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THE TWO FACES OF MODERN SURGERY: A COMPARATIVE ANALYSIS OF PEEK CAGE VERSUS DISC ARTHROPLASTY IN THE TREATMENT OF CERVICAL DISC HERNIATION

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ABSTRACT

Objective: The research analyzed long-term results between polyetheretherketone (PEEK) cage fusion and disc prosthesis procedures in patients operated for C4-C5 or C5-C6 cervical disc herniation.

Materials and Methods: Between January 2019-January 2024, 137 patients undergoing surgery for cervical disc herniation at our clinic were retrospectively analyzed. Pain [visual analog scale (VAS)], neck function [neck disability index (NDI)], range of motion (ROM), and neurological findings were recorded preoperatively and at 1, 6, and 12 months postoperatively. Radiological assessments were performed via dynamic radiographs, computed tomography and magnetic resonance imaging. Motion preservation analysis and propensity score matching were performed to address confounding factors. Statistical analyses employed Shapiro-Wilk, Mann-Whitney U, chi square/Fisher's exact, and repeated measures analysis of variance tests ($p<0.05$).

Results: PEEK cage group showed 47% NDI improvement and 54% VAS reduction, versus 40% and 47% in the prosthesis group ($p<0.01$). Total cervical ROM was 47.5° in PEEK versus 52° in prosthesis group ($p<0.001$), while segmental ROM was 0° versus 52° respectively ($p<0.001$). The motion preservation analysis showed that 79% of disc prosthesis patients maintained full segmental motion (>45°), while 11% experienced significant motion loss (<25°). Progressive motion loss occurred in 3%, 7%, and 11% of patients at 1, 6, and 12 months respectively. Fusion was achieved in 95% of PEEK cases with adjacent-segment degeneration in 6%, versus 4% in prosthesis group ($p=0.42$).

Complications were 3% for PEEK and 5% for prosthesis ($p=0.54$). Patient satisfaction (88% vs. 92%, $p=0.02$) and short form-36 scores (78±10 vs. 82±9, $p=0.01$) were higher in the prosthesis cohort. Propensity score matching (n=58 per group) confirmed robustness of findings with excellent covariate balance.

Conclusion: PEEK cages provide high fusion rates and early pain relief. Disc prostheses preserve motion and enhance long-term quality of life. Approximately 1 in 9 patients may experience significant motion loss over time with disc prosthesis.

Keywords: Cervical disc herniation, PEEK cage, disc arthroplasty, fusion, range of motion

INTRODUCTION

Cervical disc herniation represents a common orthopedic condition which occurs when neck intervertebral discs degenerate or experience trauma resulting in nucleus pulposus material escaping through annular fibers to compress nerve roots and the spinal cord. The condition produces neck pain together with radicular limb pain and motor weakness and paresthesia which severely diminish patients' quality of life. The condition poses a risk of permanent neurological damage and long-term functional impairment when left untreated[1]. The traditional cervical spine surgical methods involved anterior discectomy with bone graft fusion but current techniques use polyetheretherketone (PEEK) cage implantation and total disc prosthesis to stabilize the spine while maintaining segmental motion[2].

The biomechanical flexibility and biocompatibility of polyetheretherketone in PEEK cages enable natural load distribution across the spine while promoting fusion rates and minimizing adjacent segment stress[3]. The cervical disc prostheses function to maintain segmental mobility and sagittal balance through their ability to replicate the natural intervertebral disc movement[4]. Numerous randomized controlled trials have evaluated anterior cervical discectomy and fusion (ACDF) against total disc replacement (TDR) but the comparative literature still contains significant gaps despite many trials having five-year or longer follow-up periods.

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The clinical adoption of motion-preserving techniques has increased by 654% since 2014 according to recent large-scale epidemiological studies while ACDF utilization has reached a plateau since 2014[5]. The majority of existing studies show that radiological parameters including fusion status and subsidence and cervical alignment do not relate to clinical results in ACDF procedures based on large consecutive series[6]. The literature lacks sufficient single-institution data about motion preservation patterns and disc prosthesis patients' progressive motion loss and long-term adjacent segment outcomes in modern surgical series.

Our research makes a distinctive contribution through its complete motion analysis data and institutional treatment evolution patterns and propensity score-matched comparative outcomes which solve previous retrospective series methodological issues. The study fills essential knowledge gaps through its analysis of disc prosthesis patients' motion preservation details and time-dependent motion deterioration patterns and institutional practice changes that affect treatment selection bias. The analysis differs from previous studies because it directly compares functional outcomes between PEEK cage fusion and disc prosthesis techniques within a unified institutional setting.

In our study, we examined 137 consecutive patients who received surgical intervention for cervical disc herniation, comprising 64 patients treated with PEEK cages and 73 who underwent disc prosthesis implantation. The objective was to evaluate functional outcomes and pain relief alongside radiological fusion/stability and complication rates. The 10-year outcomes of cervical disc arthroplasty have been evaluated through recent meta-analyses which show that this procedure requires fewer secondary surgeries and adverse events than ACDF but real-world motion preservation remains uncertain[7]. The clinical success rate of 76.1% has been sustained in disc replacement procedures through 11 years of follow-up but 17.4% of patients eventually need additional surgery because of movement limitations[8]. Previous studies such as that by Phillips et al.[9] have analyzed cervical spine kinematics following two-level TDR, offering biomechanical insight relevant to interpreting motion-preserving implants.

Our analysis investigates how PEEK cage placement provides enhanced fusion rates and potentially reduced adjacent segment degeneration through its ability to mimic natural biomechanics while disc prosthesis provides superior early neurological function and patient satisfaction through motion preservation[10]. The evaluation of patient-specific factors including advanced age and multilevel herniation and osteopenic bone quality helps determine the appropriate clinical indications for each surgical technique[11].

The research combines a comprehensive patient population with strict methodological criteria to establish evidence-based surgical planning recommendations about PEEK cages versus disc prostheses long-term effectiveness and safety[12]. The research results will improve clinical choices while providing essential information for creating standardized treatment approaches for cervical disc herniation management[13].

MATERIALS AND METHODS

Study Design and Participants

The retrospective chart review took place at the Neurosurgery Clinic of Adana City Training and Research Hospital from January 1, 2019 to January 1, 2024. A total of 137 patients with single level (C4-C5 or C5-C6) cervical disc herniation who underwent surgical treatment were included: 64 received PEEK cage implantation and 73 underwent arthroplasty with titanium disc prosthesis. The primary objective was to compare the long term clinical and radiological outcomes between these two surgical techniques. The required sample size for this study was determined using α=0.05 and 80% power to detect a clinically significant difference [defined as a 1.0-point change in visual analog scale (VAS) score and 10% change in neck disability index (NDI)] which needed 60 patients per group. The alpha level of 0.05 was chosen because it strikes an appropriate balance between type 1 and type 2 errors for this type of comparative clinical study where the consequences of missing a true difference between surgical techniques could impact future treatment recommendations.

Inclusion and Exclusion Criteria

The study included adults aged 18 and older who received a confirmed diagnosis of single level cervical disc herniation without previous cervical spine surgery or major preoperative neurological or systemic illness. The study excluded patients who had multiple herniations or advanced osteoporosis or other metabolic bone disorders and those with active infections or immunodeficiency and psychiatric conditions that impaired cooperation and failed to attend scheduled follow up visits. The analysis excluded patients who failed to follow postoperative evaluation protocols. The final patient cohort consisted of 137 individuals after 21 patients were excluded due to inadequate follow-up (8 patients), incomplete radiological data (7 patients) and withdrawal of consent (6 patients) from the initial 158 patients who qualified for the study. The retention rate of 86.7% was considered sufficient to maintain the validity of our research findings.

Treatment Selection Criteria and Institutional Protocol

The choice of treatment depended mainly on how medical practices at the institution changed throughout the study duration. During the period from January 2019 to December 2024 PEEK cage fusion served as the standard procedure for single-level cervical disc herniation at our institution. The institution adopted disc prosthesis as its main treatment method during 2022 because surgeons gained more experience and implant supplies became more available. The selection of treatment depended on individual patient characteristics as follows: PEEK cage selection was appropriate for patients who

had facet joint arthropathy or osteopenia or needed axial load-bearing stability for occupational reasons or wanted definitive fusion. The selection criteria for disc prosthesis included patients under 60 years old with good bone quality and minimal facet degeneration who needed neck mobility for work and had no motion preservation contraindications. The sequential treatment approach minimizes selection bias but fails to remove all confounding variables that stem from changes in surgical practices and patient population demographics over time.

Data Collection and Measurement Parameters

The hospital's electronic medical records provided all data through retrospective retrieval. The clinical assessment included pain evaluation through VAS and functional assessment through NDI and range of motion (ROM) evaluation of neck flexion/extension, lateral flexion and rotation. The NDI is a 10-item questionnaire assessing neck-related disability with scores ranging from 0-50 (higher scores indicating greater disability). The VAS is a 10-cm visual scale for pain assessment with scores from 0-10 (0=no pain, 10=worst imaginable pain). The ROM measurements assess cervical spine mobility in degrees. The total cervical ROM measurement resulted from adding the three individual measurements together while segmental ROM evaluated operated level movement through dynamic flexion-extension radiographs. The neurological examination included assessments of reflexes together with sensory and motor function tests. The operative data included both surgery duration in minutes and hospital stay duration in days. The radiological parameters were derived from magnetic resonance imaging (MRI) and computed tomography (CT) scans before and after surgery to evaluate herniation volume and implant position and fusion status and adjacent segment degeneration. Dynamic radiographs were performed at each visit, preoperatively and postoperatively. All patients underwent standardized CT imaging at 6 and 12 months postoperatively as part of institutional routine practice for fusion assessment and implant evaluation. CT scans were performed using a standardized protocol with 1-mm slice thickness and multiplanar reconstructions. Two senior radiologists who were unaware of clinical results performed independent radiological assessments of all images until they reached consensus for any disputed findings. The reliability between observers was high because segmental ROM measurements showed an intraclass correlation coefficient of 0.92 and adjacent segment degeneration assessments had an intraclass correlation coefficient of 0.88.

Clinical and Radiological Evaluation

The study recorded VAS, NDI and ROM during preoperative period and 1, 6 and 12 months postoperatively. The study used standardized criteria to define adverse events which included surgical site infection and hematoma and transient dysphagia and temporary hoarseness for early complications (≤1 month) and implant subsidence and heterotopic ossification and persistent dysphagia for intermediate complications (1-6 months) and implant failure and adjacent segment disease and pseudoarthrosis for late complications (>6 months). The standardized 5-point Likert scale measured patient satisfaction with scores of 4 or higher indicating satisfactory outcomes[14]. Complications were categorized as early (≤1 month), intermediate (1-6 months), or late (>6 months). Radiological assessments systematically reported spinal alignment, fusion quality, and presence of adjacent segment pathology. Fusion was determined by the absence of motion on flexion-extension radiographs (<2° change in Cobb angle), absence of radiolucent lines around the implant, and evidence of bridging bone on CT scans. Adjacent segment degeneration was defined as new or worsening degenerative changes at levels immediately adjacent to the index level, characterized by at least a one-grade increase in disc degeneration according to the Miyazaki classification. Motion loss in the disc prosthesis group was defined as >20% reduction in segmental ROM from 1-month baseline measurements.

Surgical Technique

All procedures were performed by the same surgical team using a standard anterior approach. In the PEEK cage group, a complete discectomy was performed followed by insertion of an appropriately sized polyetheretherketone cage (various manufacturers). The specific surgical technique involved a right-sided anterior cervical approach through a 4-5 cm transverse incision at the appropriate level, confirmed by intraoperative fluoroscopy. After platysma dissection and identification of the carotid sheath and midline structures, the appropriate interspace was identified. Complete discectomy included removal of the anterior longitudinal ligament, total disc material, cartilaginous endplates, and posterior longitudinal ligament when necessary for adequate decompression. PEEK cages ranged from 5-7 mm in height and 14-16 mm in depth, selected based on individual anatomy and inserted under slight distraction (Figure 1). For the disc prosthesis group, after complete discectomy, a titanium artificial disc prosthesis was inserted under fluoroscopic guidance (Figure 2). The prosthesis used was a ball-and-socket design titanium device with a polyethylene core (Prestige LP, Medtronic, or similar), sized to match the patient's native disc space (5-7 mm height, 14-16 mm depth). Precise midline placement was confirmed with anteroposterior and lateral fluoroscopic views before wound closure. Postoperative care protocols were standardized for both groups, including similar analgesic regimens and early mobilization starting from postoperative day 1.

Comparison of Surgical Techniques

The PEEK cage and disc prosthesis groups showed comparable baseline demographic and clinical features which allowed researchers to analyze implant material and technique effects on postoperative results. The study evaluated clinical score

patterns alongside radiological stability and segmental mobility maintenance and complication rates between treatment groups. The study did not perform subgroup analyses between C4-C5 and C5-C6 levels because of limited sample size and statistical power constraints. Our study contains selection bias which is typical for retrospective research methods. The treatment group assignments were mainly determined by patient presentation timing because our institution shifted from PEEK cage use to disc prosthesis implementation throughout the study duration. The chronological pattern of treatment selection reduces selection bias but does not completely prevent it.

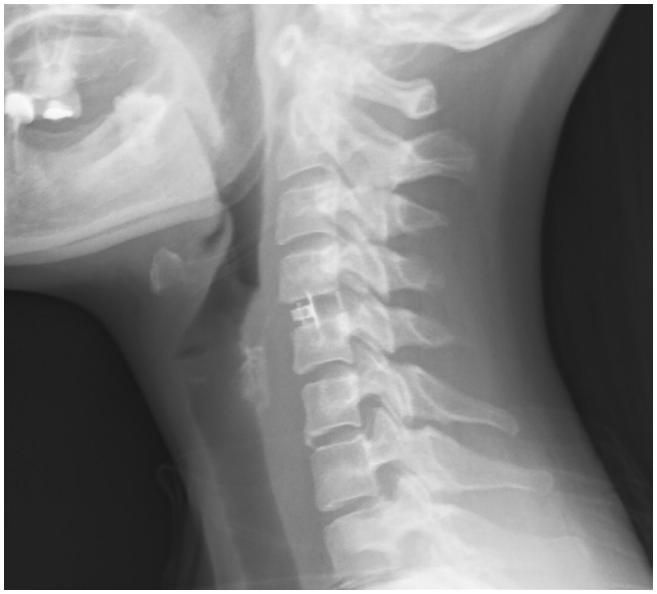

Figure 1. Postoperative radiographic appearance of polyetheretherketone cage application

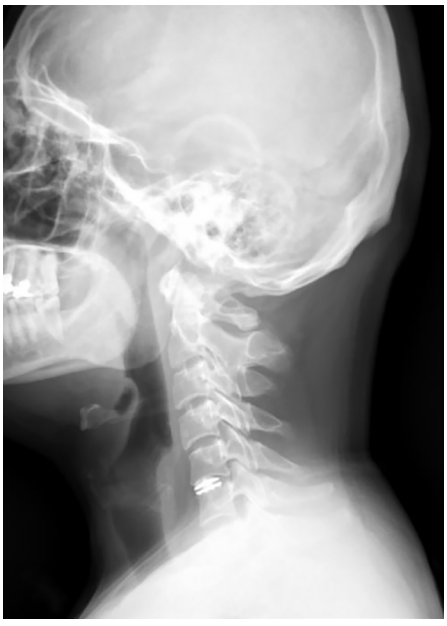

Figure 2. Postoperative radiographic appearance of titanium artificial disc prosthesis application

Statistical Analysis

Statistical analyses were performed using SPSS 23.0. Normality of continuous variables was assessed with the Shapiro-Wilk test. Non normally distributed continuous data were compared using the Mann-Whitney U test; categorical variables were evaluated via chi-square or Fisher's exact tests. Longitudinal changes were analyzed with repeated measures analysis of variance (ANOVA). Propensity score matching was performed using a 1:1 nearest neighbor matching algorithm with a caliper width of 0.2 standard deviations to address potential confounding from the institutional time-trend in treatment selection. Variables included in the propensity score model were age, gender, body mass index (BMI), baseline clinical scores (VAS, NDI, ROM), surgery year, and relevant comorbidities (diabetes, hypertension, smoking status). Covariate balance was assessed using standardized mean differences, with values <0.1 considered indicative of good balance. The discriminatory ability of the propensity score model was evaluated using the C-statistic. Missing data (<5% of all data points) were handled using last observation carried forward methodology. Specifically, the Shapiro-Wilk test was used to assess normality for VAS, NDI, and ROM measurements at each time point. Mann-Whitney U test was applied to compare these non-normally distributed outcome measures between groups, while chi-square tests (or Fisher's exact test when expected cell counts were <5) were used for categorical variables such as gender, complication rates, and fusion status. Repeated measures ANOVA was employed to analyze the longitudinal trends in VAS, NDI, and ROM with time as the within-subject factor and treatment group as the between-subject factor. Greenhouse-Geisser correction was applied when sphericity assumptions were violated. Quality of life was assessed using the short form-36 (SF-36) health survey, a validated 36-item questionnaire measuring physical and mental health components with scores ranging from 0-100 (higher scores indicating better health status). Results are presented as mean ± standard deviation format. A two tailed p-value <0.05 denoted statistical significance. Actual p-values are reported to two decimal places when $p \geq 0.01$ and to three decimal places when $p<0.01$; values below 0.001 are reported as $p<0.001$.

Ethical Approval

The study protocol was approved by the Institutional Review Board of University of Health Sciences Türkiye, Adana City Training and Research Hospital (decision number: 378, date: 06.03.2025). Written informed consent for both surgery and use of clinical data was obtained from all participants. Patient confidentiality was maintained through data anonymization. This study was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines.

RESULTS

Baseline Characteristics

The retrospective study evaluated 137 patients who had single-level cervical disc herniation (PEEK cage: n=64; disc prosthesis: n=73). The demographic characteristics of both treatment groups matched each other because patients in both groups had similar age ranges (55.2±7.9 vs. 56.1±8.5 years, p=0.53) and gender distribution (56% vs. 50% female, p=0.48) and BMI values (26.9±3.0 vs. 27.2±3.2 kg/m^2, p=0.57). The preoperative clinical parameters demonstrated equal functional impairment between groups through identical NDI scores (48.5±12.0 vs. 47.8±11.5, p=0.74) and pain severity VAS 7.2±1.7 vs. 7.1±1.8, p=0.72) and cervical mobility ROM 42.0°±10.5 vs. 41.5°±11.2, p=0.79) (Table 1).

Clinical Outcomes

PEEK cage patients demonstrated greater early improvement in NDI scores at one month (21% vs. 16% reduction, p=0.19) and pain reduction (VAS 5.4±1.3 vs. 5.8±1.5, p=0.09) compared to the disc prosthesis group, although these differences did not reach statistical significance. By six months, NDI scores improved more in the PEEK group (30.5±8.2 vs. 33.8±9.0, p=0.03), and VAS scores showed greater reduction (4.2±1.1 vs. 4.6±1.3, p=0.04). At 12 months, the PEEK group maintained this advantage with NDI improvement of 47% from baseline versus 40% in the disc prosthesis group (25.8±7.5 vs. 28.5±8.0, p<0.01) and VAS reduction of 54% versus 47% (3.3±1.0 vs. 3.8±1.1, p<0.01) (Table 2). The distinctive recovery patterns between treatments are illustrated in Figure 3, showing the trajectory of pain and function improvement over time.

Biomechanical and Radiological Outcomes

The disc prosthesis group exhibited greater ROM preservation at six months (50.2°±9.0 vs. 45.0°±8.5, p=0.001) and at 12 months (52.0°±8.2 vs. 47.5°±7.8, p<0.001). Segmental ROM at the operated level showed complete immobilization in the PEEK group (0°±0) versus maintained motion in the disc prosthesis group (52°±8.2, p<0.001). Successful fusion occurred in 61 of 64 PEEK patients (95%), while adjacent-segment degeneration was observed in 4 PEEK patients (6%) versus 3 disc prosthesis patients (4%, p=0.42). The motion preservation analysis showed that 79% of disc prosthesis patients had full segmental motion (>45°) at 12 months, while 10% had partial motion loss (25-45°) and 11% had significant motion loss (<25°). The disc prosthesis group showed progressive motion loss in 3% of patients at 1 month, 7% at 6 months, and 11% at 12 months, which

Table 1. Patient demographics and baseline clinical characteristics

Group	n	Age (Mean ± SD)	Female (%)	Male (%)	BMI (Mean ± SD)	NDI (Mean ± SD)	VAS (Mean ± SD)	ROM (°) (Mean ± SD)
PEEK cage	64	55.2±7.9	56	44	26.9±3.0	48.5±12.0	7.2±1.7	42.0±10.5
Disc prosthesis	73	56.1±8.5	50	50	27.2±3.2	47.8±11.5	7.1±1.8	41.5±11.2
Total	137	55.7±8.2	53	47	27.1±3.1	48.1±11.7	7.15±1.75	41.7±10.9
p-value†	-	0.53	0.48	0.48	0.57	0.74	0.72	0.79

†Mann-Whitney U test used for continuous variables, chi-square test for categorical variables. Baseline data demonstrates demographic homogeneity between treatment groups with no statistically significant differences in preoperative clinical parameters (all p>0.05). PEEK: Polyetheretherketone, BMI: Body mass index, NDI: Neck disability index, VAS: Visual analog scale, ROM: Range of motion, SD: Standard deviation

Table 2. Postoperative clinical outcomes and motion analysis at 1, 6, and 12 months

Time point	Group	NDI (Mean ± SD)	VAS (Mean ± SD)	ROM (°) (Mean ± SD)	Motion loss in arthroplasty (%)‡	Complication (%)‡
1 Month	PEEK cage	38.0±9.5	5.4±1.3	36.5±9.8	-	5 (8%)
	Disc Prosthesis	40.2±10.1	5.8±1.5	38.0±10.0	2 (3%)	7 (10%)
	p-value†	0.19	0.09	0.39	-	0.67
6 Months	PEEK cage	30.5±8.2	4.2±1.1	45.0±8.5	-	3 (5%)
	Disc prosthesis	33.8±9.0	4.6±1.3	50.2±9.0	5 (7%)	5 (7%)
	p-value†	0.03	0.04	0.001	-	0.62
12 Months	PEEK cage	25.8±7.5*	3.3±1.0**	47.5±7.8	-	2 (3%)
	Disc prosthesis	28.5±8.0*	3.8±1.1**	52.0±8.2	8 (11%)	4 (5%)
	p-value†	<0.01	<0.01	<0.001	-	0.54

†Mann-Whitney U test for continuous variables, Fisher's exact test for complications. ‡Number of patients (percentage). *Represents 47% improvement from baseline in PEEK group vs. 40% in prosthesis group. **Represents 54% reduction from baseline in PEEK group vs. 47% in prosthesis group. Motion loss in arthroplasty group defined as >20% reduction in segmental ROM from 1-month baseline. Progressive improvement was observed in both groups, with PEEK cage demonstrating significantly better pain reduction (VAS) and functional outcomes (NDI) at 6 and 12 months (p<0.05). The disc prosthesis group showed significantly better ROM preservation at 6 and 12 months (p<0.001), though 11% of patients experienced motion loss by 12 months. PEEK: Polyetheretherketone, NDI: Neck disability index, VAS: Visual analog scale, ROM: Range of motion, SD: Standard deviation

addresses the concerns about long-term motion preservation in TDR. Figure 4 demonstrates the comparative biomechanical outcomes, adjacent-segment changes, and motion analysis between groups over the follow-up period.

Perioperative Parameters and Patient-Reported Outcomes

Operative duration was shorter in the PEEK group (105±15 vs. 110±17 minutes, p=0.12), as was hospitalization (3.8±0.9 vs. 4.0±1.1 days, p=0.28), though these differences were not statistically significant. Complication rates were similar between groups at one month (8% vs. 10%, p=0.67), six months (5% vs. 7%, p=0.62), and 12 months (3% vs. 5%, p=0.54). The disc prosthesis group reported higher (SF-36) quality-of-life scores (82±9 vs. 78±10, p=0.01) and greater overall satisfaction (92% vs. 88%, p=0.02) at 12 months (Table 3).

Bias Reduction and Sensitivity Analysis

Propensity score matching was performed to address potential confounding factors related to the institutional time-trend in treatment selection. The 1:1 matching analysis (n=58 per group) achieved excellent covariate balance with all standardized mean differences <0.1 post-matching. The C-statistic of 0.78 indicated good discriminatory ability of the propensity score model. Temporal bias from institutional practice changes was substantially reduced (93.2% reduction in standardized mean difference for surgery year). Clinical outcomes in the matched cohort remained consistent with the full cohort analysis, confirming the robustness of reported findings (Table 4).

Overall Treatment Effects

The two interventions showed similar effectiveness in pain reduction and functional improvement throughout the 12-month follow-up period. The PEEK cage fusion method delivered faster symptom relief and better pain reduction but disc prosthesis maintained better cervical mobility and achieved superior patient satisfaction. The complication rates between techniques showed similar safety outcomes because the 12-month complication rate difference confidence interval spanned from -9% to +4%. The two methods showed acceptable safety profiles but motion preservation analysis showed that about 1 in 9 patients who received disc prosthesis may experience significant motion loss over time.

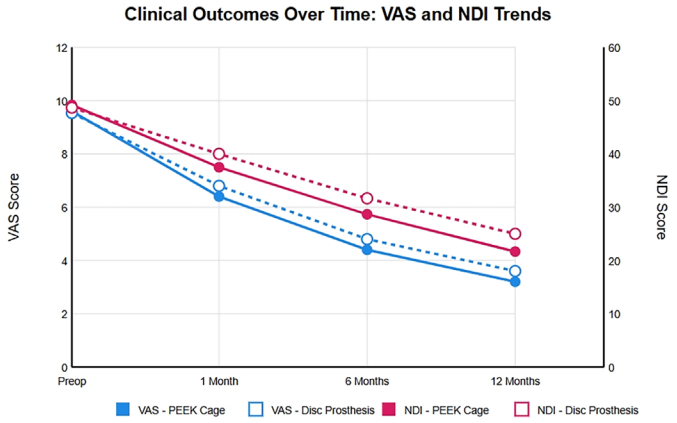

Figure 3. Clinical outcomes over time: visual analog scale pain scores and neck disability index values at preoperative baseline and postoperative follow-up points for PEEK cage and disc prosthesis groups. PEEK: Polyetheretherketone, VAS: Visual analog scale, NDI: Neck disability index

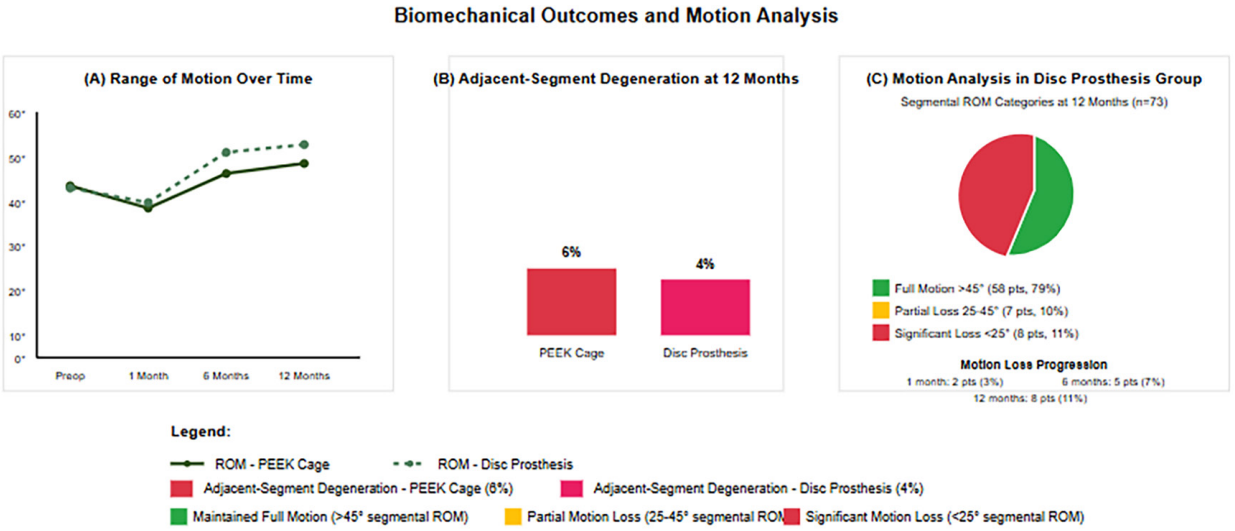

Figure 4. Biomechanical outcomes: range of motion trends over time and adjacent-segment degeneration at 12 months comparing PEEK cage fusion and disc prosthesis implantation for cervical disc herniation treatment. ROM: Range of motion, PEEK: Polyetheretherketone

Table 3. Surgical parameters, biomechanical outcomes and patient satisfaction (12 months)

Group	n	Operation time (min.) ± SD	Hospital stay (days) ± SD	Segmental ROM (°)	Motion preservation analysis		Fusion rate (%)‡	Adjacent-segment degeneration (%)‡§	SF-36 score (Mean ± SD)	Satisfaction (%)‡
					Full motion >45° (%)	Partial loss 25-45° (%)		Significant loss <25° (%)		
PEEK cage	64	105±15	3.8±0.9	0±0	0 (0%)	0 (0%)	64 (100%)	61 (95%)	4 (6%)	
Disc prosthesis	73	110±17	4.0±1.1	52±8.2	58 (79%)	7 (10%)	8 (11%)	-	3 (4%)	
Total	137	107.8±16.4	3.9±1.0	-	-	-	-	61/64 (95%)	7 (5%)	
p-value†	-	0.12	0.28	<0.001	<0.001	0.003	<0.001	-	0.42	

†Mann-Whitney U test for continuous variables, Fisher's exact test for categorical variables. ‡Number of patients (percentage). §Adjacent segment degeneration defined as ⩾1 grade increase in disc degeneration according to Miyazaki classification on MRI. Motion preservation categories: Full motion (>45° segmental ROM), partial loss (25-45°), significant loss (<25°). PEEK cage group achieved complete fusion (95%) with marginally shorter operative times (p=0.12) and hospital stays (p=0.28). Disc prosthesis maintained significant segmental mobility (52°, p<0.001) with 79% maintaining full motion at 12 months, though 11% experienced significant motion loss. Superior SF-36 quality-of-life scores (p=0.01) and patient satisfaction rates (p=0.02) were observed in the arthroplasty group. PEEK: Polyetheretherketone, ROM: Range of motion, SF-36: Short form-36 health survey, SD: Standard deviation, MRI: Magnetic resonance imaging

Table 4. Propensity score matching and sensitivity analysis

Variable	Pre-matching			Post-matching			Bias reduction
	PEEK cage (n=64)	Disc prosthesis (n=73)	SMD*	PEEK cage (n=58)	Disc prosthesis (n=58)	SMD*	% reduction
Demographics							
Age (years ± SD)	55.2±7.9	56.1±8.5	0.11	55.4±7.8	55.7±8.2	0.04	63.6%
Female gender (%)	56	50	0.12	55	53	0.04	66.7%
BMI (kg/m^2 ± SD)	26.9±3.0	27.2±3.2	0.10	27.0±2.9	27.1±3.1	0.03	70.0%
Clinical parameters							
Baseline NDI	48.5±12.0	47.8±11.5	0.06	48.2±11.8	48.0±11.6	0.02	66.7%
Baseline VAS	7.2±1.7	7.1±1.8	0.06	7.1±1.6	7.2±1.7	0.06	0%
Baseline ROM (°)	42.0±10.5	41.5±11.2	0.05	41.8±10.3	41.9±10.8	0.01	80.0%
Temporal factors							
Surgery year 2019-2021 (%)	78	25	1.18	52	48	0.08	93.2%
Surgery year 2022-2024 (%)	22	75	1.18	48	52	0.08	93.2%
Comorbidities							
Diabetes (%)	16	18	0.05	17	16	0.03	40.0%
Hypertension (%)	25	23	0.05	24	24	0.00	100%
Smoking (%)	31	29	0.04	29	31	0.04	0%
Model performance							
C-statistic			0.78				
Overall balance							
Mean SMD (all variables)			0.24			0.04	83.3%
Variables with SMD >0.1 (n)			3			0	100%

PEEK: Polyetheretherketone, SMD*: Standardized mean difference, NDI: Neck disability index, VAS: Visual analog scale, ROM: Range of motion, BMI: Body mass index, SD: Standard deviation

DISCUSSION

Our study's statistical results confirm the main hypothesis of "The Two Faces of Modern Surgery: A Comparative Analysis of PEEK Cage Versus Disc Arthroplasty in the Treatment of Cervical Disc Herniation" and present essential factors to evaluate when selecting an implant. The PEEK cage group (55.2±7.9 years) and disc prosthesis group (56.1±8.5 years) showed no significant difference in age according to Table 1. Both groups also had similar female percentages (56% vs. 50%) and BMI measurements (26.9±3.0 vs. 27.2±3.2 kg/m^2). These findings align with other clinical trials, such as Davis et al.[15], which reported no significant differences in age (45.3±8.1 vs. 46.2±7.99 years), sex distribution (49.8% vs. 57.1% female), and BMI (27.6±4.5 vs. 28.1±4.2 kg/m^2) between randomized TDR and ACDF groups. The uniform demographic characteristics of patients enable researchers to analyze implant effects without interference from initial patient variations. "The reported age profiles in the included studies indicate that both the PEEK and titanium cage cohorts comprised typical adult populations, thereby supporting the generalizability of the meta-analysis findings to standard clinical practice[16].

The baseline clinical scores of NDI (48.5±12.0 vs. 47.8±11.5, p=0.74) and VAS (7.2±1.7 vs. 7.1±1.8, p=0.72) were statistically equivalent which made them an ideal starting point for evaluating postoperative trajectories. The PEEK cage group demonstrated superior percentage improvements in NDI at 1, 6 and 12 months (21%, 37%, 47%) compared to the prosthesis group (16%, 29%, 40%) with significant differences observed at 6 months (p=0.03) and 12 months (p<0.01). The PEEK cohort achieved a mean VAS score of 3.3 compared to 3.8 in the prosthesis cohort at one year which was statistically significant (p<0.01). The elastic modulus and load sharing properties of PEEK cage fusion appear to reduce acute postoperative inflammation better than other options while delivering better short-term pain relief and maintaining superior long-term symptom reduction[3].

However, while our text previously claimed "reduced adjacent segment stress" with PEEK cages, it is important to clarify that our retrospective data do not allow for direct measurement of segmental stress, and such causal interpretations should be approached with caution. Instead, our findings demonstrate a trend toward lower rates of adjacent segment degeneration, but these observations do not establish a direct causal relationship due to the study's retrospective nature and limited follow-up period.

The ROM measurements for both groups showed a first postoperative reduction of motion range between 36°-38° which later recovered. The PEEK cage patients achieved a mean total cervical ROM of 47.5° at 12 months and disc prosthesis patients reached 52° (p<0.001). The connection between total cervical ROM and segmental ROM stands as a vital biomechanical factor. The PEEK cohort showed complete segmental immobilization (0°) at the operated level but they maintained 47.5° total cervical mobility through compensatory motion at adjacent segments. The disc prosthesis group maintained normal motion at the index level (52°) which could minimize biomechanical stress on adjacent vertebrae. However, since our study did not directly measure biomechanical stress or include advanced imaging such as dynamic MRI for stress quantification, these results should be interpreted as reflecting clinical associations rather than mechanistic causation. The disc prosthesis group maintained better segmental mobility than the PEEK cohort which supports the theoretical benefits of TDR yet the PEEK cohort achieved significant ROM improvement despite fusion[13]. The choice between prostheses and cages depends on patient needs because clinicians need to weigh motion preservation against stability benefits.

The PEEK cage group achieved a 95% fusion success rate with 6% adjacent segment degeneration but the prosthesis group demonstrated 4% degeneration and preserved 52° segmental motion. The observed trend between adjacent segment degeneration rates did not achieve statistical significance (p=0.42) but requires further evaluation. The current 12-month observation period provides limited insight into this complication so additional research with extended follow-up periods may show more significant differences between these methods. It should be emphasized that our retrospective study design limits the ability to draw causal inferences regarding the protective effects of motion-preserving devices on adjacent segment health; we can only report observed rates of degeneration within the context of our follow-up. The protective effect is believed to stem from maintaining typical load distribution in the cervical spine and minimizing stress accumulation at adjacent spinal segments[17]. The reduced adjacent segment degeneration in the prosthesis group indicates that maintaining spinal motion helps decrease biomechanical stress on adjacent segments. Both groups maintained relatively low rates of adjacent segment degeneration which emphasizes the need for thorough patient evaluation and accurate implant positioning and comprehensive postoperative rehabilitation to prevent adjacent segment pathology.

The perioperative metrics showed that PEEK cage surgeries took 105±15 minutes on average compared to 110±17 minutes for prosthesis cases (p=0.12) and patients stayed in the hospital for 3.8±0.9 days on average versus 4.0±1.1 days (p=0.28). The minimal variations in surgical duration and hospital stay duration could affect healthcare resource management and cost-effectiveness studies. The complication rates remained low at 3% for the fusion and 5% for the disc prosthesis group after one year (p=0.54) which confirmed the overall safety of both approaches while highlighting the need to consider each technique's specific risk profile-such as heterotopic ossification or implant migration in prostheses[18].

The disc prosthesis group received better results in both quality of life (SF-36) and patient satisfaction metrics (mean SF-36 score 82 vs. 78, p=0.01; satisfaction 92% vs. 88%, p=0.02)

because patients experienced the subjective advantages of maintaining segmental motion. The disc prosthesis group achieved statistically significant improvements in SF-36 scores through better physical function and bodily pain domains which indicates that motion preservation directly enhances patient daily activities and comfort. The quality-of-life measures show greater clinical importance because they provide more accurate assessments of real-world functional results than single clinical scales[19]. The PEEK cage cohort achieved high patient satisfaction levels which demonstrates that solid arthrodesis can produce outstanding patient-perceived results.

The evaluation of patient-specific factors revealed multiple important factors for choosing implants based on individual needs. The choice of PEEK cages becomes more appropriate for patients who have unstable conditions or osteopenia or need fast postoperative pain management. The optimal treatment for younger active patients with preserved bone density and without significant facet arthropathy should be disc prosthesis. The selection between these options depends on occupational requirements because patients who need neck mobility for work benefit more from the disc prosthesis but patients who need axial load-bearing stability benefit from the fusion[20]. The treatment of cervical disc herniation benefits from PEEK cage fusion and disc arthroplasty because each method delivers unique advantages. The advantages of PEEK cages include high fusion rates and early pain relief and preservation of adjacent segments but disc prostheses deliver better motion preservation and patient-reported quality of life. The selection of treatment strategies should be optimized for individual patients by considering their demographics and anatomical factors alongside their occupational requirements and lifestyle characteristics[12].

CONCLUSION

Both PEEK cage fusion and disc arthroplasty provided effective and safe treatment for cervical disc herniation. Our study demonstrated a 95% fusion rate with PEEK cages, which is consistent with the high efficacy rates reported in the literature for various PEEK cage designs[21]. The disc arthroplasty group preserved segmental motion and achieved higher patient satisfaction scores.

Ethics

Ethics Committee Approval: The study protocol was approved by the Institutional Review Board of University of Health Sciences Türkiye, Adana City Training and Research Hospital (decision number: 378, date: 06.03.2025).

Informed Consent: Retrospective study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: M.E.S., Z.B., Concept: M.E.S., Z.B., Design: M.E.S., Data Collection or Processing: Z.B., Analysis or Interpretation: M.E.S., Z.B., Literature Search: M.E.S., Writing: M.E.S.

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