ORIGINAL RESEARCH

Bagcilar Med Bull 2023;8(3):293-304
DOI: 10.4274/BMB.galenos.2023.2023-08-074

Morphometric Comparison of Interbody Fusion with Cage and Autograft at L4-L5 Levels versus Autograft Alone for Fusion

L4-L5 Seviyesinde Kafes ve Otogreftle Yapılan İnterbody Füzyonunun Tek Başına Otogreftle Yapılan Füzyonla Morfometrik Karşılaştırılması

Azmi Tufan[1], Feyza Karagöz Güzey[2], Abdurrahman Aycan[3]

[1]Demiroğlu Bilim University, Kadıköy Florence Nightingale Hospital, Department of Neurosurgery, İstanbul, Turkey
[2]University of Health Sciences Turkey, İstanbul Bağcılar Training and Research Hospital, Clinic of Neurosurgery, İstanbul, Turkey
[3]Yüzüncü Yıl University Faculty of Medicine, Department of Neurosurgery, İstanbul, Turkey

Abstract

Objective: Lumbar interbody fusion (LIF) entails the placement of a bone graft within the intervertebral space, with or without the use of a cage, subsequent to discectomy. While numerous studies have explored caged LIF methods within the literature, limited attention has been given to direct comparisons between caged and cageless LIF techniques. This study aims to scrutinize the delayed outcomes of interbody fusion involving peek-caged and cageless laminar autografts. The investigation was specifically carried out at the L4-5 level.

Method: This retrospective comparative study was conducted on patients who underwent surgical procedures at our institution's neurosurgery clinic between 2011 and 2018, with the sanction of the ethics committee from the same institution. The study group (Group 1, n=27) comprised patients who underwent L4-5 single-level lumbar instrumentation and transforaminal LIF using a banana cage alongside autograft for the purpose of fusion. The control group (Group 2, n=31) consisted solely of cases that underwent posterior LIF operations with the utilization of autografts. Corticocancellous bone fragments sourced from posterior structures during decompression were utilized as autografts. The study parameters encompassed fusion rates, segmental and lumbar lordosis angles, disc height, ipsilateral and contralateral foramen heights, as well as slip distance.

Results: Within our study, the late-stage fusion rates were determined to be 96.3% in the caged group and 96.7% in the cageless autograft group. No alterations were identified in segmental and lumbar lordosis angles across both groups. Notably, the caged group exhibited a propensity for late-stage cage embedding, while graft migration was the most prevalent complication within the autograft group.

Öz

Amaç: Lomber interbody füzyon (LIF), diskektomi yapıldıktan sonra intervertebral boşluğa bir kafesle veya kafes olmaksızın kemik greft yerleştirilmesi işlemidir. Literatürde kafesli LIF yöntemlerini karşılaştıran birçok çalışma vardır. Buna rağmen kafesli ve kafessiz LIF yöntemlerini karşılaştıran çalışma çok azdır. Bu çalışmada peek kafesli ve kafessiz laminar otogreft kullanılarak yapılan interbody füzyonun geç dönem sonuçlarının karşılaştırılması amaçlanmıştır. Çalışma spesifik olarak L4-5 seviyesinde yapılmıştır.

Yöntem: Bu retrospektif karşılaştırmalı çalışma 2011-2018 yılları arasında kurumumuz nöroşirurji kliniğinde opere edilen hastalar üzerinde aynı kurumdan etik kurul onayı alınarak yapılmıştır. L4-5 tek seviyeli lomber enstrümantasyon uygulanıp füzyon amacıyla otogreftle birlikte muz kafes kullanılarak transforaminal LIF operasyonu yapılan hastalar çalışma grubunu (Grup 1, n=27), sadece otogreft ile arka LIF operasyonu yapılan olgular kontrol grubunu oluşturdu (Grup 2, n=31). Otogreft olarak dekompresyon esnasında posterior yapılardan elde edilen kortikokanselloz kemik parçaları kullanıldı. Füzyon oranları, segmental ve lomber lordoz açısı, disk yüksekliği, ipsilateral ve kontralateral foramen yüksekliği ve kayma mesafesi ölçüldü.

Bulgular: Yaptığımız çalışmada kafesli ve kafessiz gruplarda geç dönem füzyon oranları sırasıyla %96,3 ve %96,7 olarak bulundu. Segmental ve lomber lordozda iki grupta da değişiklik olmadı. Kafesli grupta geç dönem kafes gömülmesi, kafessiz grupta ise greft göçü en sık komplikasyonlardı.

Sonuç: Hem kafesli hem de kafessiz LIF yüksek füzyon oranları olan cerrahi tekniklerdir. Füzyon açısından otogreft grubu, dizilim açısından ise kafesli grubun sınırlı bazı avantajları vardır. Kafessiz otogreftle LIF basit,

Address for Correspondence: Azmi Tufan, Demiroğlu Bilim University, Kadıköy Florence Nightingale Hospital, Department of Neurosurgery, İstanbul, Turkey
E-mail: tufanazmi@gmail.com **ORCID:** orcid.org/0000-0001-9042-8542 **Received:** 14.08.2023 **Accepted:** 28.08.2023

Cite this article as: Tufan A, Karagöz Güzey F. Morphometric Comparison of Interbody Fusion with Cage and Autograft at L4-L5 Levels versus Autograft Alone for Fusion. Bagcilar Med Bull 2023;8(3):293-304

Abstract

Conclusion: Both caged and cageless LIF methodologies are associated with elevated fusion rates. The autograft group demonstrates certain limited advantages in terms of fusion, whereas the caged group exhibits some benefits primarily related to alignment. The implementation of cageless autograft LIF, marked by its straightforwardness, simplicity, and cost-effectiveness, appears to be an underappreciated surgical technique within the current context.

Keywords: Autograft, cage, interbody fusion, peek cage

Öz

sade ve düşük maliyet gibi özellikleriyle yeterince takdir edilmeyen bir cerrahi teknik olarak görünmektedir.

Anahtar kelimeler: Gözetleme kafesi, kafes, otogreft, vücutlar arası füzyon

Introduction

Lumbar interbody fusion (LIF) is a surgical procedure involving the placement of a bone graft within the intervertebral space, often accompanied by the use of a cage, subsequent to a discectomy. In contemporary practice, LIF is approached through five primary surgical techniques: Posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF or MI-TLIF), oblique lumbar interbody fusion/anterior psoas (OLIF/ATP), anterior lumbar interbody fusion (ALIF), and lateral lumbar interbody fusion (LLIF). While a discernible array of advantages and disadvantages have been documented for each of these modalities, it remains noteworthy that extant literature does not yet furnish definitive evidence substantiating the unequivocal superiority of any single approach over the others (1). The related literature is replete with numerous investigations that meticulously juxtapose the divergent dimensions of caged LIF techniques (2-8). It is, however, discernible that a paucity of comprehensive studies exists in relation to the comparative evaluation between caged and cageless LIF methodologies (9-12). This emerging trend underscores the progressive propensity towards the integration of intervertebral cages as a de facto standard within the LIF procedure.

The utilization of autografts for LIF has conventionally entailed their extraction from either the iliac crest or the posterior osseous structures during decompression procedures. Iliac crest grafts manifest optimal graft attributes owing to their corticocancellous architecture; nevertheless, they are concomitantly linked to pronounced wound morbidity (13). Conversely, grafts acquired from the lamina and spinous processes during decompression, while susceptible to challenges in sustaining structural integrity, obviate the necessity for supplementary surgical interventions and proffer inherent cost-related benefits. The deployment of autograft material confers an advantageous edge in fusion dynamics when juxtaposed with allograft and synthetic alternatives, primarily attributed to its heightened tissue compatibility.

Interbody cages exhibit a diverse array of structural profiles and configurations, commonly crafted from titanium or polyetheretherketone (PEEK) materials. The osteoconductive attributes of titanium cages are prominently evident, accentuating their capacity to foster optimal bone integration. However, it is noteworthy that the inherent rigidity of titanium constructs may engender an elevated susceptibility to implant embedding, which is a recognized concern (5). In contrast, PEEK lattice architectures offer a distinctive advantage characterized by a closer approximation to the mechanical elasticity of osseous tissue. Nevertheless, the advantageous mechanical harmony offered by PEEK structures is counterbalanced by certain challenges, such as their inherently smooth and hydrophobic surfaces, which may, in turn, impede the process of fusion (5).

In this study, it was aimed a comprehensive comparative analysis of long-term outcomes of interbody fusion employing PEEK cages versus cageless laminar autografts. Potential advantages and disadvantages of two methods were evaluated by meticulous assessment of demographic attributes, radiological metrics, and clinical presentations. The investigation was meticulously circumscribed to a patient cohort exclusively encompassing those who underwent only single-level L4-L5 interbody fusion. This methodological constraint was carefully instituted to confer precision and specificity to the study outcomes, enabling a more incisive examination of the parameters under consideration.

Materials and Methods

This retrospective comparative study was undertaken within the purview of the neurosurgery clinic at our esteemed institution, spanning the duration encompassing 2011 to 2018. The study was executed subsequent to obtaining the requisite endorsement from the ethics committee affiliated with the same institution. Consent was obtained from all participants. The study cohort, herein referred to as Group I, was composed of patients who underwent TLIF procedures. This involved the application of single-level lumbar instrumentation at the L4-5 level, accompanied by the utilization of a banana-shaped cage housing autograft material. The control group, denoted as Group II, exclusively encompassed cases subjected to PLIF interventions. The autograft was derived from corticocancellous bone fragments sourced from posterior osseous structures during the process of decompression in both groups. The patients were randomly divided into two groups.

The investigation encompassed an extensive review of the hospital registry system and patient records. During this process, meticulous attention was directed towards capturing pivotal demographic attributes, encompassing elements such as operation duration, intraoperative hemorrhage volume, body mass index (BMI), comorbid conditions, as well as postoperative complications. The clinical parameters of interest were supported by the inclusion of preoperative metrics, including visual analog scale (VAS) scores and Oswestry disability index (ODI) assessments.

At distinct time intervals, a comprehensive evaluation of patient outcomes was conducted. This entailed administering questionnaires at the 3-month juncture postoperatively, followed by a subsequent assessment extending beyond the span of 2 years post-surgery. For the sake of methodological rigor, participants who were deceased or rendered uncontactable were judiciously excluded from the analytical framework, thereby fortifying the integrity of the study cohort.

Inclusion Criteria

Individuals who had undergone surgical intervention involving L4-L5 pedicle screw instrumentation in conjunction with interbody fusion were enrolled into the study. This procedural selection was contingent upon a diagnostic framework characterized by degenerative grade 1 listhesis, accompanied by demonstrable clinical and radiological indicators of instability. Furthermore, a key criterion necessitated that these patients had exhausted conservative therapeutic modalities, thus warranting surgical intervention as a subsequent step in their clinical management.

Exclusion Criteria

Exclusion criteria encompassed cases involving procedures beyond the confines of the L4-L5 spinal segment, as well as instances involving multi-level operations. Moreover, patients with a documented history of prior instrumentation, those subjected to either solitary or supplementary posterolateral fusion procedures, and individuals afflicted by malignancy, traumatic injuries, or severe osteoporosis, were methodologically precluded from participation. Additionally, participants meeting the unfortunate outcome of deceased status or deemed non-compliant with the requisite follow-up protocol were excluded from the study. Furthermore, a stipulation was imposed mandating the availability of postoperative lumbar imaging records for a minimum duration of two years subsequent to the surgical intervention. Patients for whom lumbar computerized tomography (CT) and radiographic data were unavailable within the hospital's radiological record system were systematically excluded from the cohort under consideration.

Radiological Investigations

The radiological investigations constituted an integral facet of this study, engaging a comprehensive array of parameters to discern and quantify pertinent anatomical variables. The timeline of measurement encompassed preoperative, early postoperative, and late postoperative stages, extending over a minimum of two years. These assessments were meticulously executed employing both CT imaging and standing X-ray examinations.

Noteworthy metrics subject to meticulous quantification included segmental and lumbar lordosis angles, disc height dimensions, ipsilateral and contralateral foramen heights, as well as slip distances. The determination of segmental lordosis (SL) was methodologically anchored in the calculation of angular deviation from the lower L4 and upper L5 endplates. In parallel, the computation of lumbar lordosis was derived from lines tangentially projected from the upper L1 to S1 endplates.

Concurrently, disc heights were ascertained through meticulous measurement along the anterior, middle, and posterior planes tangential to the respective endplates. The computation of the mean disc height necessitated the division of the cumulative measurements by a factor of three. Correspondingly, foramen heights were discerned through the measurement of distances between lines spanning from the inferior aspect of the L4 pedicle to the superior region of the L5 pedicle (Figure 1).

The framework established by Lee et al., as adapted for this context, constituted the basis for evaluating the fusion status (14). This framework discerns the presence or absence of bridging bony trabeculae, graft-to-bone space, and dynamic motion (≥3°) as evident in radiographs acquired during dynamic movements. The meticulous examination of dynamic radiographs for motion, as indicated in Table 1, underpinned the fusion evaluation.

Ensuring methodological rigor, measurements were conducted by two independent neurosurgeons, with their findings subjected to subsequent averaging. Instances of interpretational discrepancies concerning fusion assessments were judiciously arbitrated through a consensus-driven resolution process (Figure 2).

Surgical Technique

All procedural interventions were undertaken by the co-authors of this study. Employing a posterior midline approach, the surgical field encompassed exposure of the distal facet of L3-4, the entire facet of L4-5, and the initial region of the transverse process. Predominantly, pedicle screws were deployed, save for specific cases involving advanced stenosis where alternative measures were considered. Following this, decompression procedures were administered either unilaterally or bilaterally contingent upon the direction of pressure. In scenarios necessitating unilateral decompression, an extended approach was favored to ensure optimal bone graft capacity.

Post-discectomy and thorough endplate preparation, the implantation of a banana cage was executed at a height commensurate with physiological norms, thereby avoiding encroachment upon the posterior one-third of the intervertebral disc space. It is germane to note that facet osteotomy was executed with judicious precision, calibrated to facilitate the placement of the banana cage. This strategic choice was underscored by the imperative to mitigate the risk of potential instability in prospective revision scenarios. This surgical modality, in essence, mirrors an adapted version of the TLIF technique. Conspicuously, the strategy deployed forgoes complete L4 total laminectomy, a decision rooted in the intention to preclude the exacerbation of superior adjacent segment disease. Instead, an approach characterized by laminectomy of a scope adequate to accommodate microdiscectomy and the subsequent introduction of the cage is employed. Prior to the final placement of rods, meticulous maneuvering of the operating table is undertaken to optimize lumbar lordosis. Importantly, the procedural execution refrains from aggressive compression, as the potential for foraminal stenosis dictates caution.

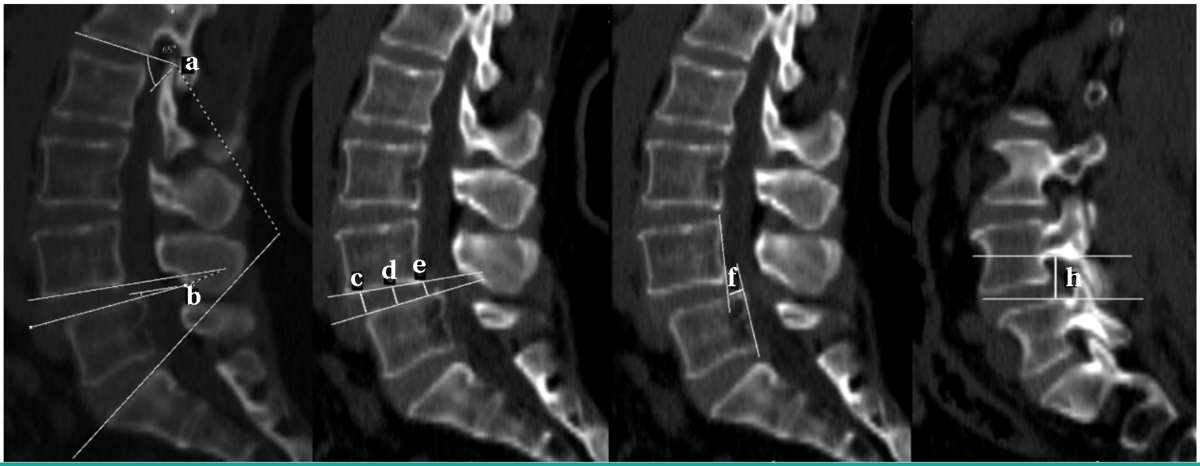

Figure 1. a (lumbar lordosis), **b** (segmental lordosis), **c** (anterior disc height), **d** (middle disc height), **e** (posterior disc height), **f** (shift distance), **h** (foramen height) measurement

Table 1. Modified Lee et al. classification

	Presence of bridging trabecular bone	Gap between corpus and graft	Motion in dynamic radiograph
Fusion	+	-	-
Possible fusion	-	-	-
Possible non-fusion	-	+	-
Non-fusion	-	+	+

In instances where the only autograft technique is embraced, an allocation of 20 to 30 bone fragments, varying in size, is thoughtfully inserted. Conversely, the cage group encompasses the utilization of approximately 10 bone graft pieces, with half of the allocation seamlessly integrated within the confines of the cage apparatus.

Statistical Analysis

Descriptive statistical measures encompassing mean, standard deviation, median, minimum, maximum, frequency, and ratio were employed to elucidate the inherent characteristics of the dataset. The distributional properties of the variables were assessed via the Kolmogorov-Smirnov test. To expound upon the analysis of quantitative independent data, both the Independent Sample t-test and the Mann-Whitney U test were judiciously administered. In parallel, the scrutiny of dependent quantitative data entailed the application of the Paired-Sample t-test and the Wilcoxon test, aptly tailored to accommodate the investigative context. Qualitative independent data underwent rigorous evaluation through the application of the chi-square test, thereby affording insights into the interrelationships within this stratum of variables. All statistical analyses were conducted utilizing the SPSS version 28.0 software.

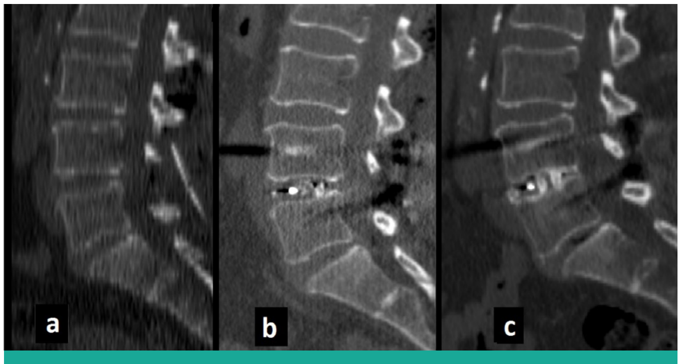

Figure 2. In the case of interbody cage; **a** (preoperative), **b** (early postoperative), **c** (late postoperative) sagittal CT reconstruction

CT: Computerized tomography

Results

The distribution of patients' age, gender, blood loss amount, operation time, and follow-up period demonstrated no significant disparities between Groups I and II ($p<0.05$), as evidenced through the BMI distribution. Similarly, no substantial variation in fusion values was observed between two groups ($p<0.05$) (Table 2).

Disc Height

The preoperative mean disc height (DH) value revealed no substantial distinction ($p>0.05$) between Group I and Group II. Notably, early and late postoperative mean DH values in Group II were significantly diminished relative to those in Group I ($p<0.05$). Conversely, Group I exhibited a noteworthy increase in early and late postoperative mean DH values compared to the preoperative values ($p<0.05$). Meanwhile, Group II experienced a significant

Table 2. Comparison of demographic data and fusion

		Group I		Group II		p	
		Mean ± SD/n-%	Median	Mean ± SD/n-%	Median		
Age		58.3±9.0	57.0	56.6±8.6	56.0	0.473	t
Gender	Female	20, 74.1%		25, 80.6%		0.549	X^2
	Male	7, 25.9%		6, 19.4%			
Weight		82.0±12.3	85.0	76.5±10.4	80.0	0.071	t
Height		161.9±7.2	160.0	161.3±6.8	160.0	0.820	m
BMI		31.4±5.4	30.0	29.6±4.9	29.4	0.179	t
Loss of blood		481.5±170.1	450.0	427.4±183.0	400.0	0.226	m
Duration of surgery		174.1±30.3	170.0	167.4±26.8	160.0	0.446	m
Follow of period		34.7±12.8	28.0	31.9±10.9	29.0	0.638	m
Fusion							
Fusion		17, 63.0%		25, 80.6%		1.000	X^2
Possible fusion		9, 33.3%		5, 16.1%			
Possible non-fusion		1, 3.7%		0, 0.0%			
Non-fusion		0, 0.0%		1, 3.2%			

^{t}t-test, ^{m}Mann-Whitney U test, $^{X^2}$chi-square test, SD: Standard deviation, BMI: Body mass index increase in early postoperative mean DH value compared to the preoperative baseline (p<0.05), while the late postoperative mean DH value in Group II exhibited no significant difference from the preoperative metric (p>0.05). Within Group II, the preoperative/early postoperative and preoperative/late postoperative mean DH increments were significantly lower in comparison to Group I (p<0.05) (Table 3).

Lumbar Lordosis

No substantial disparity emerged in preoperative, early postoperative, and late postoperative lumbar lordosis (LL) values between Group I and Group II (p>0.05). Furthermore, early postoperative and late postoperative LL values exhibited no significant differentiation in either Group I or Group II relative to their preoperative values (p>0.05) (Table 4).

SL

Preoperative, early postoperative, and late postoperative SL values demonstrated no notable discrepancies between Group I and Group II (p>0.05). However, in both groups, the early postoperative SL value exhibited no significant deviation from the preoperative benchmark (p>0.05), while

Table 3. Comparison of disc height between and within groups

	Group I		Group II		p	
	Mean ± SD	Median	Mean ± SD	Median		
Avg DH						
Preop	7.0±2.1	6.5	6.6±1.8	6.8	0.516	t
Early postop	9.1±1.8	8.8	7.6±1.7	7.6	**0.003**	t
Late postop	7.8±2.1	7.5	6.5±1.9	6.8	**0.015**	t
Change according to preop						
Preop/early postop	2.1±1.6	1.8	1.0±1.1	0.9	**0.004**	t
Intra-group change p	**0.000**	E	**0.011**	E		
Preop/late postop	0.8±1.6	0.4	-0.1±1.3	-0.4	**0.012**	t
Intra-group change p	**0.000**	E	0.561	E		

E Paired sample t-test, t Independent sample t-test, SD: Standard deviation, DH: Disc height

Table 4. Comparison of lordosis and foramen heights between and within groups

	Group I		Group II		p	
	Mean ± SD	Median	Mean ± SD	Median		
LL						
Preop	52.0±11.1	53.0	52.7±11.1	55.0	0.827	m
Early postop	53.3±8.8	52.0	51.5±9.8	54.0	0.679	m
Late postop	52.6±10.0	53.0	51.7±10.9	52.0	0.623	m
Change according to preop						
Preop/early postop	1.3±7.4	1.0	-1.2±4.2	-1.0	0.211	m
Intra-group change p	0.526	w	0.161	w		
Preop/late postop	0.6±7.7	1.0	-1.0±3.6	-1.0	0.352	m
Intra-group change p	0.656	w	0.137	w		
SL						
Preop	5.9±3.3	5.0	6.6±3.6	6.0	0.461	m
Early postop	6.3±2.3	6.0	6.2±3.2	6.0	0.771	m
Late postop	4.6±2.1	4.0	4.9±3.1	5.0	0.813	m
Change according to preop						
Preop/early postop	0.4±2.5	1.0	-0.4±3.5	-1.0	0.165	m
Intra-group change p	0.263	w	0.531	w		
Preop/late postop	-1.2±2.8	-1.0	-1.7±3.0	-1.0	0.551	m
Intra-group change p	**0.046**	w	**0.003**	w		

Table 4. Continued

	Group I		Group II		p	
	Mean ± SD	Median	Mean ± SD	Median		
FH						
Preop	15.4±2.4	15.5	14.5±3.1	14.4	0.091	m
Early postop	17.7±2.4	17.8	16.2±2.4	15.9	**0.035**	m
Late postop	16.2±2.5	15.7	15.0±2.4	14.8	0.097	m
Change according to preop						
Preop/early postop	2.2±1.5	2.1	1.8±2.5	1.8	0.177	m
Intra-group change p	**0.000**	w	**0.000**	w		
Preop/late postop	0.8±2.1	0.4	0.5±2.7	0.4	0.507	m
Intra-group change p	0.096	w	0.428	w		
CLFH						
Preop	15.9±1.9	16.2	15.6±2.1	15.1	0.454	m
Early postop	17.7±2.1	17.8	16.4±2.4	16.5	**0.015**	m
Late postop	16.0±2.3	16.9	15.1±1.9	14.7	0.098	m
Change according to preop						
Preop/early postop	1.7±1.6	1.7	0.7±1.2	0.5	**0.023**	m
Intra-group change p	**0.000**	w	**0.002**	w		
Preop/late postop	0.1±1.9	0.4	-0.6±1.3	-0.5	0.062	m
Intra-group change p	0.501	w	**0.028**	w		

SD: Standard deviation, [m]Mann-Whitney U test, [w]Wilcoxon test, LL: Lumbar lordosis, SL: Segmental lordosis, FH: Foraminal height, CLFH: Controlateral foraminal height

the late postoperative SL value underwent a significant reduction ($p<0.05$) (Table 4).

Foraminal Height (FH)

Preoperative and late postoperative FH values yielded no considerable distinction between Group I and Group II ($p>0.05$). However, the early postoperative FH value in Group II was significantly lower compared to Group I ($p<0.05$). In both groups, the early postoperative FH values significantly increased in comparison to the preoperative measures ($p<0.05$), while the late postoperative FH values returned to the preoperative values ($p>0.05$). The preoperative/early postoperative and preoperative/late postoperative FH changes exhibited no substantial differences between Group I and Group II ($p>0.05$) (Table 4). Contralateral and ipsilateral foramen height yielded analogous statistical results, as indicated in Table 4.

Slip Measurements

The preoperative, early postoperative, and late postoperative slip values displayed no discernible differentiation between Group I and Group II ($p>0.05$). In Group I, both early postoperative and late postoperative deviation values exhibited a significant decrease in contrast to the preoperative values ($p<0.05$). Parallelly, Group II showcased a similar pattern ($p<0.05$). The preoperative/early postoperative and preoperative/late postoperative slip reduction, however, was markedly lower in Group II ($p<0.05$) compared to Group I (Table 5).

Functional Outcomes

No noteworthy differences emerged in preoperative, early postoperative, and late postoperative ODI values between Group I and Group II ($p>0.05$). In both groups, both early postoperative and late postoperative values displayed a significant decline compared to the preoperative measures ($p<0.05$). The preoperative/early postoperative and preoperative/late postoperative ODI changes presented a similar trend across both groups ($p>0.05$) (Table 5).

Analogous patterns were observed in the assessment of leg VAS scores. Specifically, preoperative, early postoperative, and late postoperative leg VAS scores exhibited no substantial differentiation between Group I and Group II ($p>0.05$). In both groups, both early postoperative and late postoperative leg VAS scores registered a significant reduction compared to the preoperative values ($p<0.05$). The preoperative/early postoperative and preoperative/late postoperative leg VAS score reductions were analogous between Group I and Group II ($p>0.05$) (Table 6). Analogously, the back VAS score results echoed the trends observed in leg VAS scores across both groups (Table 6).

Table 5. Intergroup and intragroup comparison of slippage distance and ODI changes

	Group I		Group II		p	
	Mean ± SD	Median		Median		
Slippage						
Preop	3.7±3.0	4.0	3.4±2.9	2.0	0.906	m
Early postop	1.3±1.5	1.0	2.4±2.3	2.0	0.072	m
Late postop	1.3±1.5	1.0	2.3±2.3	2.0	0.113	m
Change according to preop						
Preop/early postop	-2.4±2.3	-2.0	-1.0±1.5	0.0	**0.011**	m
Intra-group change p	**0.000**	w	**0.001**	w		
Preop/late postop	-2.4±2.3	-2.0	-1.1±1.5	0.0	**0.024**	m
Intra-group change p	**0.000**	w	**0.001**	w		
ODI						
Preop	56.5±12.4	58.0	54.2±12.8	56.0	0.826	m
Early postop	29.4±12.9	26.0	29.2±8.7	30.0	0.536	m
Late postop	27.3±15.2	24.0	26.6±12.9	22.0	0.833	m
Change according to preop						
Preop/early postop	-27.1±9.3	-26.0	-24.9±13.4	-26.0	0.579	m
Intra-group change p	**0.000**	w	**0.000**	w		
Preop/late postop	-29.3±10.3	-30.0	-27.5±14.8	-30.0	0.628	m
Intra-group change p	**0.000**	w	**0.000**	w		

m Mann-Whitney U test, w Wilcoxon test, SD: Standard deviation, ODI: Oswestry disability index

Table 6. Comparison of VAS waist and VAS leg changes between and within groups

	Group I		Group II		p	
	Mean ± SD	Median	Mean ± SD	Median		
VAS score-leg						
Preop	7.6±1.3	8.0	7.7±1.6	8.0	0.574	m
Early postop	2.7±1.6	2.0	2.9±1.4	2.0	0.351	m
Late postop	2.6±1.6	2.0	2.8±1.7	2.0	0.602	m
Change according to preop						
Preop/early postop	-4.9±1.5	-5.0	-4.7±1.8	-5.0	0.545	m
Intra-group change p	**0.000**	w	**0.000**	w		
Preop/late postop	-5.0±1.5	-5.0	-4.9±2.0	-5.0	0.633	m
Intra-group change p	**0.000**	w	**0.000**	w		
VAS score-waist						
Preop	7.1±1.4	7.0	7.2±1.7	8.0	0.512	m
Early postop	3.4±1.1	3.0	3.2±1.0	3.0	0.636	m
Late postop	3.0±1.4	3.0	2.9±1.5	3.0	0.652	m
Change according to preop						
Preop/early postop	-3.8±1.5	-4.0	-4.0±1.6	-4.0	0.540	m
Intra-group change p	**0.000**	w	**0.000**	w		
Preop/late postop	-4.1±1.6	-4.0	-4.3±1.9	-5.0	0.496	m
Intra-group change p	**0.000**	w	**0.000**	w		

m Mann-Whitney U test, w Wilcoxon test, SD: Standard deviation, VAS: Visual analog scale

Complications

A total of 23 complications were seen within the caged group (Group I) with 11 cases of cage embedding, while 14 complications with 4 cases of graft displacement were noted in the cageless cohort. No substantial intergroup disparities emerged concerning dural injury, new-onset loss of strength, reoperation, or the incidence of adjacent segment disease.

Discussion

The central impetus behind employing interbody cages or grafts in lumbar degenerative disease surgeries is to augment fusion rates. Notably, the literature has consistently demonstrated that PLIF and TLIF yield higher fusion rates and superior clinical outcomes when juxtaposed with posterolateral fusion (PLF) approaches (15,16). This trend has culminated in the integration of PLIF and TLIF methodologies as near-standard practices, with interbody cage utilization becoming an inherent component of any posterolateral interbody fusion (PIF) intervention. Contemporary studies, in lieu of pitting against PLF, are now inclined to contrast PLIF and TLIF with innovative minimally invasive modalities such as ALIF, LLIF, and OLIF (17).

Despite the pervasive prevalence of PIF procedures and the amplification of the data corpus in scientific literature, studies on only interbody fusion employing autografts remain underrepresented. Autografts sourced from patients possess an array of merits, devoid of immunological complications and characterized by elevated fusion rates. The application of iliac crest grafts as a graft source in PIF has also been explored (18). Regrettably, despite the benefits, this ideal graft comes with the associated burdens of pain, bleeding, and infection due to secondary incisions, which has led surgeons to seek more minimally invasive alternatives, such as avoiding the utilization of iliac crest grafts.

Bone decompression stands as a necessity in the majority of surgeries related to degenerative spondylolisthesis. Even in cases where minimally invasive methods like ipsilateral contralateral decompression are pursued, ample bone fragments can be sourced to facilitate fusion over a single disc distance. This prompts the inquiry: Can these naturally obtained bone fragments be judiciously placed within the discectomy space, effectively fostering fusion? Does the prevailing attention granted to interbody cages align with their true significance?

Within our study, late fusion rates were observed to reach 96.3% in the caged group and 96.7% in the cage-free autograft group, concordant with existing literature. This echoes findings in independent studies that employed laminar bone fragments, where fusion outcomes correlated with our results. However, divergences in evaluation timeframe and criteria necessitate caution when drawing direct comparisons (9,10).

Although notable fusion rates exhibited by both groups in this study, more definitive evidence of fusion was observed in the autograft group (Group II). In the caged group (Group I), the device appeared to constrict the fusion area, engendering a hypodense space between the device and bone. Fusion was realized through autografts positioned anteriorly and posteriorly to the cage, rather than within the cage itself. These hypodense regions between the cage and end plates might potentially show a disadvantage for PEEK material in terms of fusion. Noteworthy, certain studies have reported the superiority of titanium cages over PEEK cages in terms of fusion efficacy (19).

Furthermore, even though posterolateral fusion was not a primary objective in both groups, significant fusion was observed within the facets, hinting at how PIF methodologies indirectly foster posterior fusion via the rigid construct formed anteriorly. While results pertaining to fusion alignment in both groups were comparable, the autograft group (Group II) exhibited a relative advantage due to its simplicity and cost-effectiveness. Additionally, the diminished facetectomy requirements associated with autograft interbody fusion mitigate the risk of potential instability upon instrument removal. Following the preliminary outcomes of this study, cageless autograft interbody fusion has evolved into the standard modality in our clinical setting for cases focused solely on achieving fusion.

These findings collectively underscore the significance of exploring alternative avenues for achieving successful interbody fusion, with a particular emphasis on harnessing autografts and simplifying procedural approaches, while maintaining an eye on long-term stability and cost-effectiveness.

An integral motivation underlying the adoption of interbody cages is the mitigation of root compression stemming from potential foramen stenosis, accomplished through the preservation of disc and foramen height. Related literature underscores the utility of employing solid interbody cages to sustain disc height (20).

Conversely, another study reported a reduction in disc height when autografts were utilized (21). In the current study, significant early postoperative augmentation in mean disc height within the caged group failed to persist in the long-term. In other words, although late-phase mean disc height exhibited superiority within the caged group, noteworthy collapse ensued in both caged and cage-free groups, deviating from anticipated findings. The incapacity to maintain early postoperative mean disc height increment within the caged group could potentially be attributed to the predominantly elderly female patient cohort, where probable osteoporosis was a contributing factor. The majority of cases avoided complete excision of both ipsilateral and contralateral facets, opting instead for a physiological-sized device. The lack of supraphysiological devices might explain the failure to sustain late-phase disc height, despite prior literature suggesting that such devices are more intrinsically integrated (22,23).

In the realm of lumbar PIF procedures, the paramount objective of employing interbody devices pertains to the rectification of lordosis angles and the achievement of optimal alignment. A systematic review investigating lumbar angle enhancements following PIF revealed mean corrections of 4.67, 4.47, and 3.89 degrees for ALIF, LLIF, and TLIF, respectively (24). In our investigation, no substantive enhancements in lumbar or SL emerged in preoperative, early postoperative, and late postoperative phases within or between both study groups. Notably, even the autograft group (Group II) exhibited a significant decline in late postoperative periods. This divergence from existing literature could stem from a multitude of factors such as a homogeneous patient population without kyphotic deformity, midline device placement rather than anterior placement, usage of interbody cages without angles, not to be performed ipsilateral and contralateral facetectomy, as well as not to be performed compression during rod insertion to avoid foraminal stenosis. Furthermore, the studies reporting some values that should be performed for lordosis correction were usually the studies evaluating operations of diverse levels and multi-level lumbar interbody fusions (LIF), whereas our study exclusively enrolled single-level fusion cases. These findings underscore the pivotal role of procedural application in effecting lumbar lordosis correction, transcending the choice of interbody fusion method. Consequently, our study has prompted an inclination toward the preferential use of interbody cages for lumbar lordosis correction, predominantly employing angled and supraphysiological dimensions. This entails ipsilateral and contralateral facet osteotomies, coupled with enforced compression to facilitate lordotic correction.

Evaluation of slip distances in our statistical analyses revealed a substantial decline in both groups during the early and late postoperative phases. Notably, intergroup scrutiny underscored superior deviation correction within the device group compared to its counterpart. This effect can be attributed to a more aggressive discectomy approach in the device group, coupled with the corrective influence exerted by distraction during cage insertion on the slippage.

Past studies have accentuated the connection between successful fusion and clinical contentment. Moreover, it is postulated that the preservation and enhancement of disc height could theoretically correlate with the amelioration of leg pain (25). In line with this notion, both groups within our study demonstrated notable improvement in VAS and ODI values during early and late postoperative stages, displaying remarkable congruence. While foramen heights were relatively better preserved in the caged group, no significant divergence in leg VAS values was observed. This observation aligns with existing literature (9-11). However, we posit that a larger prospective study would be indispensable to reveal any discernible disparity.

In summary, our findings underscore the multifaceted nature of lumbar PIF interventions, particularly in relation to the deployment of interbody cages. The interplay between patient characteristics, procedural nuances, and device attributes collectively shapes clinical outcomes, thereby advocating for a comprehensive approach that integrates existing evidence with nuanced clinical judgment.

This elevated frequency of cage embedding potentially correlates with the high prevalence of female patients possibly afflicted with osteoporosis, mirroring the diminished maintenance of disc height. However, the challenge of comparing this complication across existing literature persists due to disparities in mean age and gender distribution. A second salient complication manifested in the cageless autograft group, characterized by four instances of graft displacement. This outcome underscores the possibility that solitary reliance on autografts may not invariably yield structurally robust outcomes. A potential remedy lies in modulating the surgical approach, necessitating the creation of a more conservative window within the posterior longitudinal ligament for cageless PIF scenarios. Additionally, judicious placement of grafts posterior to the disc space involves the utilization of substantial bone fragments, preferentially deposited in the anterior and middle regions of the disc space.

Noteworthy, no substantial intergroup disparities emerged concerning dural injury, new-onset loss of strength, reoperation, or the incidence of adjacent segment disease. Anticipating the contours of prospective inquiries, the investigation of larger cohorts emerges as a beneficial avenue, particularly concerning the intricacies of adjacent segment disease. In summary, the intricacies of complications within both interbody cage and cageless autograft scenarios reinforce the necessity of context-sensitive approaches, adeptly reconciling patient-specific attributes, procedural intricacies, and prior scholarly findings.

Study Limitations

The study is constrained by its relatively modest sample size and its retrospective design, which collectively curtail its robustness. The retrospective acquisition of clinical data, encompassing metrics like ODI and VAS at distinct time points, introduces certain vulnerabilities in terms of data comprehensiveness and reliability.

Study Strengths

In contrast to akin investigations in the literature, the distinctive attribute of our study rests in its meticulous focus on cases pertaining exclusively to a single fusion level (L4-5). Moreover, the anatomical dimensions of segmental and lordosis angles were meticulously gauged from standing radiographs, while the evaluation of fusion was grounded in comprehensive CT scans. We posit that the fusion assessment conducted through CT scans yields results of greater significance. The multifaceted nature of parameters inherent to PIF procedures, including factors like cage height, angle, osteotomy configuration, and rod positioning involving compression or distraction, imparts complexity to the interpretative realm. The insight garnered from our study holds potential to serve as a guiding compass for fledgling surgeons, elucidating the nuances behind the dearth of lumbar lordosis enhancement within our study cohort.

Conclusion

Both the caged and cageless autograft LIF cohorts evinced comparably elevated fusion rates, paired with commendable clinical outcomes. Upon juxtaposition, the cageless contingent exhibited certain modest advantages in terms of fusion outcomes, while the caged group showcased superior alignment attributes. The method of autograft only LIF surfaces as an unheralded surgical modality, marked by its streamlined, uncomplicated, and cost-effective attributes.

Ethics

Ethics Committee Approval: Ethical authorization for this study was granted by the University of Health Sciences Turkey, İstanbul Bağcılar Training and Research Hospital Clinical Research Ethics Committee on 18.12.2020, under the auspices of decision number: 2020.12.2.05.

Informed Consent: Consent was obtained from all participants.

Peer-review: Internally and externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.T., F.K.G., A.A., Concept: A.T., F.K.G., A.A., Design: A.T., F.K.G., A.A., Data Collection or Processing: A.T., A.A., Analysis or Interpretation: A.T., F.K.G., A.A., Literature Search: A.T., F.K.G., A.A., Writing: A.T., F.K.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Teng I, Han J, Phan K, Mobbs R. A meta-analysis comparing ALIF, PLIF, TLIF and LLIF. J Clin Neurosci 2017;44:11-17.
2. Lynch CP, Cha EDK, Rush Iii AJ, Jadczak CN, Mohan S, Geoghegan CE, et al. Outcomes of Transforaminal Lumbar Interbody Fusion Using Unilateral Versus Bilateral Interbody Cages. Neurospine 2021;18(4):854-862.
3. Woodward J, Koro L, Richards D, Keegan C, Fessler RD, Fessler RG. Expandable versus Static Transforaminal Lumbar Interbody Fusion Cages: 1-year Radiographic Parameters and Patient-Reported Outcomes. World Neurosurg 2022;159:e1-e7.
4. Wanderman N, Sebastian A, Fredericks DR Jr, Slaven SE, Helgeson MD. Bullet Cage Versus Crescent Cage Design in Transforaminal Lumbar Interbody Fusion. Clin Spine Surg 2020;33(2):47-49.
5. Loenen ACY, Peters MJM, Bevers RTJ, Schaffrath C, van Haver E, Cuijpers VMJI, et al. Early bone ingrowth and segmental stability of a trussed titanium cage versus a polyether ether ketone cage in an ovine lumbar interbody fusion model. Spine J 2022;22(1):174-182.
6. Gray MT, Davis KP, McEntire BJ, Bal BS, Smith MW. Transforaminal lumbar interbody fusion with a silicon nitride cage demonstrates early radiographic fusion. J Spine Surg 2022;8(1):29-43.
7. Pisano AJ, Fredericks DR, Steelman T, Riccio C, Helgeson MD, Wagner SC. Lumbar disc height and vertebral Hounsfield units: association with interbody cage subsidence. Neurosurg Focus 2020;49(2):E9.
8. Massaad E, Fatima N, Kiapour A, Hadzipasic M, Shankar GM, Shin JH. Polyetheretherketone Versus Titanium Cages for

Posterior Lumbar Interbody Fusion: Meta-Analysis and Review of the Literature. Neurospine 2020;17(1):125-135. Erratum in: Neurospine 2020;17(2):473.

9. Lin B, Yu H, Chen Z, Huang Z, Zhang W. Comparison of the PEEK cage and an autologous cage made from the lumbar spinous process and laminae in posterior lumbar interbody fusion. BMC Musculoskelet Disord 2016;17(1):374.

10. Wang G, Han D, Cao Z, Guan H, Xuan T. Outcomes of autograft alone versus PEEK+ autograft interbody fusion in the treatment of adult lumbar isthmic spondylolisthesis. Clin Neurol Neurosurg 2017;155:1-6.

11. Koehler S, Held C, Stetter C, Westermaier T. Alloplastic or Autologous? Bone Chips versus PEEK Cage for Lumbar Interbody Fusion in Degenerative Spondylolisthesis. J Neurol Surg A Cent Eur Neurosurg 2021;82(6):562-567.

12. Fathy M, Fahmy M, Fakhri M, Aref K, Abdin K, Zidan I. Outcome of instrumented lumbar fusion for low grade spondylolisthesis; Evaluation of interbody fusion with & without cages. Asian J Neurosurg 2010;5(1):41-47.

13. Putzier M, Strube P, Funk JF, Gross C, Mönig HJ, Perka C, Pruss A. Allogenic versus autologous cancellous bone in lumbar segmental spondylodesis: a randomized prospective study. Eur Spine J 2009;18(5):687-695.

14. Patil SS, Rawall S, Nagad P, Shial B, Pawar U, Nene AM. Outcome of single level instrumented posterior lumbar interbody fusion using corticocancellous laminectomy bone chips. Indian J Orthop 2011;45(6):500-503.

15. Liu XY, Wang YP, Qiu GX, Weng XS, Yu B. Meta-analysis of circumferential fusion versus posterolateral fusion in lumbar spondylolisthesis. J Spinal Disord Tech 2014;27(8):E282-E293.

16. Müslüman AM, Yılmaz A, Cansever T, Cavuşoğlu H, Colak I, Genç HA, et al. Posterior lumbar interbody fusion versus posterolateral fusion with instrumentation in the treatment of low-grade isthmic spondylolisthesis: midterm clinical outcomes. J Neurosurg Spine 2011;14(4):488-496.

17. Rathbone J, Rackham M, Nielsen D, Lee SM, Hing W, Riar S, Scott-Young M. A systematic review of anterior lumbar interbody fusion (ALIF) versus posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), posterolateral lumbar fusion (PLF). Eur Spine J 2023;32(6):1911-1926.

18. Abou-Madawi AM, Ali SH, Abdelmonem AM. Local Autograft Versus Iliac Crest Bone Graft PSF-Augmented TLIF in Low-Grade Isthmic and Degenerative Lumbar Spondylolisthesis. Global Spine J 2022;12(1):70-78.

19. Tan JH, Cheong CK, Hey HWD. Titanium (Ti) cages may be superior to polyetheretherketone (PEEK) cages in lumbar interbody fusion: a systematic review and meta-analysis of clinical and radiological outcomes of spinal interbody fusions using Ti versus PEEK cages. Eur Spine J 2021;30(5):1285-1295.

20. Elias WJ, Simmons NE, Kaptain GJ, Chadduck JB, Whitehill R. Complications of posterior lumbar interbody fusion when using a titanium threaded cage device. J Neurosurg 2000;93(Suppl 1):45-52.

21. Kai Y, Oyama M, Morooka M. Posterior lumbar interbody fusion using local facet joint autograft and pedicle screw fixation. Spine (Phila Pa 1976) 2004;29(1):41-46.

22. Rastegar S, Arnoux PJ, Wang X, Aubin CÉ. Biomechanical analysis of segmental lumbar lordosis and risk of cage subsidence with different cage heights and alternative placements in transforaminal lumbar interbody fusion. Comput Methods Biomech Biomed Engin 2020;23(9):456-466.

23. Bach K, Ford J, Foley R, Januszewski J, Murtagh R, Decker S, Uribe JS. Morphometric Analysis of Lumbar Intervertebral Disc Height: An Imaging Study. World Neurosurg 2018:S1878-8750(18)32836-5.

24. Rothrock RJ, McNeill IT, Yaeger K, Oermann EK, Cho SK, Caridi JM. Lumbar Lordosis Correction with Interbody Fusion: Systematic Literature Review and Analysis. World Neurosurg 2018;118:21-31.

25. Yu CH, Wang CT, Chen PQ. Instrumented posterior lumbar interbody fusion in adult spondylolisthesis. Clin Orthop Relat Res 2008;466(12):3034-3043.