computed tomography (CT) examinations were used to determine the pathological level in all cases. In all cases, lumbar CT was performed in the early postoperative period to assess screw malposition.

MRI was performed in the postoperative follow-up, and instability, disc herniation, disc bulging and canal stenosis were evaluated as ASD findings.

RESULTS

There were 53.5% (n=85) female cases and 46.5% (n=74) male cases. In all cases, the mean age was 59.5 yr (38-69). Group A (n=72) used a rigid rod, and 54.2% (n=39) of the cases were female, whereas 45.8% (n=33) were male. There were 58 patients in this group who had three or fewer levels of fusion. In group B (n = 87), which used a hybrid rod, 52.9% (n=46) of the cases were female, whereas 47.1% (n=41) were male. In this group, 82 patients had three or fewer levels of fusion. Demographic factors and other clinical parameters of the cases are summarized in Table 1.

ASD was found on radiographs in 48.6% (n=35) of the patients in group A, (Figure 1). There were 45.7% (n=16) cases reoperated because they were symptomatic. In this group, the mean follow-up time from the first operation was 50.2 months (12-62).

ASD was found on radiographs in 25.3% (n=22) of the patients in group B, (Figure 2). There were 18.2% (n=4) cases reoperated because they were symptomatic. In this group, the mean follow-up time from the first operation was 56.5 months (15-61).

ASD developed above the fusion level in all cases. In patients who underwent reoperation, the fusion level was extended by ascending to an upper segment including the adjacent segment. Because the rods had to be removed to prolong the fusion level, the hybrid rod was used in cases where rigid rods were inserted.

Statistical Analysis

IBM SPSS Version 25.0 for data analysis (IBM Corp., Armonk, NY) statistical package program was used. Categorized variables were explained as the number of patients (n) and percentage (%) with descriptive statistics. The relationship between categorical data in independent groups was examined with the chi-square (χ^2) test. Differences at the $p<0.05$ level were considered statistically significant.

The relationship between patient groups and development of ASD is shown in Table 2. There is a statistically significant difference between the development of ASD and the instrumentation method ($p=0.002$). ASD developed more frequently in patients with rigid rods.

The relationship between patient groups and reoperation is shown in Table 3. There is a statistically significant difference between the reoperation situation and the instrumentation method ($p=0.001$). The need for reoperation developed more frequently in patients with rigid rods.

DISCUSSION

Spinal decompression and fusion surgery are common treatments for degenerative lumbar pathologies[27-29]. However, after lumbar fusion, there may be hypermobility in the proximal adjacent segments and a decrease in disc height. As a result, ASD may develop[30,31].

Radiologically, ASD is common but may not always be symptomatic. In a review that included many studies, it was reported that the incidence of ASD radiologically varied between 8% and 100%, whereas the incidence of symptomatically varied between 5.2% and 18.5%[25].

Table 1. Demographic and clinical characteristics of the cases

Characteristic		Group A (n, %)	Group B (n, %)
Number of patients		72	87
Average age		60.8	58.3
Sex	Female	39 (54.1)	46 (52.8)
	Male	33 (45.8)	41 (47.1)
Fusion level	≤3	58 (80.5)	82 (94.2)
	>3	14 (19.4)	5 (5.7)
Adjacent segment disease		35 (48.6)	22 (25.3)
Reoperation		16 (45.7)	4 (18.1)
Follow-up (month)		50.2	56.5

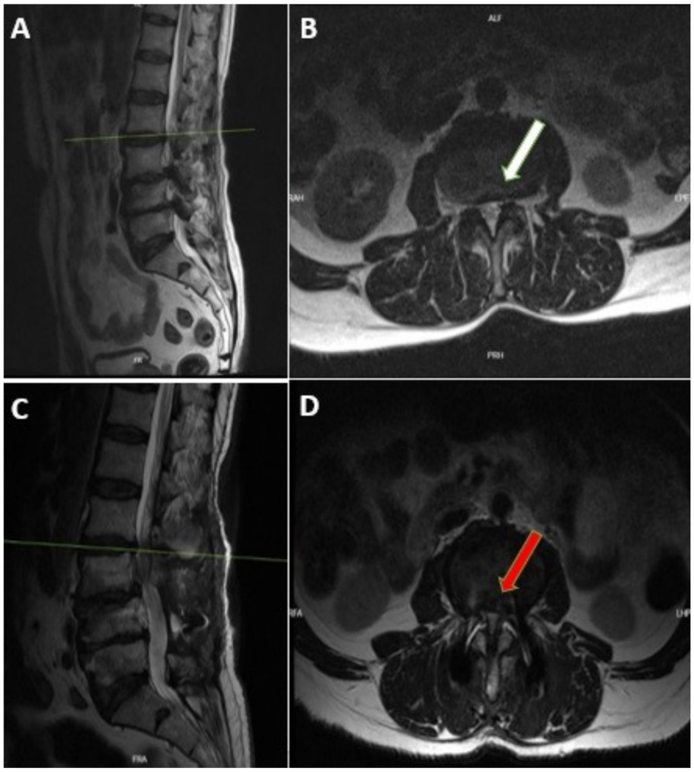

Figure 1. **A** and **B**, preoperative sagittal and axial lumbar T2 MRI. A 58-year-old male patient underwent lumbar decompression and fusion surgery for L3-L5 spinal stenosis. **C** and **D**, postoperative sagittal and axial lumbar T2 MRI. A rigid rod was used during the operation. Lumbar MR imaging performed on the patient's leg pain and neurogenic claudication complaints at the postoperative 15th month revealed adjacent segment disease at the L2-L3 level. The patient was reoperated. White arrow: Canal diameter at L2-L3 level in the preoperative period. Red arrow: Canal diameter at L2-L3 level in the postoperative period.
MRI: Magnetic resonance imaging

Because the lumbar region contains five mobile segments, when any segment joins the fusion, loading in adjacent segment areas increases. Therefore, fusion surgery accelerates the progression of degenerative changes in adjacent segments[23]. When the effects of anterior and posterior fusion surgery on ASD were compared, posterior fusion surgery was found to have a higher rate of ASD than anterior (44% and 82.6%, respectively)[32]. The cause of this is disruption of the posterior ligament system at the level of the adjacent segment, which accelerates the existing degenerative process[33]. Cunningham et al.[9] demonstrated that rigid instrumentation resulted in a 45% increase in axial compressive and flexion loads in upper adjacent disc tissue.

Kumar et al.[34] reported that the most common cause of radiological ASD is retrolisthesis. On the other hand, Min et al.[35] blamed the most common angular instability in the etiology. Other factors implicated in the etiology are disc degeneration, hypertrophic facet joint arthritis, widespread degeneration and weakness of the paraspinal muscles, nucleus pulposus herniation, and stenosis[19,25,30]. It has also been reported that loss of lumbar segmental lordosis has an effect on the development of ASD[36,37]. Age is an important factor in etiology, and the probability of ASD is higher in fusions over 55 yr of age. Due to age-related widespread deterioration, the resistance of the adjacent segment to increasing stress decreases after fusion[27,38,39]. In our study, the mean age of all cases was evaluated as 59.5 yr.

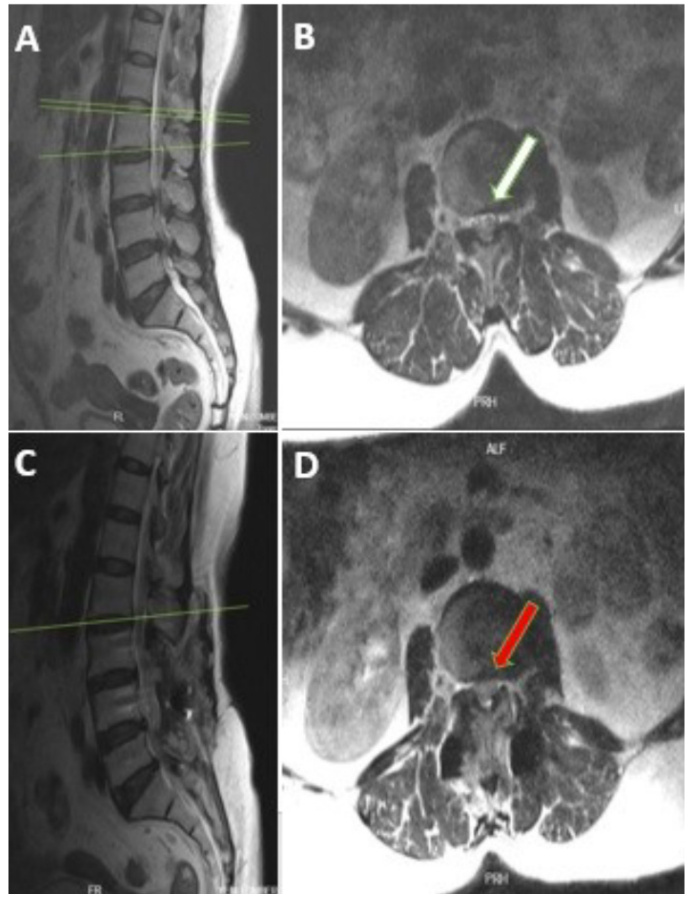

Figure 2. **A** and **B**, preoperative sagittal and axial lumbar T2 MRI. A 63-year-old female patient underwent lumbar decompression and fusion surgery for L3-L5 spinal stenosis. **C** and **D**, postoperative sagittal and axial lumbar T2 MRI. A hybrid rod was used during the operation. The patient presented with mild low back pain at the postoperative 18th month. In the lumbar MRI, there was no apparent adjacent segment disease in the upper segments. White arrow: Canal diameter at L2-L3 level in the preoperative period. Red arrow: Canal diameter at L2-L3 level in the postoperative period.
MRI: Magnetic resonance imaging

Kim et al.[37] retrospectively evaluated 69 patients who had L4-L5 fusion for lumbar stenosis or degenerative spondylolisthesis. They concluded that maintaining 20° or more segmental lordosis is important in preventing ASD[37]. Bae et al.[36] reported similar results. Anandjiwala et al.[40] found that pre-existing adjacent segment degeneration, rather than postoperative balance, was a risk factor for radiological ASD in a 5yr prospective follow-up after lumbar spinal fusion. Other studies have found that the incidence of adjacent segment degeneration increases with the number of fusion levels and that there is a significant correlation between patient clinical outcomes and the number of fusion levels[24,41].

Correlation studies between clinical manifestations of ASD and

Table 2. Development of adjacent segment disease according to patient groups

Patient group	Adjacent segment disease + (n=57)	- (n=102)	p value
Group A (n=72)	35 (48.6%)	37 (51.4%)	0.002
Group B (n=87)	22 (25.3%)	65 (74.7%)	

Pearson chi-square test, p<0.05

Table 3. Reoperation relationship according to patient groups

Patient group	Reoperation + (n=20)	- (n=139)	p value
Group A (n=72)	16 (22.2%)	56 (77.8%)	0.001
Group B (n=87)	4 (4.6%)	83 (95.4%)	

Pearson chi-square test, p<0.05

radiological findings are discussed separately. There are many studies in this area. Boden et al.[42] discovered that although ASD findings were seen on lumbar MRI, approximately 57% of patients aged 60 yr and older did not have clinical symptoms. Disc degeneration or disc bulging was observed at a rate of 35% in radiological examinations of healthy young adults aged 20 to 39[42]. The rate of radiologically detected ASD in our study was 35.8%, whereas the rate of symptomatic ASD was 12.5% in all cases.

During fusion in the lumbar spine, hybrid stabilization is utilized by using a dynamic rod in the proximal segment and a rigid rod in the distal segments. Unlike the posterior rigid stabilization technique, the posterior hybrid stabilization technique carries the load applied to the spine. The load is not shared with the spine in the rigid system[43]. The instrumented segments in the rigid system are motionless and behave like long bones. Therefore, the spine increases motion in the adjacent segments of the instrumented segments to reach its natural range of motion, causing an increase in load in the adjacent segments[11]. The significant difference in loading (stress) between the instrumented segment and the adjacent non-instrumented segment allows deformity to develop[44].

In recent years, posterior dynamic stabilization techniques have been used to treat spinal deformities with chronic instability. In this regard, Graf[27], who coined the term "dynamic artificial ligament", was the first to use it in the treatment of degenerative disc disease in 1992. Schwarzenbach et al.[45] found a statistically significant improvement in both fusion development and clinical complaints after a mean follow-up of 39 months in 31 patients who used a hybrid system for degenerative disc disease. While the rate of symptomatic ASD in our cases with dynamic stabilization using a hybrid system rod was 25.3%, the rate of symptomatic KSH in cases with rigid rod was 48.6%. When the hybrid system rod was used, statistically less KSH developed compared with the rigid system, and there was less reoperation (p<0.05).

Study Limitations

Our research has some limitations. The first is the small number of cases. Second, because it is a retrospective study, the data were analyzed over the files, and the unsaved data of the patients could not be accessed.

CONCLUSION

In degenerative lumbar spine pathologies, fusion surgery is still an effective treatment method. However, due to different factors, ASD occurs due to biomechanical stress, particularly in the upper segment where the fusion ends. This biomechanical stress and ASD are reduced when hybrid or dynamic rods are used instead of rigid rods. With the advancement of rod and other instrumentation techniques, it is expected that postoperative ASD will be reduced even further in the future.

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Ethics

Ethics Committee Approval: Approval was obtained for the study from University of Health Sciences Turkey, Gülhane Scientific Research Ethics Committee for in this retrospective study (decision no: 2021-238, date no: 20.05.2021).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: İ.G., A.D., Concept: A.D., H.T., Design: İ.G., A.D., Data Collection or Processing: A.D., H.T., M.O.D., Analysis or Interpretation: İ.G., A.D., Literature Search: A.D., M.O.D., Writing: A.D., M.O.D.

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