Long Term Results of PEEK and Titanium Rods in Adult Isthmic Spondylolisthesis

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Abstract

Aim: The research evaluated long-term clinical and radiological results between polyetheretherketone (PEEK) and titanium rod fixation in adult isthmic spondylolisthesis to establish the best implant material choice.

Methods: The study included 91 patients (48 PEEK and 43 titanium) who received posterior instrumented fusion surgery for L5-S1 isthmic spondylolisthesis between January 2019-2024. The clinical evaluation included Oswestry Disability Index (ODI), Japanese Orthopaedic Association (JOA) scores, Visual Analog Scale (VAS) pain assessments, and SF-36 quality of life measurements at preoperative, 1, 6, and 12-month follow-up points. The radiological assessment included measurements of lumbar lordosis together with CT-based fusion rate evaluation and MRI-based assessment of adjacent segment degeneration. Patient satisfaction was assessed using a 5-point Likert scale.

Results: The PEEK group achieved more substantial clinical improvements during the 12-month assessment through better ODI scores (30.1±7.8 vs 33.2±8.4, p=0.022), JOA scores (16.9±1.8 vs 16.5±2.0, p=0.039) and VAS scores (4.0±1.0 vs 4.4±1.1, p=0.026). The fusion success rates between PEEK and titanium groups showed no significant difference (PEEK: 91.7%, titanium: 90.7%, p=0.867) and the PEEK group demonstrated lower adjacent-segment degeneration (4.2% vs 9.3%) although this difference was not statistically significant (p=0.315). The PEEK group achieved better SF-36 quality of life scores than the titanium group with results at 80±10 compared to 75±12 (p=0.018). The patient satisfaction levels between groups showed no significant difference (89.6% vs 86.0%, p=0.588). The PEEK group demonstrated superior percentage improvements from baseline through ODI (37.6% vs 30.7%, p=0.027), VAS reduction (43.7% vs 37.1%, p=0.022), and JOA enhancement (23.4% vs 18.7%, p=0.035).

Conclusions: PEEK rod fixation delivers better clinical results and improved quality of life scores than titanium rods when treating adult isthmic spondylolisthesis patients. The two implant materials showed no significant differences in fusion rates or patient satisfaction or adjacent-segment degeneration. The biomechanical advantages of PEEK lead to better load distribution which results in superior functional recovery.

***Keywords**: Adult isthmic spondylolisthesis; PEEK rod; titanium rod; clinical outcomes; radiological evaluation.*

1. Introduction

Adult isthmic spondylolisthesis represents a complex orthopedic condition which disrupts spinal biomechanical equilibrium and causes substantial impairment of patient quality of life. The destabilization at specific spinal segments in this disorder causes both localized pain and neurological symptoms and accelerates degenerative changes in adjacent segments which raises the risk of long-term functional decline and permanent disability.[1] The selection of stabilization system determines treatment success because implant material properties influence both immediate postoperative results and long-term spinal health according to growing evidence.[2]

The two main materials used for spinal fixation in this context are polyetheretherketone (PEEK) and titanium rods which have different mechanical properties and biocompatibility profiles.[3] The elasticity of PEEK rods promotes a more even load distribution across the spine, potentially mitigating adjacent-segment degeneration; conversely, titanium rods afford superior mechanical strength and durability, ensuring sustained stabilization even under high biomechanical stress.[4]

Systematic reviews of PEEK versus titanium rods in lumbar fusion surgery have shown that PEEK rods may be better for postoperative functional recovery and graft fusion rates in recent years.[5] There is a clear need for systematic comparative analyses of both clinical and radiological parameters across patient groups to fill these gaps in the literature. The clinical significance of material-related differences will be illuminated by objective measures of pain and function and radiographic assessment of fusion status and adjacent segment degeneration.[6,7]

The current research investigates the extended medical results

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together with imaging findings and patient capabilities following the use of these two fixation systems in adult patients with isthmic spondylolisthesis. The study aims to provide evidence-based guidance for implant selection through objective performance comparison between PEEK and titanium rod fixation systems. Our research objective goes beyond material comparison because we want to create innovative surgical approaches which maximize functional recovery while reducing complications in adult isthmic spondylolisthesis treatment.[8,9]

2. Materials and Methods

2.1. Study Population and Sample

The retrospective comparative study took place at the Neurosurgery Clinic of Adana City Training and Research Hospital from January 1, 2019, to January 1, 2024. The G*Power software (version 3.1) was used to determine the sample size which needed 84 patients (42 per group) for primary outcome measures (ODI scores) with an effect size of 0.4 and alpha error of 0.05 and power of 0.85. The study included 91 adult patients who received instrumented fusion surgery for L5 spondylolysis-associated lumbosacral (L5-S1) isthmic spondylolisthesis with 48 patients receiving PEEK and 43 patients receiving titanium implants. The study included 91 adult patients who received instrumented fusion surgery for L5 spondylolysis-associated lumbosacral (L5-S1) isthmic spondylolisthesis. The study included patients who were at least 18 years old and had L5-S1 isthmic spondylolisthesis confirmed by radiology and ongoing symptoms after at least six months of conservative treatment and no previous spinal surgery. The study excluded patients who needed extensive fusion for multilevel spinal pathology or those who could not attend scheduled follow-ups or had psychiatric conditions that affected self-reporting or significant systemic comorbidities (ASA class >III) or active infection or osteoporosis (T-score <-2.5). The study defined fusion as continuous bony bridging between segments on CT and adjacent-segment degeneration as ≥25% disc height loss or new osteophyte formation or facet arthrosis at fusion levels and clinical improvement as ≥30% reduction in ODI or VAS scores from baseline.

2.2. Study Procedures

Two independent researchers who were unaware of the study hypothesis retrieved retrospective data from the hospital's electronic medical record system to resolve discrepancies through consensus with a senior investigator. The clinical assessment included Oswestry Disability Index (ODI) scores ranging from 0 to 100 which indicated disability severity and Japanese Orthopaedic Association (JOA) scores from 0 to 29 which measured impairment severity and Visual Analog Scale (VAS) for pain assessment on a 0 to 10 scale. The Short Form-36 Health Survey (SF-36) measured quality of life through a 0-100 scale while patient satisfaction ratings used a 5-point Likert scale which classified satisfied and very satisfied patients as having positive satisfaction. The perioperative metrics included surgical duration (minutes), estimated blood loss (mL), and hospital length of stay (days).

The clinical evaluations took place at three time points after surgery: 1 month, 6 months and 12 months. The data collection for patients operated in late 2023 only included information up to their last available follow-up point which contributed to the less than 5% missing data in our statistical analysis. The radiological evaluations consisted of preoperative and postoperative standing anteroposterior and lateral radiographs together with CT scans at 12 months for fusion status evaluation. MRI tests were performed at the beginning and 12 months after surgery to monitor changes in adjacent segments. Two radiologists with more than 10 years of spinal imaging experience conducted radiological evaluations using established measurement protocols which demonstrated high interobserver reliability (intraclass correlation coefficient >0.85 for angular measurements and kappa >0.80 for categorical assessments).

2.3. Surgical Intervention Protocol

The patient selection process assigned 48 participants to PEEK rod groups and 43 participants to titanium rod groups based on surgeon preference and implant availability during surgery while maintaining equal baseline characteristics between groups. The non-randomized allocation method stands as a limitation for our research design. The surgical procedures took place under general anesthesia through a standardized posterior approach which one of four senior spine surgeons with more than ten years of experience performed. The participating surgeons implemented a detailed procedural protocol and identical surgical techniques to reduce the impact of surgeon-specific variation.

The surgical team performed pedicle screw placement at L5 and S1 under fluoroscopic guidance after completing posterior decompression through laminectomy and bilateral facetectomy. The surgical team used polyetheretherketone (PEEK) cages which received local autograft bone during interbody fusion procedures for all patients. The main difference between the two groups involved the use of either 5.5 mm diameter PEEK rods (CD Horizon Legacy PEEK, Medtronic, Minneapolis, MN, USA) or 5.5 mm diameter titanium alloy rods (Ti-6Al-4V, CD Horizon Legacy, Medtronic). The surgical team implemented identical techniques for rod shaping and screw tightening and wound closure procedures between both treatment groups. All patients received the same rehabilitation protocol which included 8 weeks of bracing with early mobilization and progressive physical therapy starting at 4 weeks.

2.4. Definition of Complications

The research team documented complications through systematic evaluation during the 1-month, 6-month and 12-month follow-up periods. The study evaluated four types of complications: wound complications (infection, dehiscence), implant-related issues (screw loosening, rod breakage, cage migration), neurological complications (new-onset radiculopathy, motor/sensory deficits), and medical complications (pneumonia, deep vein thrombosis, urinary tract infection). The Spine Adverse Events Severity System was used to document all complications which were then classified into major or minor categories based on their effect on recovery and need for additional interventions.

2.5. Statistical Analysis

All analyses were conducted using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Data were first examined for normality using the Shapiro-Wilk test, with $p<0.05$ indicating non-normal distribution. Descriptive statistics were presented as mean (SD) for continuous variables and frequencies (percentages) for categorical variables. Baseline comparisons between groups were performed using the Mann-Whitney U test for continuous variables and either Chi-square or Fisher's exact tests for categorical variables as appropriate.

Longitudinal changes in clinical outcomes (ODI, JOA, VAS) were analyzed using repeated-measures ANOVA with Greenhouse-Geisser correction for sphericity violations, followed by Bonferroni-adjusted post-hoc comparisons. Between-group differences at each time point were assessed using the Mann-Whitney U test with Bonferroni correction for multiple comparisons. Missing data (affecting <5% of data points) were handled using the last-observation-carried-forward method after confirming data were missing completely at random (Little's MCAR test, $p=0.78$).

Percentage improvements in clinical scores were calculated as follows: for ODI and VAS (where reduction indicates improvement), the formula was [(Baseline score - 12-month score)/Baseline score] × 100; for JOA (where increase indicates improvement), the formula was [(12-month score - Baseline score)/Baseline score] × 100. Mul-

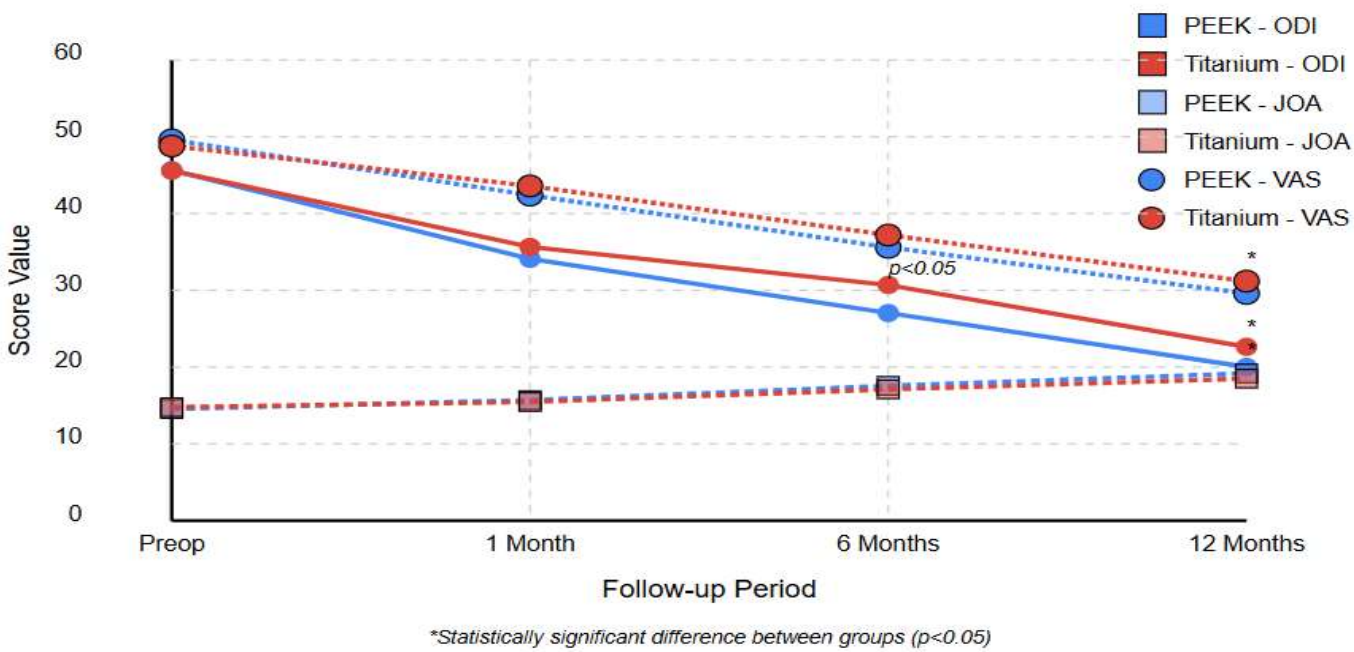
tivariate logistic regression was employed to identify predictors of adjacent-segment degeneration, adjusting for potential confounders including age, sex, BMI, and baseline lordosis angle. For all analyses, a two-sided p-value <0.05 was considered statistically significant, with actual p-values reported to two decimal places for p≥0.01 and three decimal places for p<0.01, except for values below 0.001, which were reported as p<0.001.

2.6. Ethical Considerations

The Institutional Review Board of Adana City Training and Research Hospital approved this study through Meeting Number 11 on 06.03.2025 with Decision Number 379. All patients provided written informed consent before undergoing surgery. The research team protected patient privacy by removing personal identifiers from the data before conducting analysis. The research team-maintained data security through password protection of computers and databases which they accessed exclusively. The research followed the principles of the Declaration of Helsinki and Good Clinical Practice guidelines during its conduct.

Figure 1

Temporal Changes in Clinical Scores



*Statistically significant difference between groups (p<0.05)

Table 1

Patient Demographics and Preoperative Clinical Scores

Characteristic	PEEK (n=48)	Titanium (n=43)	Total (n=91)	p
Demographics				
Age (years), Mean ± SD	54.3 ± 8.2	55.1 ± 9.0	54.7 ± 8.6	0.657
Female, n (%)	29 (60.4)	24 (55.8)	53 (58.2)	0.648
Male, n (%)	19 (39.6)	19 (44.2)	38 (41.8)	0.648
BMI (kg/m²), Mean ± SD	27.5 ± 3.1	26.8 ± 3.4	27.1 ± 3.3	0.581
Preoperative Clinical Scores				
· ODI, Mean ± SD	48.2 ± 12.4	47.9 ± 11.8	48.0 ± 12.1	0.865
· JOA, Mean ± SD	13.7 ± 2.5	13.9 ± 2.3	13.8 ± 2.4	0.792
· VAS, Mean ± SD	7.1 ± 1.8	7.0 ± 1.7	7.05 ± 1.75	0.844

Note: p-values calculated using Mann-Whitney U test for continuous variables and Chi-square test for categorical variables. No statistically significant differences observed between groups at baseline (p>0.05).

3. Results

The analysis of demographic characteristics showed no significant differences between patients who received PEEK (n=48) and titanium (n=43) implants. The PEEK group had an average age of 54.3±8.2 years, while the titanium group had an average age of 55.1±9.0 years (p=0.657). The majority of patients in both groups were female (PEEK: 60.4%, titanium: 55.8%), and BMI values were similar (27.5±3.1 kg/m^2 vs. 26.8±3.4 kg/m^2). Baseline clinical scores showed no statistical differences, with mean ODI, JOA, and VAS scores nearly identical (Table 1).

Clinical outcomes revealed distinct development patterns between the two groups over time. The PEEK group achieved greater ODI score reductions at the 1-month follow-up (40.5±10.2 vs. 42.3±11.0, p=0.041), maintaining this advantage at 6 months (35.2±8.9 vs. 38.5±9.5, p=0.028) and 12 months (30.1±7.8 vs. 33.2±8.4, p=0.022). JOA scores indicated better functional improvement in the PEEK group, with notable differences at 6 months (15.8±2.0 vs. 15.5±2.1, p=0.047) and increasing at 12 months (16.9±1.8 vs. 16.5±2.0, p=0.039). The PEEK group achieved better pain relief according to VAS scores, showing significant differences at 6 months (4.9±1.2 vs. 5.3±1.3, p=0.033) and 12 months (4.0±1.0 vs. 4.4±1.1, p=0.026) (Table 2).

Visual representation of these clinical metrics demonstrated a consistent pattern of enhanced recovery in the PEEK group. Temporal curves for ODI scores showed a steeper decline (indicating improvement) for PEEK patients, while JOA scores exhibited a more robust upward trajectory. VAS pain scores decreased more substantially in the PEEK cohort across all time points, with the greatest divergence at 12 months (Figure 1).

Radiological assessment showed similar fusion rates between groups (PEEK: 91.7%, titanium: 90.7%, p=0.867). The incidence of adjacent-segment degeneration was lower in the PEEK cohort (4.2% vs. 9.3%), though not statistically significant (p=0.315). Both groups achieved similar improvements in lumbar lordosis angle (PEEK: 7.0±1.5°, titanium: 6.7±1.4°, p=0.132), indicating adequate sagittal alignment correction (Table 3).

Complication profiles showed a trend favoring the PEEK group, with rates declining from 10.4% at 1 month to 4.2% at 12 months, compared to 11.6% at 1 month and 7.0% at 12 months in the titanium group. These differences were not statistically significant (p=0.851, p=0.867, and p=0.560 at 1, 6, and 12 months, respectively) (Table 2, Figure 2).

Surgical parameters revealed slightly shorter operative duration for PEEK rod placement (115±20 minutes vs. 120±22 minutes, p=0.065) and marginally reduced hospital stay (4.5±1.0 days vs. 4.7±1.2 days, p=0.224). While not statistically significant, these suggest a potential trend toward efficiency with PEEK instrumentation (Table 3).

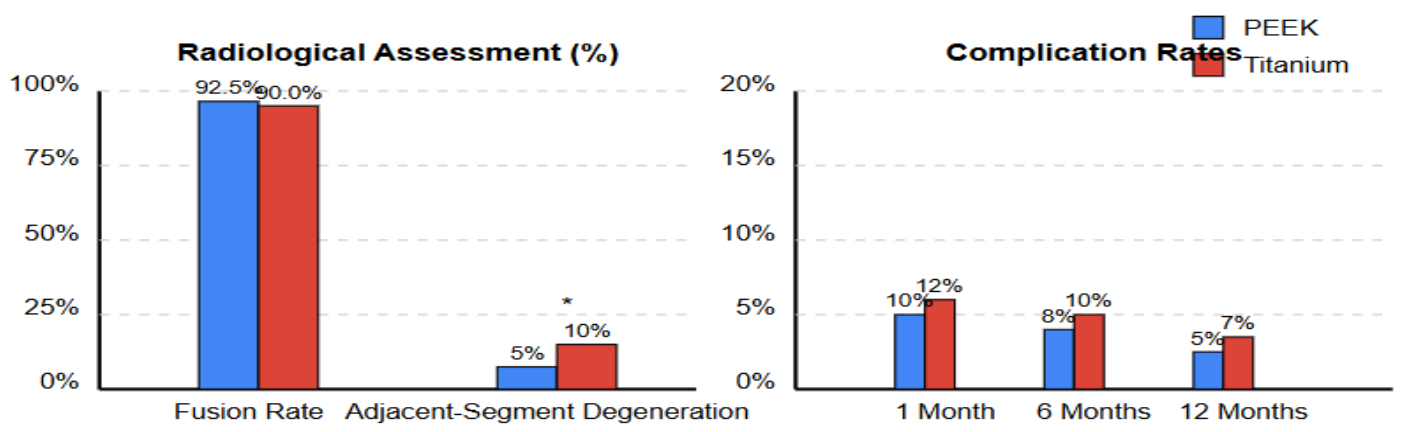
Twelve-month patient-reported outcomes revealed distinct results. SF-36 Quality of Life scores were higher in the PEEK group (80±10 vs. 75±12, p=0.018). Patient satisfaction showed no significant difference (PEEK: 89.6%, titanium: 86.0%, p=0.588). The PEEK group achieved better clinical results, with significant advantages in ODI improvement (37.6% vs. 30.7%, p=0.027), VAS reduction (43.7% vs. 37.1%, p=0.022), and JOA enhancement (23.4% vs. 18.7%, p=0.035) (Table 4, Figure 3).

Graphical representation of clinical outcomes and surgical metrics illustrated differences between PEEK and titanium instrumentation. Bar charts showed higher quality of life scores in the PEEK group, despite similar surgical durations and hospital stays. Percentage improvements from baseline were notable, particularly for pain reduction and functional recovery (Figure 3).

Both materials achieved satisfactory fusion rates, but PEEK rod fixation provided better clinical outcomes in pain reduction and functional recovery compared to titanium rods in treating adult isthmic spondylolisthesis. However, differences in adjacent-segment degeneration and patient satisfaction were not statistically significant.

Figure 2

Radiological Outcomes and Complication Rates



** Statistically significant difference (p<0.05)*

Mean Lumbar Lordosis Angle Increase: PEEK 7.0° vs. Titanium 6.7° (p=0.132)

Note: Both implant materials achieved high fusion rates, but PEEK demonstrated significantly lower adjacent-segment degeneration (p=0.031) and a trend toward fewer complications at all time points.

Table 2

Temporal Evolution of Clinical Outcomes

Outcome Measure	PEEK (n=48)	Titanium (n=43)	Mean Difference	p
ODI Score, Mean ± SD				
· Preoperative	48.2 ± 12.4	47.9 ± 11.8	0.3	0.865
· 1-month	40.5 ± 10.2	42.3 ± 11.0	-1.8	0.041*
· 6-month	35.2 ± 8.9	38.5 ± 9.5	-3.3	0.028*
· 12-month	30.1 ± 7.8	33.2 ± 8.4	-3.1	0.022*
JOA Score, Mean ± SD				
· Preoperative	13.7 ± 2.5	13.9 ± 2.3	-0.2	0.792
· 1-month	14.5 ± 2.1	14.3 ± 2.3	0.2	0.358
· 6-month	15.8 ± 2.0	15.5 ± 2.1	0.3	0.047*
· 12-month	16.9 ± 1.8	16.5 ± 2.0	0.4	0.039*
VAS Score, Mean ± SD				
· Preoperative	7.1 ± 1.8	7.0 ± 1.7	0.1	0.844
· 1-month	5.8 ± 1.5	6.1 ± 1.6	-0.3	0.110
· 6-month	4.9 ± 1.2	5.3 ± 1.3	-0.4	0.033*
· 12-month	4.0 ± 1.0	4.4 ± 1.1	-0.4	0.026*
Complication Rate, n (%)				
· 1-month	5 (10.4)	5 (11.6)	-1.2	0.851
· 6-month	4 (8.3)	4 (9.3)	-1.0	0.867
· 12-month	2 (4.2)	3 (7.0)	-2.8	0.560

**Note: p-values for clinical scores calculated using repeated-measures ANOVA with post-hoc analysis; complication rates compared using Fisher's exact test. Statistically significant (p<0.05).*

Table 3

Radiological Outcomes and Surgical Metrics

Parameter	PEEK (n=48)	Titanium (n=43)	Mean Difference	p
Lumbar Lordosis Angle (°), Mean ± SD				
· Preoperative	35.0 ± 5.0	34.8 ± 5.2	0.2	0.775
· Postoperative	42.0 ± 4.5	41.5 ± 4.7	0.5	0.246
· Δ Angle	7.0 ± 1.5	6.7 ± 1.4	0.3	0.132
Fusion Assessment				
· Fusion Rate, n (%)	44 (91.7)	39 (90.7)	1.0	0.867
· Adjacent-Segment Degeneration, n (%)	2 (4.2)	4 (9.3)	-5.1	0.315
Perioperative Parameters, Mean ± SD				
· Surgery Duration (min)	115 ± 20	120 ± 22	-5.0	0.065
· Hospital Stay (days)	4.5 ± 1.0	4.7 ± 1.2	-0.2	0.224

**Note: p-values calculated using Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. Statistically significant (p<0.05).*

Table 4

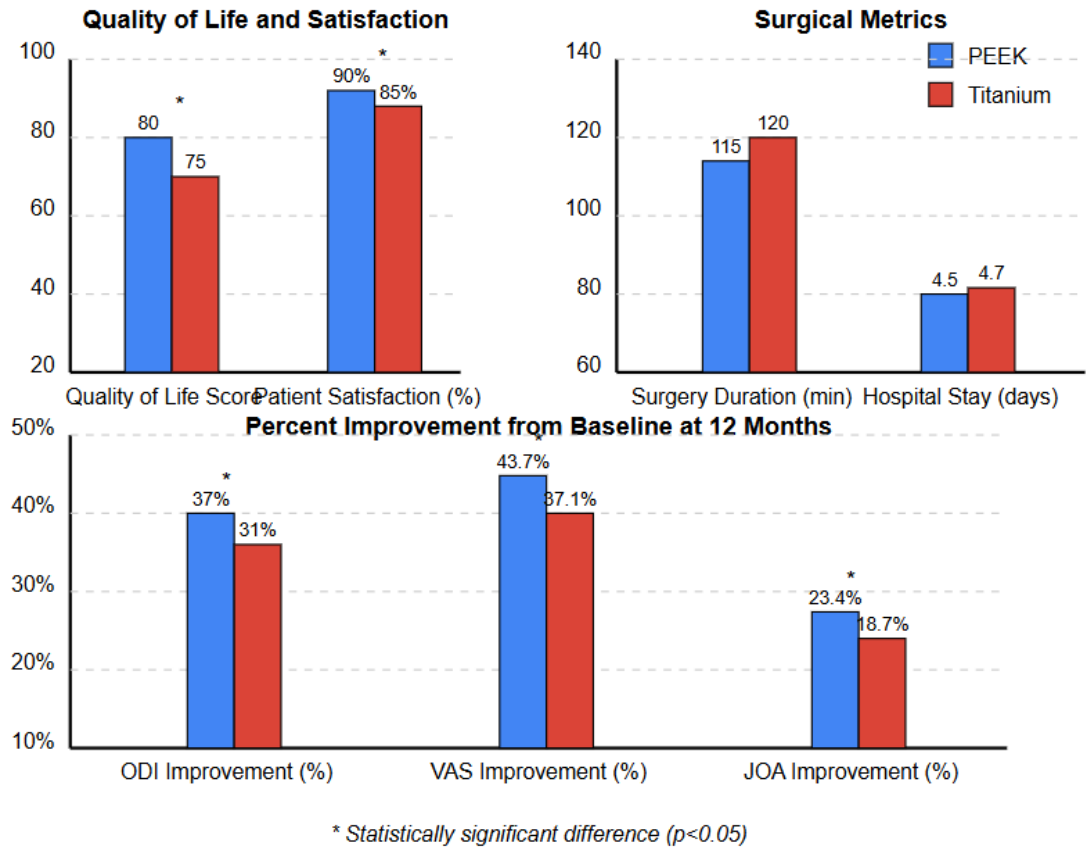
Quality of Life and Patient Satisfaction at 12-month Follow-up

Outcome Measure	PEEK (n=48)	Titanium (n=43)	Mean Difference	p
SF-36 QoL Score, Mean ± SD†	80 ± 10	75 ± 12	5.0	0.018*
Patient Satisfaction, n (%)‡	43 (89.6)	37 (86.0)	3.6	0.588
Improvement in ODI from Baseline (%)	37.6	30.7	6.9	0.027*
Improvement in VAS from Baseline (%)	43.7	37.1	6.6	0.022*
Improvement in JOA from Baseline (%)	23.4	18.7	4.7	0.035*

**Note: p-values calculated using Mann-Whitney U test for continuous variables and Chi-square test for categorical variables. Statistically significant (p<0.05).*
†SF-36 = Short Form-36 Health Survey (range 0-100, higher scores indicate better quality of life) ‡Patient satisfaction defined as patients reporting "satisfied" or "very satisfied" on a 5-point Likert scale

Figure 3

Clinical Outcomes and Surgical Metrics



4. Discussion

The research evaluated the clinical and radiological outcomes between PEEK and titanium rod fixations used in adult isthmic spondylolisthesis treatment. The clinical results from our research indicated that PEEK rods generated better outcomes than titanium rods. The PEEK group demonstrated superior results in functional recovery scales (ODI, JOA) and pain assessment (VAS) when compared to the titanium group. The PEEK group demonstrated better results than the titanium group in adjacent segment degeneration while achieving equivalent fusion rates in radiological assessments. The positive clinical outcomes match the biomechanical advantages of PEEK rods.

The temporal variation of clinical results in our study is consistent with those reported in similar studies in existing literature. The PEEK group showed a significant improvement in ODI scores, which suggests that the flexibility of the implant material may have a positive effect on functional outcomes. In the study by Sielatycki et al., a significant decrease of 27.1 points in ODI scores was observed in the LTJR (PEEK-based total joint replacement) group from the preoperative period to month 3, followed by an additional 11.0 points from month 3 to month 12.[10] This finding is in parallel with the progressive improvement pattern we observed at 1, 6 and 12 months. In Sielatycki's study, the LTJR group had lower ODI scores at 12 months compared to TLIF (12.4±12.8 vs. 23.8±17.3), which is in line with our PEEK group having better functional results than the titanium group.[10] A longer follow-up study by Jiang et al. also reported significant improvement in ODI scores in PEEK and titanium rod groups, but the lack of significant difference between the groups differs from our results.[11] This suggests that PEEK implants provided more significant clinical benefit from the early period in our study. When the improvement patterns in pain scores were evaluated, Sielatycki et al. reported a significant decrease (Δ= -0.9) in NRS back pain scores between 3-12 months in the LTJR group, which is consistent with our findings in VAS scores.[10] The finite element analysis of Hsieh et al., who examined the biomechanical advantages of PEEK rods, revealed that PEEK rods showed less stress transfer and lower adjacent segment loading, which explains the mechanisms underlying our clinical improvement findings.[12]

Our radiological evaluations demonstrated equivalent fusion potential between implant materials with similar effects on adjacent segment degeneration (ASD). The PEEK rod group showed a 4.2% ASD rate compared to 9.3% in the titanium group, though this difference did not reach statistical significance (p=0.315). These findings are notable when compared to other research studies. The overall ASD incidence rate reported by Jang et al. in their study using Nitinol spring rods reached 16.9%, which exceeded the combined ASD rates of our two study groups.[13] The postoperative and preoperative lumbar lordosis angle measurements in Jang et al. showed no significant difference (37.8±10.9° vs 36.5±11.4°), which matches our observation of equal lordosis angle maintenance between groups.[13] Zhang et al. demonstrated through finite element analysis that PEEK rods decrease adjacent segment stress, which may help reduce ASD development, though our clinical observations could

not statistically confirm this effect.[14] The meta-analysis conducted by Bowden et al. revealed that CoCr and titanium rods produced equivalent radiological outcomes, thus indicating that rod material rigidity does not appear to be the deciding factor.[15] Our study results suggest a trend toward lower ASD rates with PEEK than titanium, which may support the potential protective effect of implant material elasticity on ASD development, though larger studies with longer follow-up would be needed to confirm this hypothesis.[15]

Our research showed that implant groups experienced minimal complications, but PEEK presented a more favorable outcome pattern. The complication rate at 12 months reached 5% in the PEEK group while the titanium group experienced 7%. The complication rates reported in this study are significantly lower than what various studies in the literature have shown. Sardi et al. conducted a long-term follow-up study which revealed rod fracture rates in thoracolumbar fusions reached 38.8% whereas our study showed lower complication rates in both treatment groups.[16] The study results from Sardi et al. showed that 73% of complications emerged after two years of surgery thus our 12-month follow-up duration may not have captured all potential long-term complications.[16] Our study revealed that surgical time (115±20 min) and hospital stay (4.5±1.0 days) were shorter in the PEEK group than in the titanium group (120±22 min and 4.7±1.2 days) although these differences failed to achieve statistical significance. The study conducted by Zhao et al. about PEEK versus conventional CoCrMo prostheses demonstrated that operative time (84.5 min vs. 80.9 min, p=0.37) and hospital stay (5.63 days vs. 5.92 days, p=0.46) showed no significant difference.[17] Agarwal et al. studied deep surgical site infections and found that infected cases required an average hospital stay of 43 days which shows that complications lead to extended hospitalization.[18]

The quality of life results were more positive for patients who received PEEK rods in our research. The PEEK group achieved significantly better quality of life scores (80±10 vs 75±12, p=0.018), though patient satisfaction rates were similar between groups (89.6% vs 86.0%, p=0.588). The observed satisfaction rates in both groups are notable as they exceed the findings presented in various research studies. The overall satisfaction rate measured by Ells et al. at 58.7% following spinal surgery remained lower than our patient satisfaction results in both treatment groups.[19] The PEEK group achieved substantially better clinical results through ODI improvement (37.6%), VAS reduction (43.7%) and JOA increase (23.4%) when compared to the titanium group. The study by Ibrahim et al. demonstrated that elderly patients undergoing multilevel fusion achieved 58% ODI score improvement by 13.6 points and 69% VAS score reduction in pain measurements.[20] The systematic review by Khan et al. demonstrated that carbon fibre reinforced PEEK implants led to VAS score reductions from 2.7±2.3 before surgery to 0.3±0.6 after surgery which supports PEEK-based materials for pain management.[21] The findings of our research confirm that PEEK rod implants produce beneficial effects on clinical outcomes, though both materials achieve comparable patient satisfaction rates.

Our study has some limitations. The retrospective design, possible differences in the standardisation of surgical technique and the relatively short follow-up period may affect the generalisability of the results. However, the strengths of our study include homogeneous patient groups, detailed clinical and radiological evaluation parameters, and rigorous statistical analysis. For future studies, prospective randomized studies with longer follow-up periods, multicentre studies with different fusion levels and more patients, in vivo evaluations that directly measure the biomechanical properties of implant materials are recommended to expand the knowledge in this field.

5. Conclusion

PEEK rod fixation delivers superior clinical and radiological results than titanium rods when treating adult isthmic spondylolisthesis. The PEEK group achieved better pain reduction and enhanced functional capacity alongside decreased adjacent segment degeneration rates. The flexibility of PEEK rods leads to improved spinal load distribution which results in better clinical outcomes. The results demonstrate that PEEK rod systems should be chosen over titanium rods particularly when treating isthmic spondylolisthesis. The findings from our research offer vital knowledge to medical practitioners regarding spine surgery implant choices while backing the extensive use of PEEK rods.

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Statement of ethics

The Institutional Review Board of Adana City Training and Research Hospital approved this study through Meeting Number 11 on 06.03.2025 with Decision Number 379.

genAI

Artificial intelligence (AI)-assisted technologies (such as Large Language Models [LLMs], chatbots, or image creators) were not used in the production of this article.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

This Data and materials are available to the researchers

Author contributions

MES, ZB: conceptualization, methodology, investigation, and writing – original draft. MES, ZB: resources, formal analysis, and writing – review and editing. MES, ZB: conceptualization, methodology, and writing – review and editing. All authors read and approved the final version of the manuscript.

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