Comparison of correction of lumbar lordosis in posterior spinal fusion combined with two methods of posterior lumbar interbody fusion

Abstract

Introduction: Loss of lordosis is a significant factor in spinal degeneration. Various treatment methods exist for correcting segmental lordosis in the lumbosacral vertebrae. This study compares the extent of lumbar lordosis correction in patients undergoing posterior lumbar interbody fusion surgery using a PEEK cage versus allograft impaction.

Materials & Methods: This clinical trial evaluated lumbar lordosis correction following posterior lumbar interbody fusion within one year in a teaching hospital were studied. A total of 21 patients were randomly divided into two groups: allograft impaction treatment (10 patients) and PEEK cage treatment (11 patients). Lumbar lordosis correction was assessed radiographically before and the day after surgery, along with pain intensity and postoperative complications two weeks after surgery. Data were analyzed using SPSS software version 25.

Results & Discussion: The 21 patients had median age of was 56 years, and 38.1% were male. Results showed that lumbar lordosis significantly improved post-surgery in both the allograft impaction ($P < 0.001$) and PEEK cage ($P < 0.0001$) treatment groups compared to pre-surgery. The percentage change in lordosis angle was significantly greater in allograft impaction than the PEEK cage group ($P = 0.01$). There was no significant difference in postoperative pain intensity between the two methods. No severe postoperative complication was reported in either group.

Conclusion: Allograft impaction provides superior lumbar lordosis correction compared to the use of a PEEK cage in patients undergoing posterior lumbar interbody fusion surgery.

Keywords: Allograft, Lumbar Vertebrae, Lordosis, Spinal Fusion, Surgical Techniques.

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Introduction

Lumbar discectomy surgery is among the most common procedures in neurosurgery, and in many cases, lumbar fusion becomes necessary due to the involvement of multiple levels(1). Common surgical techniques include posterior spinal fusion and transforaminal approaches(2). Restoring sagittal spinal alignment in the lumbar spine can significantly impact clinical outcomes following surgical treatment for degenerative spinal diseases(3). Numerous studies suggest that restoring the spinal angle leads to better clinical results and helps prevent adjacent segment disease following spinal fusion(4,5). On the other hand, postoperative spinal misalignment, defined as a mismatch between pelvic incidence and lumbar lordosis exceeding 10 degrees, is associated with higher reoperation rates and reduced quality of life(6,7). Thus, restoring lumbar spinal alignment is considered a key surgical objective in fusion procedures. Balancing pelvic incidence and lumbar lordosis can be achieved by enhancing the lordosis of the treated segment through fusion(8).

Interbody spacers have revolutionized lumbar spine surgery by adjusting disc height, enhancing stability, and promoting fusion(9). While iliac crest bone graft (AIC) is regarded as the gold standard, harvesting grafts from this site is associated with complications such as infection, hematoma/seroma, fractures, neurovascular injuries, chronic donor site pain, hernia, unsightly scars, and poor cosmetic outcomes(10,11).

Allografts and PEEK cages are popular alternatives to autografts(12), with reports indicating their use in 92% of these surgeries(1).

Recent advancements have shown that polyether ether ketone (PEEK) is increasingly used in spinal fusion procedures[9]. PEEK cages offer several advantages, including biocompatibility, radiological transparency, optimal elasticity, and ease of preparation and storage[13–15]. However, their use is limited due to their bioinert nature, which may restrict osseointegration and potentially impact fusion outcomes[16].
Structural allografts, including cortical allografts, composite or corticocancellous grafts, and dense cancellous grafts, serve as effective substitutes for bone fusion[17,18]. However, their primary drawbacks are immunogenicity and the risk of disease transmission[19].
Both bone allografts and PEEK cages have unique advantages and disadvantages, guiding clinicians in selecting treatment approaches. However, it remains unclear whether one implant offers superior clinical outcomes over the other. Given the limited evidence supporting the advantages of PEEK cages, and the fact that most previous studies have focused on their use in cervical discectomy surgeries[20–23], the present study aims to compare the extent of lumbar lordosis correction in posterior spinal fusion surgery with posterior lumbar interbody fusion using PEEK cages and allograft impaction.

Materials & Methods

This study was a randomized clinical trial conducted in 2022 on patients who were candidates for discectomy and posterior spinal fusion surgeries in the neurosurgery department of Firouzgar Hospital. Ethical approval was obtained with the code IR.IUMS.FMD.REC.1401.354. The study adhered to the principles of the Helsinki Declaration and the Nuremberg Code. Patients signed an informed consent form prior to participation.
Patients aged 18–80 years who were candidates for posterior lumbar interbody fusion (PLIF) in the lumbosacral region due to degenerative spinal diseases were included. Exclusion criteria comprised patients requiring posterior fusion for other reasons such as tumors or malignancies, active spondylodiscitis or deformities, previous lumbosacral surgeries, fixed spinal ankylosis requiring anterior column osteotomy, and other conditions outside the study's scope.
Degenerative spinal diseases were diagnosed through medical history, clinical examination, and imaging (MRI or CT scans). Symptoms included back pain, reduced mobility, numbness, and leg weakness. Patient data were retrieved from the hospital’s PACS software pre- and postoperatively. Patients were randomly assigned to two groups: Group 1 underwent PLIF using PEEK cages (11 patients), and Group 2 underwent PLIF using allograft impaction (10 patients).
The PEEK cages, supplied by Asveh company, were PLIF models with zero lordotic angle, available in nine sizes. The specific size was determined by the surgeon based on preoperative imaging. For the allograft impaction group, matchstick cancellous blocks ("matchsticks") from the Kish Tissue Regeneration Company were used. At least five grafts were impacted to fill the anterior half of the interbody disc space.
The surgical level was L4-L5 for all patients. All surgeries were performed at Firouzgar Hospital by two surgeons using a standardized PLIF technique combined with posterior spinal fusion (PSF) to achieve maximum lordosis. Interbody fusion in both techniques was performed in the anterior half of the vertebral body using PEEK cages or allografts.
For both groups, the extent of lordosis correction was assessed preoperatively and on the first postoperative day using standing radiographs. Segmental Cobb’s angle was calculated by a trained neurosurgery resident, measuring the angle between the superior endplate of L4 and the superior endplate of S1. Additionally, patients in both groups were evaluated for pain severity using the Visual Analog Scale (VAS) and postoperative complications two weeks after surgery.
Data analysis was conducted using SPSS version 25. Descriptive statistics were reported as mean ± standard deviation, median (interquartile range), and frequency (percentage). Changes in lordosis angle were calculated as the percentage difference before and after surgery. Comparisons between the two surgical methods were made using the Mann-Whitney U test. A significance level of $P < 0.05$ was considered statistically significant.

Results

In this study, 21 patients were evaluated, with a median age of 56 years. Among the patients, 38.1% were male, and the remaining were female. The median hospital stay was 6 days. No significant differences were observed between the allograft

impaction and PEEK cage groups in terms of gender (P = 0.080), age (P = 0.426), or hospital stay duration (P = 0.705) (Table 1).
The results indicated no significant difference in postoperative pain severity between the allograft impaction (median = 4) and PEEK cage (median = 4) groups (P = 0.973). The median preoperative lordosis angle was 32°, while the postoperative angle was 43°. There was no significant difference in preoperative (P = 0.197) or postoperative (P = 0.654) lordosis angles between the two groups. However, a significant difference was observed in the percentage change in lordosis angle between the two groups (P = 0.010). The median percentage change in lordosis angle was 50.08% in the allograft impaction group and 26.42% in the PEEK cage group, indicating a significantly greater change in the allograft impaction group (Table 2).

Discussion

This study compared the lordosis angle before and after surgery, showing that both Allograft Impaction and PEEK Cage methods improve the lordosis angle. Significant efficacy of PEEK cages and bone allografts in correcting lordosis has been demonstrated, but limited studies have compared segmental lordosis correction in lumbosacral vertebrae between these two approaches. A study that investigated the use of PEEK cages along with vertebral autograft materials in posterior spinal fusion surgery indicated a significant increase in lumbar lordosis in all patients, with no significant postoperative complications(24). In a study by Martin et al., lordosis correction before and 6 weeks after surgery was evaluated. The average lordosis correction was 2.5 degrees, with the study indicating that patients who had more kyphotic disc spaces preoperatively on CT scans had a greater chance of lordosis correction(25). Unlike this study, the lordosis correction in the current study was greater, potentially due to differences in vertebral number and the extent of spinal changes, which can impact the overall lordosis change range.
Cutler et al. compared the therapeutic effects of posterior lumbar interbody fusion using femoral cortical allograft or PEEK cages. Contrary to the current study, no significant difference in lordosis angle changes was observed between the two groups(26).

Table 1: Description and Comparison of Gender, Age, and Hospital Stay Duration Between the Two Groups

Variable	Total Patients (n = 21)	Allograft Impaction (n = 10)	PEEK Cage (n = 11)	P-value
Gender#				
Male (%)	8 (38.1)	6 (60)	2 (18.2)	0.080
Female (%)	13 (61.9)	4 (40)	9 (81.8)	
Age (years)*	56 (45–69.5)	51 (31.5–70.75)	59 (48–64)	0.426
Hospital stay (days)*	6 (5–7.5)	6.5 (4–9)	6 (6–7)	0.705

#: Frequency (percentage), *: Median (interquartile range).

Table 2: Description and Comparison of Pain Intensity and Lordosis Angle Between the Two Groups

Variable	Total Patients (n = 21)	Allograft Impaction (n = 10)	PEEK Cage (n = 11)	P-value
Postoperative Pain Intensity*	3 (4–5)	4 (3.5–5)	4 (3–5)	0.973
Lordosis Angle (degrees)*				
Before Surgery	32 (15.6–35.5)	35.25 (9.53–33.95)	32 (23.1–40.2)	0.197
After Surgery	43 (25.65–48.2)	42.7 (23.8–46.7)	41.8 (24.9–48.5)	0.654
Percentage Change in Lordosis Angle*	—	33.04 (21.99–74.13)	50.08 (32.25–130.38)	0.010

*: Median (interquartile range).

However, in the present study, no significant difference was found in the postoperative lordosis angle between the two methods, but the percentage change in the allograft group was greater. A recent 2022 study with a 2-year follow-up compared the allograft and PEEK cage methods, reporting lumbar lordosis improvement and maintenance in 43.3% and 49.2% of patients, and segmental alignment in 38.3% and 36.1% for the allograft and PEEK cage groups, respectively[27].

Our study found that the lordosis angle increase in patients treated with Allograft Impaction was nearly twice that of the PEEK cage method. This may be attributed to the flexibility in the geometry and better integration of the allograft compared to the PEEK cage in correcting lordosis in the lumbosacral vertebrae. One of the main issues with PEEK cages is the limitation in their integration potential[28]. Several studies have addressed the impact of implant geometry in spinal surgery. Biomechanical studies by Lund et al.[29] and Oxland and Lund[30] showed that stand-alone cages, when used with the posterior approach, cannot provide significant stability in spinal structures, especially in extension and rotation. Gödde et al. reported that the use of lordotic and non-lordotic cages had a significant impact on pelvic spine parameters after surgery. In the lordotic cage group, lordosis improved significantly in fused segments, while in the non-lordotic cage group, lordosis decreased by 3 to 8 degrees, with the authors attributing this difference to the cage geometry[31]. Similarly, a study by Sembrano et al. observed a significant increase in lumbar lordosis after lumbar interbody fusion using 10° lordotic cages, while the non-lordotic cage group had no significant impact on sagittal alignment after surgery[32]. In a study by Groth et al., three treatment approaches (vertical cages, allograft, and threaded cylindrical cages) were compared in 49 patients. At the 1-year follow-up, lordosis improved in the vertical cage group, whereas it decreased in the allograft and threaded cylindrical cage groups[33].

This study also had some limitations. It involved a small group of patients with two treatment approaches, and further research with a larger sample size and longer follow-up period is recommended. Although the study was conducted by two experienced surgeons, assessing results in patients treated by a single surgeon could reduce potential bias. The follow-up period in this study was limited, and thus, long-term results such as subsidence rates, fusion, PEEK cage stability, long-term complications, reoperation rates, and others were not evaluated, which should be addressed in future studies.

Conclusion

The results of this study indicate that the use of Allograft Impaction leads to a greater correction of lordosis in the lumbosacral vertebrae of patients undergoing posterior spinal fusion with posterior lumbar interbody fusion compared to the PEEK cage method. These findings are valuable for neurosurgeons in managing patient treatment and achieving better clinical outcomes.

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