Annals of Medical Research
DOI: 10.5455/annalsmedres.2019.08.502 2020;(27)2:431-5

Original Article

Short-segment pedicle screw-based semi-rigid stabilization with poly (etheretherketone) rods for treatment of degenerative lumbar scoliosis in elderly patients

Goktug Akyoldas

Koc University Faculty of Medicine, Department of Neurosurgery, Istanbul, Turkey

Abstract

Aim: This study analyzed outcomes after short-segment pedicle screw-based semi-rigid stabilization with Poly (etheretherketone) (PEEK-polymer) rods in elderly patients with degenerative lumbar scoliosis. To date, there is no high level of evidence (Level-I) in the relevant literature. Therefore, this is the initial report about use of PEEK-polymer rods in elderly patients with degenerative lumbar scoliosis.

Material and Methods: From January 2015 to June 2017, 31 patients aged over 60 years with degenerative lumbar scoliosis, who underwent pedicle screw-based semi-rigid stabilization with PEEK-polymer rods were investigated. All medical records and radiological images were reviewed to evaluate surgery-related complications and clinical outcomes.

Results: Patients demonstrated clinically significant functional improvement (Oswestry Disability Index) with an average of 69.3% during an average follow-up of 36.1 months (range, 24–54 months) after surgery. Patients displayed significant Visual Analog Scale (VAS) improvements when comparing pre- and postoperative scores at an average change of 76% and 80% for VAS for back pain and leg pain, respectively. No neurological deficit was observed after surgery.

Conclusion: Satisfactory percentage in functional and pain improvement as well as low rate of instrument-related complications was obtained after pedicle screw-based stabilization with PEEK-polymer rods. This system can now be considered a viable option in elderly patients with the degenerative lumbar scoliosis.

Keywords: Lumbar degenerative scoliosis; lumbar spine; PEEK rods; semi-rigid fusion; stabilization

INTRODUCTION

Degenerative lumbar scoliosis (DLS) or de novo scoliosis is a common spinal disorder among elderly individuals with an incidence ranging from 6%–68% (1-4). The frequency of DLS increases with age (5). The predominant causes of DLS are intervertebral disc degeneration, vertebral corpus wedging, and joint facet arthritis (2,6-9). In addition, degenerative stenosis and spondylolisthesis are highly relevant to DLS as a cause (5,10,11). The most common surgical treatment of DLS often consists of posterolateral fusion with pedicle screws in addition to decompression of neuronal elements (6,12-15). However, many studies showed that the incidence of complications ranges from 20%–80% in elderly patients after fusion surgery for degenerative spinal disorders (6,13-15).

Dynamic stabilization systems have been developed to permit restricted motion across a functional spinal unit. Some reports presented successful application of dynamic system in elderly patients with DLS (16–18). Therefore, given that posterior rigid fixation shows high rate of complications in elderly patients, semi-rigid or dynamic stabilization systems may offer a promising solution to treat such patients. PEEK-polymer rods have been presented as a semi-rigid system for stabilization of the spine (Figure 1). Biomechanical and clinical studies showed that PEEK-polymer has a modulus of elasticity

Received: 28.08.2019 **Accepted:** 24.02.2020 **Available online:** 06.03.2020
Corresponding Author: Goktug Akyoldas, Koc University, Faculty of Medicine, Department of Neurosurgery, Istanbul, Turkey
E-mail: goktug_akyoldas@hotmail.com

between that of cortical and cancellous bones (19-21). Therefore, PEEK-polymer shows behavior that mimics the features of the physiological environment (21-23).

No study in the literature to date analyzed outcomes of semi-rigid posterior stabilization with PEEK-polymer rod for elderly patients with DLS. The aim of our study is to evaluate the clinical and radiological results of pedicle screw-based stabilization with PEEK-polymer rods in patients with DLS.

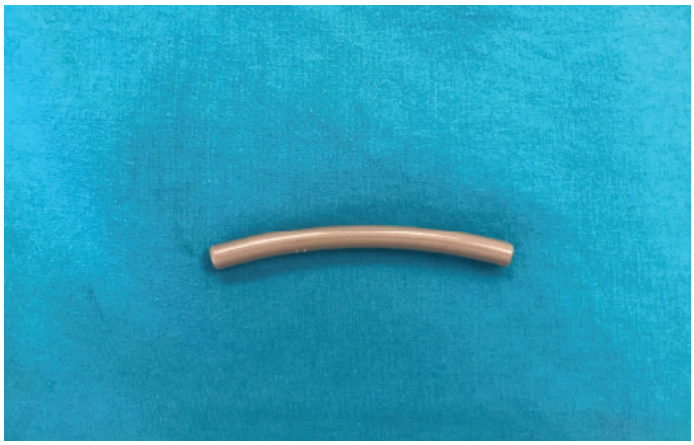

Figure 1. A PEEK-polymer rod

MATERIAL and METHODS

Patients Series

We retrospectively reviewed our single center's database of patients with DLS who underwent stabilization with PEEK-polymer rods between January 2015 and June 2017. Aebi's classification (6) was used to diagnose DLS. The inclusion criteria of patients with DLS were as follows: i) minimum age of 60 years at time of surgery, ii) Cobb angle from 10°-40° before surgery, iii) no benefit from conservative treatment, iv) minimum of 24 months follow-up, and v) no history of previous surgery. A total of 31 patients who met the criteria were included in the present study.

Clinical Follow-up and Radiological Assessments

The VAS for leg pain (VAS-LP) and back pain (VAS-BP) were used to assess the pain levels at preoperative period and at 12 and 24 months after surgery. Oswestry Disability Index (ODI) was used at preoperative period and at 12 and 24 months after operation to assess disability. Radiographical assessments included preoperative standing plain radiographs, computerized tomography and magnetic resonance imaging, and postoperative and follow-up standing plain radiographs. During follow-up, the presence of a "double halo sign" or "halo zone sign" on radiograph was considered as screw loosening (24). Preoperative Cobb angle measurements, postoperative adjacent segment degeneration, and instrumentation failure were assessed.

Surgical Treatment

All patients were administered with general anesthesia and were operated in the prone position. Surgery started with a midline lumbar incision. Bilateral paravertebral muscles and soft tissues were dissected. After sufficient dissection, pedicle screws were placed and tested using neurophysiological monitoring. Posterior decompression was performed at the appropriate segments. The degenerated disc was replaced when necessary. PEEK-polymer rods were placed and tightened with screw heads. The operation site was irrigated and closed with a drain. Prophylactic cefuroxime was administered to all patients upon induction of anesthesia and continued until the next 48 h. Patients were mobilized on the first postoperative day and discharged after 4-5 days.

Statistical Evaluation

Student's t-test was performed to analyze clinical results. Commercially available statistical processing software (SPSS, version 26.0, SPSS Inc.) was used for all calculations, and $p < 0.05$ was considered statistically significant.

RESULTS

Patient Attributes

The cases of 31 patients whose records contained complete information after dynamic stabilization with PEEK-polymer rod were included in the present study. Among these patients, women and men were 23 (74%) and 8 (26%), respectively. The median age was 70.1 (ranging from 60-86 years old). Mean follow-up was 36.1 months (ranging from 24-54 months). All of the 31 (100%) patients complained of back pain, and 27 (84%) of them reported leg pain before surgery. Preoperative VAS-BP and VAS-LP scores were 7.3 and 5.6, respectively.

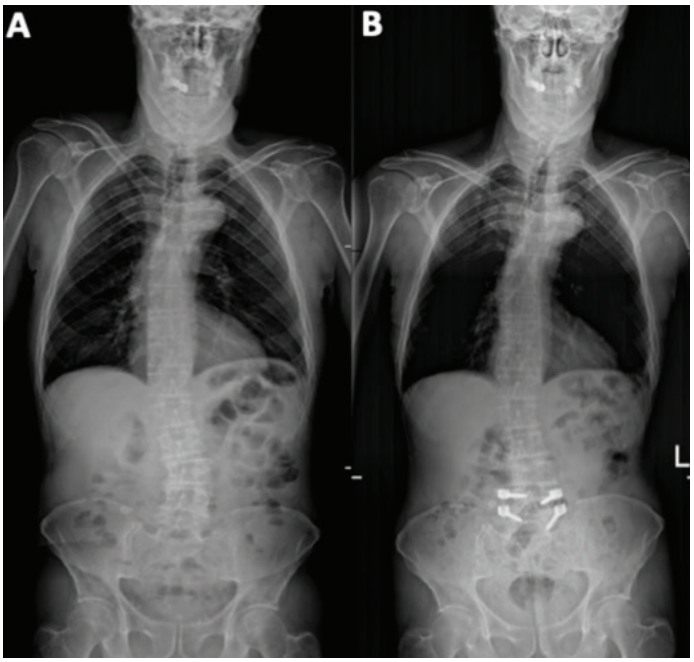

Figure 2. A 72-year-old man. Preoperative anterior-posterior radiograph showing a 12 degrees degenerative lumbar scoliosis (A). Treatment: L4-5 dynamic stabilization and decompressive laminectomy. Two-year postoperative radiographs showing stable scoliosis with L4-5 pedicle screw-based semi-rigid stabilization with PEEK-polymer rod (B).

All patients did not benefit from conservative treatment conducted for at least 6 months. All patients had DLS. In addition, 22 (71%), 12 (38%), and 4 (13%) patients had vertebral canal stenosis, extruded or sequestrated herniated intervertebral disc, and degenerative spondylolisthesis, respectively.

Perioperative Data

All patients underwent lumbar stabilization with pedicle screws and PEEK-polymer rods (Figure 2). A total of 160 pedicle screws were placed with 62 PEEK-polymer rods. One level was stabilized in 15 patients (48%; L3-L4 in 1, L5-L5 in 12, and L5-S1 in 2) and two levels in 16 patients (52%; L2-L4 in 5 and L3-5 in 15).

Clinical Outcome

In our series, a significant clinical improvement was observed after surgery. Preoperative VAS-BP showed statistically significant decrease from 7.32±0.90 to 1.77 ±0.71 during the final follow-up after surgery ($p < 0.001$) (Figure 3). Meanwhile, preoperative VAS-LP showed statistically significant decrease from 5.63 ± 3.08 to 1.4 ±0.80 during the final follow-up after surgery ($p < 0.001$) (Figure 3). ODI scores improved significantly during the final follow-up after surgery when compared with preoperative scores. ODI scores decrease from a preoperative score of 48% ± 10.9 to a postoperative score of 17% ± 6.57 at final follow-up ($p < 0.001$) (Figure 4).

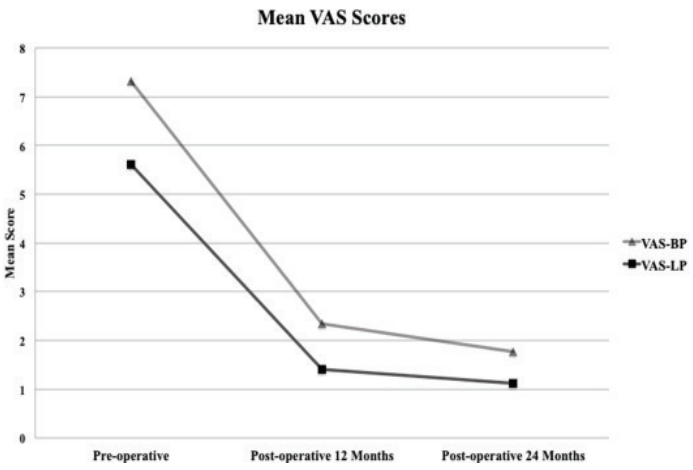

Figure 3. Visual Analog Scale for back pain (VAS-BP) and Visual Analog Scale for leg pain (VAS-BP) results of both groups over time

Complications

No neurological deficit was observed after surgery. Three patients had dural tear during operation, which was immediately repaired without clinical consequences. No infection was observed during follow-up period. After surgery, one patient complained of severe leg pain without neurological deficit. Screw malposition was observed on radiological examinations. Revision surgery was performed on postoperative day 2, and patient's complaints were resolved immediately after surgery. At follow-up, no screw or PEEK-polymer rod breakage was observed. Asymptomatic screw loosening was observed in 5 patients (16%). However, no patient was required to undergo revision surgery because of screw loosening. No symptomatic adjacent segment degeneration (ASD) was observed at the last follow-up.

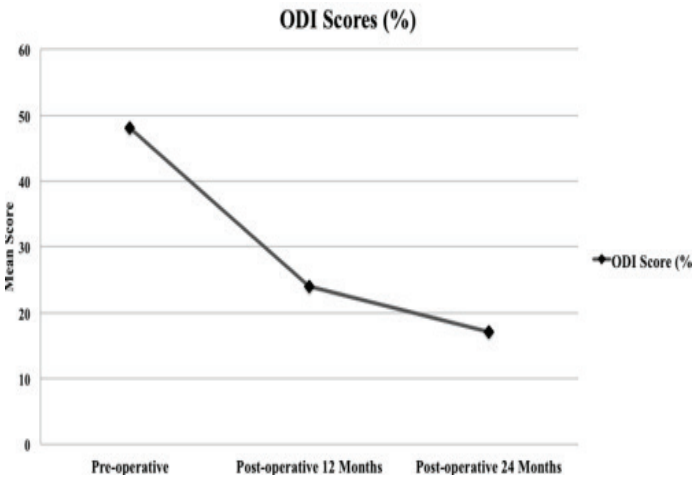

Figure 4. Clinical results of non-fusion surgery using PEEK-polymer rod systems measured by ODI

DISCUSSION

The surgical treatment of DLS in elderly population presents demanding aspects. The main goals of surgery are pain relief and improvement in the quality of life. The deformity correction is desirable but not essential. The common surgical treatment consisted of posterolateral fusion with pedicle screws and bony decompression (6, 12–15). Many studies have reported increased complication rates in elderly patients who underwent spinal fusion procedures (13, 14, 25–29). Overall complication rate of posterior fixation in elderly patients with DLS ranges from 20%–80% (6, 13–15). In addition, major complication rate was reported up to 55% (13, 14). Raffo et al. (26) concluded that the number of medical comorbidities, length of hospitalization, and intensive care unit stay were the main factors that could lead to the development of complications. Daubs et al. (27) noted that patients older than 69 years are 9 times more likely to develop major complications after spinal deformity surgery. In the light of the literature, surgical treatment of elderly patients with DLS frequently can present with several health problems; thus, it is important to limit the aggressiveness of surgery as much as possible in elderly patients when necessary. Moreover, one of the most important drawbacks of solid fixation and fusion is ASD. In a comprehensive meta-analysis containing 94 literature reports with 34,716 patients who underwent spinal fusion, Xi et al. found ASD rates range from 5% –77% (30).

Semi-rigid instrumentation with PEEK-polymer rods has become available to support stabilization in DLS in the last decades. Biomechanical studies showed that the modulus of elasticity of PEEK-polymer is similar to that of vertebral bone features (19–21). In addition, PEEK-polymer rods achieved similar stabilization and fusion rate when compared with titanium rods (21). Moreover, Panjabi

et al. reported that torsion testing and static compressive bending tests did not fracture the PEEK-polymer rod or show deformation (31). These features allow adequate rigidity such as bone fusion and are associated with a significant decrease in stress-shielding characteristics when compared with its usual metal counterparts. Therefore, PEEK-polymer rods provide reduction of the stress on pedicle screws and may decrease the risk of instrument failure, particularly in elderly patients with osteoporotic bone (21–23).

To date, six PEEK-polymer rod series were reported in the literature (32–37). None of those reported PEEK-polymer rod fractures. Likewise, we did not observed PEEK-polymer rod breakage during the last follow-up in our study. Three studies assessed screw loosening data and reported an average rate of 2.9% (ranging from 0%–3.3%) (34, 36, 37). In our study, the screw loosening rate is significantly high (16%, n = 5). Possible reasons for the high rate might be that the mean age of patients in our series is very high (70.1 years), and follow-up period is higher (36.5 months) than that in the literature. Three studies assessed screw breakage data in their PEEK-polymer rod series, and reported it to be 2.6% (ranging from 0%–3.8%) (33, 34, 36, 37). In the present study, we did not observe screw breakage.

When preoperative and postoperative function scores in the literature were compared, patients who underwent surgery with PEEK-polymer rods showed significant improvement with an average rate of 69.3% (ranging from 60.5%–76.9%) (33–35, 37). We observed a significant decline in mean ODI scores with a rate of 64.3% at final follow-up ($p < 0.001$). When preoperative and postoperative pain scores in the literature were compared, patients who underwent surgery with PEEK-polymer rods showed significant improvement in mean VAS-BP and mean VAS-LP at an average change of 68.9% and 76.6%, respectively (33, 34, 37). We observed mean VAS-BP score improvements of 68% at 12 months follow-up and 75% at 24 moths follow-up ($p < 0.001$). Meanwhile, mean VAS-LP score showed 76% and 80% improvement at 12 and 24 months follow-up, respectively ($p < 0.001$).

Two comprehensive meta-analysis and systematic reviews about the use of PEEK-polymer rods for the treatment of degenerative spine have recently been published (38, 39). Li et al. evaluated the use of PEEK-polymer rods in nonfusion and fusion spine stabilization surgeries. They concluded that PEEK-polymer rods can be used for semi-rigid stabilization to treat patients with degenerative spine disease and mild lumbar spondylolisthesis (38). Selim et al. concluded that posterior stabilization with PEEK-polymer rods provides satisfactory pain and functional improvements as well as very low rate of instrument failure (39).

This study has some limitations. First, the sample size is relatively small. Second, this study is retrospective with inherent design limitations. Third, there is no control group, such as patients who underwent spinal stabilization with a different dynamic or rigid instrumentation system.

In summary, our results are consistent with those in the literature. It is important to highlight that pedicle screw-based instrumentation with PEEK-polymer rods provided significant clinical improvement in elderly patients with DLS at a mean follow-up.

CONCLUSION

In conclusion, the midterm results obtained from pedicle screw-based posterior stabilization with PEEK-polymer rods are promising and show satisfactory clinical improvement in elderly patients with DLS. In addition, with low rate of instrument failure, posterior stabilization with PEEK-polymer rods in addition to bony decompression is a safe procedure in elderly patients with DLS. However, prospective cohort studies with long-term follow-up are needed to support the recommendation of semi-rigid stabilization with PEEK-polymer rods as the ideal method for treatment for degenerative spinal disordersAcknowledgments: The authors would like to thank the staff of the IVF center for the benefits.

Acknowledgement: English language editing of this article was partly supported by Turkish Neurosurgical Society.

Competing interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical approval: There is no consent of ethics because this is a retrospective study.

Goktug Akyoldas ORCID: 0000-0003-4234-6520

REFERENCES

1. Vanderpool DW, James JIP, Wynne-Davies R. Scoliosis in the elderly. J Bone Joint Surg Am 1969;51:446-55.
2. Kobayashi T, Atsuta Y, Takemitsu M, et al. A prospective study of de novo scoliosis in a community based cohort. Spine (Phila Pa 1976) 2006;31:178-82.
3. Schwab F, Dubey A, Gamez L, et al. Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. Spine 2005;30:1082-5.
4. Weinstein SL, Ponseti IV. Curve progression in idiopathic scoliosis. J Bone Joint Surg Am 1983;65:447-55.
5. Pritchett JW, Bortel DT. Degenerative symptomatic lumbar scoliosis. Spine (Phila Pa 1976) 1993;18:700-3.
6. Aebi M. The adult scoliosis. Eur Spine J 2005;14:925-48.
7. Robin GC, Span Y, Steinberg R, et al. Scoliosis in the elderly: a follow-up study. Spine (Phila Pa 1976) 1982;7:355-9.
8. Murata Y, Takahashi K, Hanaoka E, et al. Changes in scoliotic curvature and lordotic angle during the early phase of degenerative lumbar scoliosis. Spine 2002;27:2268-73.
9. Benoist M. Natural history of the aging spine. Eur Spine J 2003;12:86–98.
10. Ploumis A, Transfledt EE, Denis F. Degenerative lumbar scoliosis associated with spinal stenosis. Spine J 2007;7:428-36.

11. Liu H, Ishihara H, Kanamori M, et al. Characteristics of nerve root compression caused by degenerative lumbar spinal stenosis with scoliosis. Spine J 2003;3:524-9.
12. Simmons ED. Surgical treatment of patients with lumbar spinal stenosis with associated scoliosis. Clin Orthop Relat Res 2001;384:45-53.
13. Carreon LY, Puno RM, Dimar JR 2nd, et al. Perioperative complications of posterior lumbar decompression and arthrodesis in older adults. J Bone Joint Surg Am 2003;85:2089-92.
14. Cho KJ, Suk SI, Park SR, et al. Complications in posterior fusion and instrumentation for degenerative lumbar scoliosis. Spine (Phila Pa 1976) 2007;32:2232-7.
15. Cho KJ, Suk SI, Park SR, et al. Short fusion versus long fusion for degenerative lumbar scoliosis. Eur Spine J 2008;17:650-6.
16. Ozer AF, Cevik OM, Erbulut DU, et al. A Novel Modular Dynamic Stabilization System for the Treatment of Degenerative Spinal Pathologies. Turk Neurosurg 2019;29:115-20.
17. Lee SE, Jahng TA, Kim HJ. Decompression and nonfusion dynamic stabilization for spinal stenosis with degenerative lumbar scoliosis: Clinical article. J Neurosurg Spine 2014;21:585-94.
18. Di Silvestre M, Lolli F, Bakaloudis G. Degenerative lumbar scoliosis in elderly patients: dynamic stabilization without fusion versus posterior instrumented fusion. Spine J 2014;14:1-10.
19. Kurtz SM, Devine JN. PEEK biomaterials in trauma, orthopedic, and spinal implants. Biomaterials 2007;28:4845-69.
20. Ahn YH, Chen WM, Lee KY, et al. Comparison of the load-sharing characteristics between pedicle-based dynamic and rigid rod devices. Biomed Mater 2008;3:044101.
21. Ponnappan RK, Serhan H, Zarda B, et al. Biomechanical evaluation and comparison of polyetheretherketone rodsystem to traditional titanium rod fixation. Spine J 2009;9:263-7.
22. Highsmith JM, Tumialán LM, Rodts GE Jr. Flexible rods and the case for dynamic stabilization. Neurosurg Focus 2007;22:11.
23. Cavagna R, Tournier C, Aunoble S, et al. Lumbar decompression and fusion in elderly osteoporotic patients: a prospective study using less rigid titanium rod fixation. J Spinal Disord Tech 2008;21:86-91.
24. Dakhil-Jerew F, Jadeja H, Cohen A, et al. Inter-observer reliability of detecting Dynesys pedicle screw using plain X-rays: a study on 50 post-operative patients. Eur Spine J 2009;18:1486-93.
25. Deyo RA, Ciol MA, Cherkin DC, et al. Lumbar spinal fusion. A cohort study of complications, reoperations, and resource use in the Medicare population. Spine (Phila Pa 1976) 1993;18:1463-70.
26. Raffo CS, Lauerman WC. Predicting morbidity and mortality of lumbar spine arthrodesis in patients in their ninth decade. Spine (Phila Pa 1976) 2006;31:99-103.
27. Daubs MD, Lenke LG, Cheh G, et al. Adult spinal deformity surgery. Complications and outcomes in patients over age 60. Spine (Phila Pa 1976) 2007;32:2238-44.
28. Wang MY, Green BA, Shah S, et al. Complications associated with lumbar stenosis surgery in patients older than 75 years of age. Neurosurg Focus 2003;14:7.
29. Benz RJ, Ibrahim ZG, Afshar P, et al. Predicting complications in elderly patients undergoing lumbar decompression. Clin Orthop Relat Res 2001;384:116-21.
30. Xia XP, Chen HL, Cheng HB. Prevalence of adjacent segment degeneration after spine surgery: a systematic review and meta-analysis. Spine (Phila Pa 1976) 2013;38:597-608.
31. Panjabi MM. Hybrid multidirectional test method to evaluate spinal adjacent-level effects. Clin Biomech 2007;22:257-65.
32. De Iure F, Bosco G, Cappuccio M, et al. Posterior lumbar fusion by peek rods in degenerative spine: preliminary report on 30 cases. Eur Spine J 2012;21:50-54.
33. Athanasakopoulos M, Mavrogenis AF, Triantafyllopoulos G, et al. Posterior spinal fusion using pedicle screws. Orthopedics 2013;36:951-7.
34. Qi L, Li M, Zhang S, et al. Comparative effectiveness of PEEK rods versus titanium alloy rods in lumbar fusion: a preliminary report. Acta Neurochirurgica 2013;155:1187-93.
35. Colangeli S, Barbanti Brodàno G, Gasbarrini A, et al. Polyetheretherketone (PEEK) rods: short-term results in lumbar spine degenerative disease. J Neurosurg Sci 2015;59:91-6.
36. Ormond DR, Albert L Jr, Das K. Polyetheretherketone (PEEK) rods in lumbar spine degenerative disease: a case series. Clin Spine Surg 2016;29:371-5.
37. Huang W, Chang Z, Song R, et al. Non-fusion procedure using PEEK rod systems for lumbar degenerative diseases: clinical experience with a 2-year follow-up. BMC Musculoskelet Disord 2016;17:53.
38. Li C, Liu L, Shi JY, et al. Clinical and biomechanical researches of polyetheretherketone (PEEK) rods for semi-rigid lumbar fusion: a systematic review. Neurosurg Rev 2018;41:375-89.
39. Selim A, Mercer S, Tang F. Polyetheretherketone (PEEK) Rods for Lumbar Fusion: A Systematic Review and Meta-Analysis. Int J Spine Surg 2018;12:190-200.