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Expandable Versus Static Lumbar Interbody Fusion, Would it Differ?

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Abstract

Background: This study aimed to compare both types of interbody fusion either expandable or static types regarding clinical and radiological changes in anterior disc height (ADH), posterior disc height (PDH), average disc height, foraminal height (FH), segmental lordosis (SL), and lumbar lordosis (LL).

Aim of Study: The primary outcome was detecting which of both types of interbody fusion is superior to the other one. The secondary outcomes included comparison between both types of cages regarding the rate of complications, comparison between both techniques regarding the operative time, patient complaint improvement using the Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI) scoring.

Patients and Methods: This retrospective cohort study enrolled adult patients who underwent single- or multiple-levels lumbar interbody fusion (LIF) between 2022 and 2024. Patients were categorized by the cage type used intraoperatively (static versus expandable). We enrolled 104 patients with lumbar pathology scheduled for posterior spinal fusion surgery with transpedicular screws and interbody fusion. Patients were enrolled into two groups of 60 patients in the static arm and 44 in the expandable arm.

Results: A total of 104 patients were studied (60 static non-expendable group, 44 expandable group). Groups had similar demographic characteristics. There was a significantly higher average ADH in the expandable group compared to the static group (11.3±.8 versus 10.3±.9, p<0.001). There was a significantly higher average FH in the expandable group compared to the static group. In addition, there was a significantly higher average SL in the expandable group compared to the static group (22.6±5.1 versus 19±4.4, p=0.004), and there was a significantly higher average LL in the expandable group compared to the static group (p<0.001).

Conclusions: Patients undergoing LIF using cages of either types show improvements in all the assessed parameters in our study SL, LL, ADH, PDH, and FH together with clinical improvements in the VAS score and the ODI. However, there was evidence of superiority of expandable cages over static types regarding ADH, FH, SL, and LL. With borderline superiority of expandable cages over static cages in blood loss and operative time.

Key Words: *Expandable cage – Lumbar interbody cage – Spine – Static Cage.*

Introduction

LUMBAR lordosis (LL) is one of the spinopelvic parameters which proved to be crucial in determining the patient outcome after spine surgery and it represents an integral component of sagittal balance, and its surgical correction has been shown to be reflected upon thoracic curve and sacral slope **[1]**. Correction of LL has been associated with improvements in both pain and functional outcomes **[2-4]**. Lordotic correction can be achieved by lengthening the anterior column and/or shortening the posterior column. Lumbar interbody fusion (LIF) either the transforaminal (TLIF) lumbar interbody fusion or the posterior LIF are now a very common posterior approaches that have been used to restore sagittal balance and LL **[3,5-8]**. The static intervertebral fusion cage was firstly used by Bagby and Kuslich in the 1990s and has become the device of choice in LIF **[9]**. Expandable cages are some what new devices that are assumed to achieve greater lordosis than static cages by lengthening the anterior column further by opening the cage intradiscally after its insertion inside the disc space. But the few available studies of expandable cages have not compared them to static cages **[10-16]**, have not examined changes in both SL and LL **[12,14,17]**, and have not included the TLIF procedure **[11-14,18]**. In this study,

List of Abbreviations:

ADH : Anterior disc height.
FH : Foraminal height.
LIF : Lumbar interbody fusion.
LL : Lumbar lordosis.
ODI : Oswestry Disability Index.
PDH : Posterior disc height.
SL : Segmental lordosis.
TLIF : Transforaminal lumbar interbody fusion.
VAS : Visual Analog Scale.

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we tested whether segmental lordosis (SL) or LL differ according to whether patients undergoing single-level or multiple levels LIF received a static or expandable cage. Also, we assessed other parameters such foraminal height (FH) plus anterior and posterior disc heights (ADH, PDH). In this concern we assumed that expandable cages would be superior to static cages in improving SL, LL, FH, ADH and PDH.

Patients and Methods

The study was approved by the Research Ethical Committee, Faculty of Medicine, Cairo University, Egypt. The researchers obtained informed written consent from all study participants or their parents. We ensured the confidentiality of all participants' information.

Study design:

We performed a retrospective cohort study. Of which 60 Patients were in the static group and 44 patients were in the expandable group. A total of 104 patients were included in this study.

Patient population:

Patients who underwent single-level or multiple LIF between 2022 and 2024 at a single institution were retrospectively operated by a single surgeon identified through the use of electronic medical records. Eligible patients were ≥18 years of age and had radiographic follow-up at 1 month and 1 year postoperatively.

Surgical technique:

The LIF technique used has been previously described in the literature **[19,20]**. In this technique, a unilateral facetectomy is performed to allow discectomy, endplate preparation, graft placement, and oblique interbody cage insertion. the contralateral facet joint is not directly altered during surgery. Single type of interbody cages was implanted and comprised both static and expandable design from singlecompany. All cage designs involved a straight, bulleted nose and were intended to be implanted obliquely.

Postoperative care:

Following surgery, patients were placed in an ordinary ward to facilitate close monitoring of their overall bodily functions, improve pain control, maintain proper hydration levels, and assess their degree of satisfaction. The catheter was removed 24 hours after insertion, and intravenous fluid administration was discontinued following catheter removal. All patients were permitted to ambulate either on the same evening or the following morning.

Follow-up:

Follow-up was performed at 1 month, and 1 year postoperatively. Both neurologic and radiologic evaluations were performed at each visit.

Results

The study included 104 participants of the 60 participants (57.7%) who were in static groups and 44 (42.3%) in expandable group.

Table (1) shows the sociodemographic characteristics of the studied group. The average age of the participants was 41.4±7.1 years, and nearly half of the participants (51.9%) were male. No statistically significant difference between static and expandable groups regarding age and gender (p=0.593, and 0.674 respectively).

Table (2) shows the comparison of preoperative parameters between groups. The average preoperative Visual Analog Scale (VAS) score was 6.8±1.1, the average preoperative Oswestry Disability Index (ODI) was 60.4±10.5, the average ADH was 8.9±1.1, the average SL was 15.1±4.4, and average and LL was 22.9±5.5. No statistically significant difference between groups regarding pre-VAS score, ODI, ADH, PDH, FH, and SL.

Table (3) shows the comparison of postoperative parameters between groups. There was a significantly higher average ADH in the Expandable group compared to the Static group (11.3±.8 versus 10.3±.9, p=<0.001). There was a significantly higher average FH in the Expandable group compared to the Static group, in addition, there was a significantly higher average SL in the Expandable group compared to the Static group (22.6±5.1 versus 19±4.4, p=0.004), and there was a significantly higher average LL in the Expandable group compared to the Static group (p<0.001).

Table (4) shows the comparison of blood loss and complications between groups. There was higher average blood loss in the static group 195.9±63.1 and the expandable group 174.6±59.7 with borderline significance (p=0.054). most of the participants (78.5%) didn't have complications, no statistically significant difference between groups regarding complications.

Table (5) shows the comparison of preoperative and postoperative parameters in the static group. There was a significant decrease in the average VAS score, and ODI postoperative compared to preoperative (p<0.001), however, there is an increase in ADH, PDH, FH, SL postoperative compared to preoperative (p<0.001) (Fig. 1).

Table (6) shows the comparison between preoperative and postoperative in the Expandable group. There was a significant decrease in the average VAS score, and ODI postoperative compared to preoperative (p<0.001), however, there is an increase in ADH, PDH, FH, SL postoperative compared to preoperative (p<0.001) (Fig. 2).

Table (1): Sociodemographic characteristics among the studied group.

Characteristics	Total (n=104)	Static (n=60)	Expandable (n=44)	*p*-value
Age (years), Mean ± SD	41.4±7.1	40.9±7.7	42.1±6.3	0.593
Gender:				
Female, n (%)	50 (48.1%)	30 (50%)	20 (45.5%)	0.674
Male, n (%)	54 (51.9%)	30 (50%)	24 (54.5%)	

SD: Standard deviation.

Table (2): Comparison of preoperative parameters between groups.

Characteristics	Total (n=104) Mean ± SD	Static (n=60) Mean ± SD	Expandable (n=44) Mean ± SD	*p*-value
Visual Analog Score	6.8±1.1	6.8±1.2	6.7±.973	0.593
Oswestry Disability Index	60.4±10.5	60.3±11.2	60.4±9.6	
Anterior disc height	8.9±1.1	8.9±1.0	8.9±1.2	0.674
Posterior disc height	7.7±1.1	7.8±.9	7.5±1.2	
Foraminal height	10.9±1.1	11.1±1.1	10.8±1.0	
Segmental lumbar lordosis	15.1±4.4	15.4±4.6	14.7±4.3	
Lumbar lordosis	22.9±5.5	23±5.3	22.7±5.8	

SD: Standard deviation.

Table (3): Comparison of postoperative parameters between groups.

Characteristics	Total (n=104) Mean ± SD	Static group (n=60) Mean ± SD	Expandable group (n=44) Mean ± SD	*p*-value	Adjusted *p*-value
Visual Analog Score	1.5±.9	1.6±.9	1.3±.8	0.086	0.602
Oswestry Disability Index	13.3±9.4	14.5±9.8	11.6±8.6	0.142	0.568
Anterior disc height	10.7±1.1	10.3±.9	11.3±.8	<0.001*	<0.001*
Posterior disc height	8.9±.9	8.8±.8	9.2±1.0	0.040*	0.161
Foraminal height	13±1.2	12.6±1.1	13.6±1.1	<0.001*	<0.001*
Segmental lumbar lordosis	20.5±5.0	19±4.4	22.6±5.1	0.001*	0.004*
Lumbar lordosis	33.4±5.7	31.4±5.3	36.1±5.1	<0.001*	<0.001*

SD: Standard deviation. *: Significant at $p<0.05$.

Table (4): Comparison of blood loss and complications between groups.

Characteristics	Total (n=104)	Static (n=60)	Expandable (n=44)	*p*-value
Blood loss, Mean ± SD	186.8±62.3	195.9±63.1	174.6±59.7	0.054
Complication, Mean ± SD:				
No	91 (87.5%)	52 (86.7%)	39 (88.6%)	0.764
Yes	13 (12.5%)	8 (13.3%)	5 (11.4%)	
Type of complications (n=13), n (%):				
Adjacent segment failure	1 (7.7%)	1 (12.5%)	0 (0%)	–
Anterior displacement	1 (7.7%)	1 (12.5%)	0	
Infection and debridement	1 (7.7%)	1 (12.5%)	0 (0%)	
Mild collection	1 (7.7%)	0 (0%)	1 (20%)	
Partial foot drop	1 (7.7%)	0 (0%)	1 (20%)	
Posterior displacement	3 (23.1%)	2 (25%)	1 (20%)	
Revision	2 (15.4%)	2 (25%)	0 (0%)	
Severe sacroiliitis	3 (23.1%)	1 (12.5%)	2 (40%)	

SD: Standard deviation.

Table (5): Comparison of preoperative and postoperative parameters in the static group.

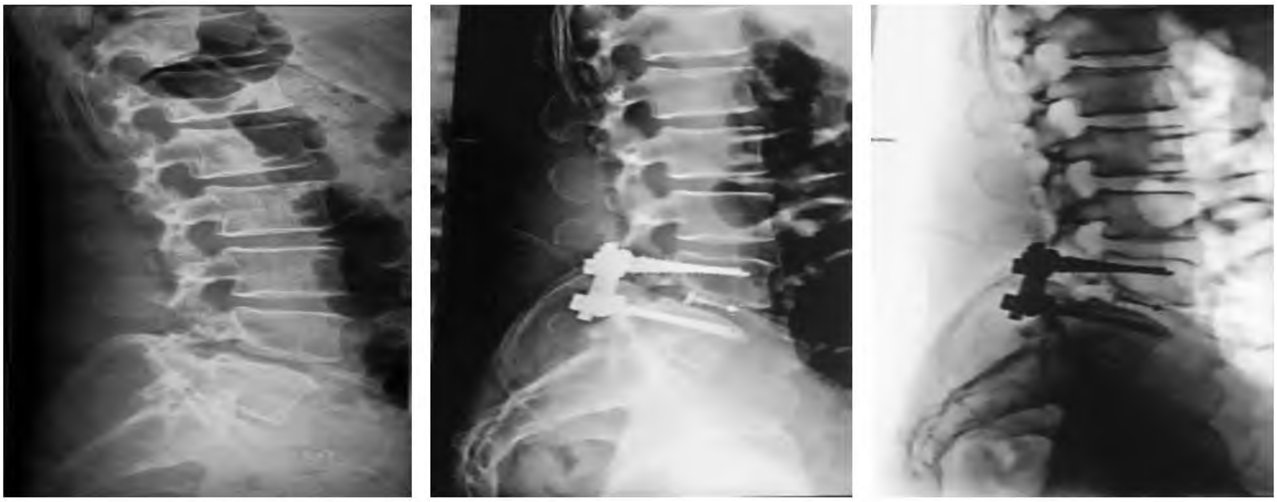
Characteristics	Static group (n=60)			
	Preoperative Mean ± SD	Postoperative Mean ± SD	*p*-value	Adjusted *p*-value
Visual Analog Score	6.8±1.2	1.6±.9	<0.001*	<0.001*
Oswestry Disability Index	60.3±11.2	14.5±9.8	<0.001*	<0.001*
Anterior disc height	8.9±1.0	10.3±.9	<0.001*	<0.001*
Posterior disc height	7.8±.9	8.8±.8	<0.001*	<0.001*
Foraminal height	11.1±1.1	12.6±1.1	<0.001*	<0.001*
Segmental lumbar lordosis	15.4±4.6	19±4.4	<0.001*	<0.001*
Lumbar lordosis	23±5.3	31.4±5.3	<0.001*	<0.001*

SD: Standard deviation. *: Significant at $p<0.05$.

Table (6): Comparison of preoperative and postoperative in the expandable group.

Characteristics	Expandable group (n=44)			
	Preoperative Mean ± SD	Postoperative Mean ± SD	*p*-value	Adjusted *p*-value
Visual Analog Score	6.7±.9	1.3±.8	<0.001*	<0.001*
Oswestry Disability Index	60.4±9.6	11.6±8.6	<0.001*	<0.001*
Anterior disc height	8.9±1.2	11.3±.8	<0.001*	<0.001*
Posterior disc height	7.5±1.2	9.2±1.0	<0.001*	<0.001*
Foraminal height	10.8±1.0	13.6±1.1	<0.001*	<0.001*
Segmental lumbar lordosis	14.7±4.3	22.6±5.1	<0.001*	<0.001*
Lumbar lordosis	22.7±5.8	36.1±5.1	<0.001*	<0.001*

SD: Standard deviation. *: Significant at $p<0.05$.



(A) (B) (C)

Fig. (1): Preoperative X-ray (A), postoperative X-ray 3 months after surgery in which static cage inserted (B), and postoperative X-ray 1 year after surgery (C).

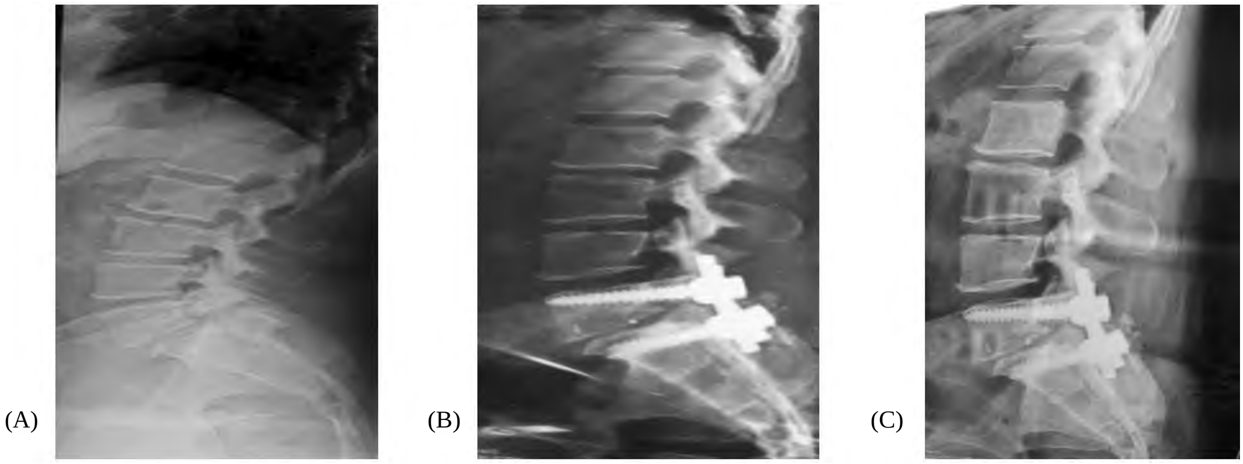


Fig. (2): Preoperative X-ray (A), postoperative X-ray 3 months after surgery in which expandable cage inserted (B), and postoperative X-ray 1 year after surgery (C).

Discussion

In the recent practice there has been increased emphasis for the restoration of lordosis with lumbar fusion, which has been associated with improvements in pain and function especially regarding the load sharing and the incidence of postoperative sacroiliac joint inflammation [2-4]. Many surgeons argue for the usage of the expandable cages and its superiority above the static type of cages. They have been hypothesized to (1) Affect greater lordosis by lengthening the anterior column, and (2) Decrease tissue disruption and neural retraction by offering a more compact size during placement as they are being put in the closed state compared to a static cage of similar final dimensions [18]. Studies examining the effect of expandable cages on lordosis in LIF are seldom. In our study we included a total of 104 patients who were suffering from degenerative spine diseases, who were studied (60 static nonexpendable group, 44 expandable group). Groups had similar demographic characteristics. There was a statistically significantly higher average ADH in the Expandable group compared to the Static group (11.3±.8 versus 10.3±.9, $p<0.001$). There was a statistically significantly higher average FH in the Expandable group compared to the Static group, in addition, there was a statistically significantly higher average SL in the Expandable group compared to the Static group (22.6±5.1 versus 19±4.4, $p=0.004$), and there was a statistically significantly higher average LL in the Expandable group compared to the Static group ($p<0.001$).

While Alimi et al. [10] retrospectively studied-Forty-nine patients who underwent LIF with implantation of expandable polyaryl-ether-ether-ketone cages and posterior instrumentation were included. They assessed the clinical outcome using the VAS and the ODI. Radiographic parameters including disk height, FH, listhesis, local disk angle of the index level/levels, regional LL, and graft subsidence were measured preoperatively, postoperatively, and at latest follow-up. Studied 49 patients with lumbar degenerative disease who underwent TLIF with expandable polyaryl-ether-ether-ketone cages. SL and LL were measured preoperatively, immediately postoperatively, and at last follow-up (average 19.3 months). There was no comparison to a static cage group. Furthermore, the cohort was non homogenous, consisting of both single-level minimally invasive TLIFs as well as open revision multilevel TLIFs.

While in Yee et al. [21], they performed a retrospective cohort study of patients who were ≥18 yearsold and underwent single-level TLIF between 2011 and 2014. Patients were categorized bycage type (static vs expandable). Primary outcome of interest was change in SL and LL frompreoperative values to those at 1 month and 1 year postoperatively. A total of 89 patients were studied (48 nonexpendable group, 41 expandable group). Groups had similar baseline characteristics. For SL, median improvement was 3° for nonexpendable and 2° for expandable at 1 month postoperatively, and 3° for nonexpendable and 1° for expandable at 1 year postoperatively. For LL, the median improvement was 1° for nonexpendable and 2° for expandable cages and 2° for nonexpendable and 5° for expandable at 1 year postoperatively. After excluding parallel expandable cages, there was still no difference in SL or LL improvement at 1 month or 1 year postoperatively between static and expandable cages. So, they concluded that patients undergoing single-level TLIF experienced similar improvements in SL and LL regardless of whether nonexpendable or expandable cages were placed.

Limitations:

The limitations of our study include its retrospective, nonrandomized design. We did attempt to mitigate selection bias via multivariate linear regression, which included validated summarymetrics of comorbidities such as the ASA and ACCI scores. While we included both minimally invasive and open TLIFs, these were all single-level procedures, and it was not a predictor of outcome in multivariate analysis. There was also the possibility of observer bias, as the individuals performing the angle measurements were not blinded to cage type. Finally, the diminished 1-year follow-up is another potential source of selection bias; however, univariateanalysis did not reveal any significant differences between these static and expandable cage groups in 1 year.

While in Crawford et al. [22], their cohort consisted of 417 patients with a mean age of 62. Static cages were used in 306 patients and expandable cages in 111. Expandable cages were associated with increased changes in disc height relative to static cages at 2 weeks (1.1mm [0.2–1.9]; p=0.01) and 6 months (1.2mm [0.2–2.3]; p=0.02) following surgery, but differences were no longer significant at 1 year (0.4mm [−0.9–1.8]; p=0.4). Expandable cages were found to subside more commonly than static cages (14.1% vs. 6.6%; p=0.04). No significant differences between cage types were identified in lordotic parameters at any timepoint (p=0.25 to p=0.97). So, the concluded that expandable cages were associated with an initial increase in disc height relative to static cages, but this difference diminished with the first year of surgery, likely due to a higher rate of subsidence within the expandable cohort.

Conclusion:

Patients undergoing LIF using cages of either types show improvements in all the assessed parameters in our study SL, LL, ADH, PDH and FH together with clinical improvements in the VAS Score and the ODI. However, there was evidence of superiority of Expandable cages over static types regarding ADH, FH, SL and LL. With borderline superiority of expandable cages over static cages in blood loss and operative time.

Declarations:

- *Ethics approval and consent to participate:* The study was approved by the Research Ethical Committee, Faculty of Medicine, Cairo University, Egypt. The researchers obtained informed written consent from all study participants or their parents.
- *Consent for publication:* Not applicable.
- *Availability of data and material:* The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- *Competing interests:* The authors declare that they have no competing interests.

- *Funding:* None.

- *Authors' contributions:* HM, MG, and MEhave full access to all the data in the study and take responsibility for the integrity of the data. Study concept and design: HM; acquisition of data: HM, MG, and ME; analysis of data: HM, MG, and ME; drafting of the manuscript: MG and ME; critical revision of the manuscript: HM. All authors have read and approved the final manuscript.

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الاقفاص الكربونية المتمددة بالمقارنة بالأقفاص الكربونية الساكنة : هل هناك فارق؟

إن استخدام الاقفاص الكربونية بين الفقرات القطنية يستخدم من فترة ليست بالقليلة. وقد أحدث تغييرات كبيرة فى نتائج جراحات العمود الفقرى من حيث التحام الفقرات ببعضها بعد عمليات تثبيت العمود الفقرى.

ويهدف البحث الى المقارنة بين نوعين من الاقفاص الكربونية أحدهما الساكنة والأخرى المتمددة فى النتائج الاكلينيكية وكذلك التغييرات التى تظهر على الاشاعات اثناء فترات المتابعة.

تم ادراج نحو ١٠٤ حالة فى هذا البحث. ٦٠حالة منهم تم تركيب القفص الكربونى الساكن و٤٤ حالة منهم تم تركيب القفص المتمدد.

كانت النتائج تفيد بأن كلا المجموعتين شهدت تحسنا من الناحية الاكلينيكية مع تفوق المجموعة التى تم تركيب قفص كربونى متمدد فى قياسات الارتفاع الأمامى للغضروف كما شهدت تفوقها أيضا فـn ارتفاع قناة مخرج العصب بشكل ملحوظ.

كذلك تفوقت المجموعة التى تم تركيب قفص متمدد بها من حيث التقعر القطنى الكلى والجزئى على المجموعة التى تم تركيب قفص كربونى ساكن.

ومن ثم فانه فى كلتا المجموعتين حدث تحسن في كل القياسات وكذلك من الناحية الاكلينيكية، ولكن كان التحسن ملحوظ بشكل افضل فى المجموعة التى تم تركيب الاقفاص الكربونية المتمددة فيها.

كان التفوق نسبى للمجموعة ذات الاقفاص المتمددة من حيث وقت الجراحة والدم المفقود اثناء اجراء الجراحة.