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ORIGINAL ARTICLE

Comparison of Long-Term Results of Dynamic and Rigid Systems at the Lumbar Level

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Abstract

Introduction: This study aimed to compare the safety, efficacy, radiological changes, and long-term results of transpedicular stabilization systems using a rigid rod with lumbar dynamics (PEEK) in terms of reoperation requirements.

Methods: Patients who underwent two-level lumbar stabilization with 92 rigid systems and 54 dynamic systems between January 2017 and January 2020 were included in the study. The VAS and ODI scores, segmental and total lumbar lordosis angles, and upper and lower segment vertebral heights of the patients were evaluated. Preop, postop 1st day, postoperative 12th month, and postoperative 24th month values were compared.

Results: Of the patients included in our study, 59 were male and 87 were female. The mean age was 58 years. Revision surgery was performed in 12 patients with a rigid system and 6 patients with a dynamic rod system. Preoperative VAS values were 8 (2-10) in the rigid group and 9 (6-10) in the dynamic group ($p<0.05$). At the 12th postoperative month, it was 4 (2-7) in the rigid group and 4 (2-6) in the dynamic group ($p<0.05$). Preoperative lumbar lordosis was 48.8 (29.6-80.8) in the rigid system, while it was 47.9 (11.5-83.7) in the dynamic system ($p>0.05$). At the 24th postoperative month, it was 46.5 (25.9-73.7) in the rigid group and 43.3 (20.2-79.6) in the dynamic group ($p>0.05$).

Discussion and Conclusion: Although the development time of adjacent segment disease is longer with PEEK rod dynamic systems compared to rigid rod systems, adjacent segment disease can be seen in both systems.

Keywords: Adjacent segment disease; dynamic system; pseudoarthrosis; rigid.

Lumbar degenerative disc disease is a progressive condition that affects a significant portion of the aging population[1,2]. In the treatment of spinal stenosis and segmental instability accompanied by degenerative disc disease in the lumbar spine, fusion with rigid stabilization together with decompression is preferred[3]. Although clinical results are good in the early postoperative period, the rate of development of adjacent segments in long-term follow-up was found to be between 2-5%[4].

Adjacent segment disease refers to degenerative changes that may lead to recurrence of symptoms in the nonunion segment by causing increased intradiscal pressure and increased mobility in the adjacent segment after fusion surgeries[5]. As a result of the hypermobility of the adjacent segment with rigid stabilization, degenerative disc disorders occur in the adjacent segment[6]. Dynamic stabilization systems have been developed to prevent the formation of adjacent segments. Dynamic stabilization reduces the

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changing biomechanical stress in adjacent segments by allowing movement in stabilized segments and contributes to spine dynamics by reducing hypermobility in adjacent segments[7]. In our study, we aimed to compare the safety, efficacy, radiological changes, and long-term results of transpedicular stabilization systems using a rigid rod with lumbar dynamics (PEEK) in terms of reoperation requirements.

Materials and Methods

Patients who underwent two-level lumbar stabilization with 92 rigid systems and 54 dynamic systems between January 2017 and January 2020 were included in the study. The visual analog scale (VAS) and Oswestry Disability Index (ODI) of the patients were evaluated preoperatively and at 1, 12, and 24 months postoperatively. During the follow-up period, patients who underwent revision surgery due to adjacent segment disease, pseudoarthrosis, instrumentation failure, and low back pain due to axial loading were evaluated. Patient data were evaluated retrospectively from the patient automation system and patient files.

To treat degenerative lumbar disc disease, degenerative lumbar narrow canal, deformities with a Cobb angle of 20 degrees or less, and those that required surgery in the long-term follow-up of lumbar dynamic and rigid stabilization systems were included in the study. Patients with spondylolisthesis, Cobb angle deformities greater than 20 degrees, a history of previous lumbar surgery, spinal tumors, and stabilization on two segments and above were not included in the study. The study was conducted in accordance with the Declaration of Helsinki. Bakırköy Dr. Sadi Konuk Training and Research Hospital ethics committee approval was received on 16/11/2020 (2020-23).

Surgical Technique

Surgical procedures were performed on the patients in the prone position under general anesthesia. A midline incision was made, and the paravertebral muscles were opened laterally. Posterior transpedicular screws were inserted into the lumbar vertebrae using a C-arm scope. Discectomies were performed on the discs after hemilaminectomy. Bone grafts were used in the rigid system users but not in the dynamic system users.

Radiological Evaluation

All patients underwent preoperative, postoperative 1st day, postoperative 12th month, and postoperative 24th month lumbar spine front-back and lateral direct radiographs (Fig. 1). The lumbar lordosis angle, segmental lordosis angle, and intervertebral disc heights were measured. Lumbar vertebra computed tomography and lumbar vertebra magnetic resonance imaging were performed on patients with complaints at the 24th month.

In our study, the distance between the vertebrae was taken as the disc area. The upper border of the discus intervertebralis was accepted as the lower border of the upper vertebral body, and the lower border was considered the upper border of the lower vertebral body. Thus, the anterior and posterior borders were determined. Then, the distances between the determined points were measured by the software of the central computer in the MRI system. The measurement results were transferred to an IBM-compatible PC.

Statistical Analysis

Statistical Package for Social Sciences (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 25.0 Armonk, NY: IBM Corp.) software was used for statistical evaluation of the study data. The Mann-Whitney U test was used for comparisons made for two independent groups, and the Friedman test statistic was used for the analysis of time-repetitive variables.

Results

Of the patients included in our study, 59 were male and 87 were female. The mean age was 58 years. Patients who underwent two-level lumbar stabilization with 92 rigid systems and 54 dynamic systems were included in the study.

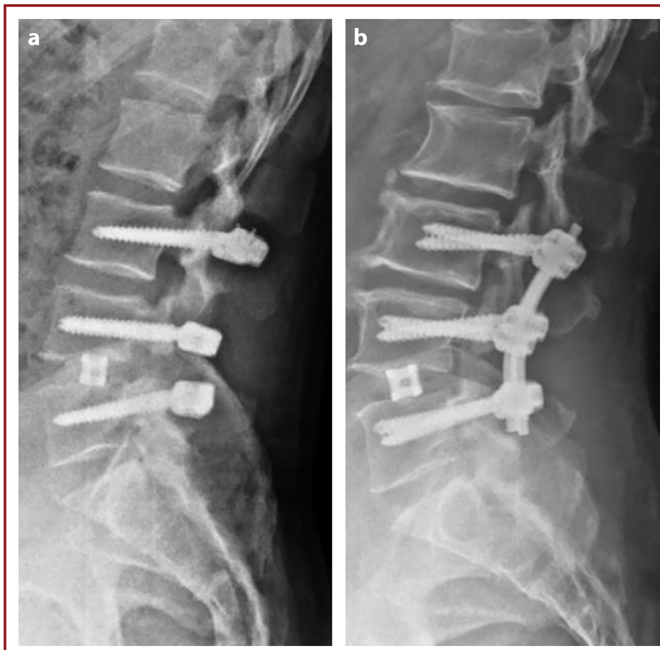

Figure 1. Lomber lateral x-ray; **(a)** peek rod, **(b)** rigid rod.

Revision surgery was performed in 18 patients. Revision surgery was performed in 12 patients who underwent the rigid system and 6 patients who underwent the dynamic rod system. The median age of the patients was 56 (min 38; max 71). The mean age of the rigid system patients was 59 years, and that of the dynamic system patients was 45 years.

The preoperative VAS and ODI scores were 8 and 69.7, respectively, in the rigid rod group. VAS and ODI were 6 and 42.9 at the 1-month postoperative evaluation. They were 4 and 20.1 at the 12th postoperative month and 2 and 16.3 at the 24th postoperative month. In the PEEK rod group, the VAS and ODI scores were 9 and 67.2 preoperatively. Postop, they were 6 and 40.7. They were 4 and 20.2 at the 12th postoperative month and 3 and 15.4 at the 24th postoperative month (Table 1). VAS and ODI scores were found to be lower in the postoperative period than in the preoperative period and were statistically significant ($p<0.05$).

The mean intraoperative bleeding in both groups was 285 ml in the rigid rod system and 234 ml in the PEEK rod system. The mean hospital stay of the two groups was 3.1 (min 2; max 6) days.

Revision surgery was performed a median of 19 months (range, 15-93 months) after the first operation. Revision surgery was performed in 10 (10.8%) patients with a rigid system due to adjacent segment disease and 2 (2.1%) due to pseudoarthrosis and instrumentation failure. Revision surgery was performed due to pseudoarthrosis in 2 (3.7%) patients and adjacent segment disease in 4 (7.4%) patients who underwent the dynamic system.

Table 1. Comparison of VAS scores between rigid and dynamic system groups

	Dynamic median (min-max)	Rigid median (min-max)	p
Lumbalgia VAS			
Preop	9 (6-10)	8 (2-10)	0.004*
Postop	6 (4-8)	6 (3-8)	0.003*
Postop 12 month	4 (2-6)	4 (2-7)	0.002*
Postop 24 month	3 (0-6)	2 (0-7)	0.210

VAS: Visual analog scale.

The segmental and total lumbar range of motion angles in both the rigid and dynamic groups were not statistically significant when the preoperative and postoperative

Table 2. Comparison of segmental and total lumbar range of motion in rigid and dynamic systems

	Dynamic median (min-max)	Rigid median (min-max)	p
Segmental Rom Preop	32.8 (0.4-66.7)	28.15 (5.7-55.1)	0.282
Segmental Rom Postop	31.8 (4.1-52.9)	26.9 (7.4-60.9)	0.273
Segmental Rom Postop 12 month	28.6 (3.5-54.8)	27.9 (1.5-54.7)	0.491
Segmental Rom Postop 24 month	28.2 (3-56.5)	27.3 (3.4-55.4)	0.846
Total Segmental Rom Preop	47.9 (11.5-83.7)	48.8 (29.6-80.8)	0.865
Total Segmental Rom Postop	39.7 (21.2-78.4)	41.6 (29.4-68.)	0.873
Total Segmental Rom Postop 12 month	44.2 (21.7-79.1)	46.3 (25-74.9)	0.849
Total Segmental Rom Postop 24 month	43.3 (20.2-79.6)	46.5 (25.9-73.7)	0.734

Table 3. Upper and lower disc distance heights in dynamic and rigid systems

	Dynamic median (min-max)	Rigid median (min-max)	p
Upper intervertebral disc height			
Preop	0.33 (0.25-0.43)	0.32 (0.20-0.42)	0.446
Postop	0.35 (0.25-0.47)	0.37 (0.22-0.44)	0.694
Postop 12 month	0.34 (0.26-0.51)	0.35 (0.20-0.44)	0.895
Postop 24 month	0.34 (0.18-0.49)	0.35 (0.24-0.42)	0.694
Lower intervertebral disc height			
Preop	0.28 (0.12-0.51)	0.33 (0.10-0.43)	0.431
Postop	0.30 (0.13-0.47)	0.33 (0.11-0.50)	0.446
Postop 12 month	0.28 (0.10-0.43)	0.32 (0.13-0.44)	0.306
Postop 24 month	0.29 (0.11-0.43)	0.33 (0.14-0.47)	0.248

periods were compared (p>0.05) (Table 2). It was found that the rigid group had less segmental ROM and a higher total lumbar ROM than the dynamic group.

In the rigid rod group, one upper and one lower intervertebral disc height of the operated level were 0.32-0.33 preoperatively. In the PEEK rod group, it was 0.33-0.28. The 1st, 12th, and 24th-month postoperative values of both groups were compared. When the lower and upper level disc distance heights of both groups were compared in the postoperative period, no statistical significance was found between them (p>0.05) (Table 3). However, it was determined that the rigid group's lower and upper level disc distance gaps were numerically better than the dynamic group.

Discussion

One of the most important causes of chronic low back pain is lumbar degenerative disc disease[8]. Various environmental factors, genetic factors, and anatomical variations are known to be associated with degenerative disc disease. In addition, recent studies have indicated that upper lumbar region subcutaneous adipose tissue is one of the factors affecting degeneration[9]. The superiority of surgical approaches in lumbar degenerative disc diseases is controversial. There are studies stating that there is no difference in long-term follow-up between patients who underwent minimally invasive approaches and open surgical fusion[10]. Fusion surgeries have been developed for spinal instability due to progressive degenerative disc disease[11]. Although fusion surgeries are successful in the early period, complications such as pseudoarthrosis, implant dysfunctions, and adjacent segment disease may occur in the long term. Decompression with rigid stabilization was applied to patients with degenerative lumbar discs, and the revision rate was found to be 6.1% after one year and 23.3% after 5 years[12]. Rigid fixation may cause adjacent segment disease due to hypermobility in the adjacent segment and partial load transfer in the unfused segment[13]. In our study, the revision rate was 13% in the rigid rod group.

Dynamic stabilization with a PEEK rod is performed to reduce motion in an unstable motion segment without stabilizing it. It also provides the transmission of forces by allowing movement in the spinal segment without fusion[14]. Patients with lumbar degenerative discs underwent surgery with a posterior dynamic system with decompression, and 4.3% of surgical site infections, 11.7% of pedicle screw loosening, 1.6% of pedicle screw fractures, and 7% of adjacent segment diseases developed[15]. The most common reasons for revision surgery in posterior dynamic devices are loosening or breakage of pedicle screws and adjacent segment disease. In the case of relaxation or fracture, preserved motion of the spinal segment is the main cause of such a complication, even if the relative rigidity of some of these devices has been demonstrated[16]. In our study, the revision rate in dynamic stabilization with the PEEK rod was 11%. Compared to the literature, our revision rate was found to be lower in the rigid group and the same in the dynamic system.

There are studies indicating that dynamic stabilization with PEEK rods is insufficient to provide lumbar lordosis[17]. It is important to plan adequate surgery to achieve ideal spinal alignment because it is less effective than rigid systems[18]. Kuo et al.[19] found that revision rates were significantly higher in patients whose lumbar lordosis could not be achieved after using the dynamic system. In a study by Rienmüller and his colleagues, the better the lumbar lordosis achieved after fusion surgery, the lower the revision requirement rate[20]. In our study, the need for revision surgery due to adjacent segment disease and pseudoarthrosis development was higher in patients with rigid systems. In patients with a dynamic system, the need for revision surgery due to pseudoarthrosis due to axial loading and low back pain was greater than that in the rigid group. Adjacent segment disease in the postoperative period was more common in the 12-month rigid group. However, the development of adjacent segments at the 24-month postoperative follow-up was at the same level in both groups, and there was no statistical significance.

The absence of fusion until the 6th postoperative month was considered pseudoarthrosis. The most important disadvantages of dynamic systems with PEEK rods are decreased rod stiffness and pseudoarthrosis due to rod breakage. There are difficulties and delays in diagnosing PEEK rod radiographic follow-up and rod dysfunction. In our study, although pseudoarthrosis was more common in the dynamic group with PEEK rods than in the rigid group, it was not statistically significant (p>0.05).

VAS and ODI scores were lower at 1, 12, and 24 months postoperatively than before surgery in both groups that did not undergo revision surgery. In patients who underwent revision surgery, VAS and ODI scores increased at 12 months in patients with rigid rods and at 24 months in those with PEEK rods. When the preoperative and postoperative periods of both groups were evaluated within themselves, there was a statistically significant difference between VAS and ODI scores. However, when both groups were compared with each other, there was no superiority in terms of VAS and ODI scores.

Conclusion

Fusion surgeries performed with a PEEK rod delay the occurrence of adjacent segment disease more than those performed with a rigid rod. However, both rigid and dynamic systems cannot prevent the formation of adjacent segments and pseudoarthrosis. More work is needed to determine specific treatment algorithms for the use of dynamic systems and revision surgeries.

Ethics Committee Approval: The study was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (no: 2020-23, date: 16/11/2020).

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