Original Article

Fusion rate in Extreme Lateral Interbody Fusion (XLIF) using Different Bone Grafting Materials: A Retrospective Study

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Background: There are no reports of the fusion rates of iliac crest bone graft combined with other bone extenders in Extreme Lateral Interbody Fusion (XLIF) surgery.

Objective: To investigate the fusion rates of different bone grafting materials and their combinations in patients who underwent XLIF surgery.

Materials and Methods: This retrospective study included patients who underwent XLIF at Siriraj Hospital (Bangkok, Thailand) during the 2015 to 2018 study period. Demographic, clinical, surgical, and radiographic data were collected, recorded, and analyzed. Bone graft fusion was defined as either bone graft bridging in interbody cage on CT scan, or <5 degrees of movement on lateral flexion-extension radiographs.

Results: Fifty-six patients (total 71 levels of spinal fusion) were included. Iliac crest bone graft (ICBG) was used in 11 levels; recombinant human bone morphogenetic protein type 2 (rhBMP-2) was used in 37 levels; and, iliac crest bone graft with bone extenders [either β-tricalcium phosphate (β-TCP) or demineralized bone matrix (DBM)] was used in 23 levels. These 4 bone grafting material groups were evaluated for fusion status by plain radiography on lumbar spine flexion and extension or on computer tomography scan at the 1-year follow-up. The fusion rate was 100%, 97.3%, 94.4%, and 80.0% in the ICBG group, the rhBMP-2 group, the ICBG+β-TCP group, and the ICBG+DBM group, respectively. However, no statistically significant difference was observed among the 4 evaluated bone grafting materials.

Conclusion: ICBG with β-TCP can be used in XLIF surgery with a result similar to that found in ICBG and rhBMP-2. ICBG with β-TCP grafting is lower cost compared to ICBG and rhBMP-2, and has lower donor site morbidity due to less harvested bone graft compared to ICBG alone. The results of this study confirmed XLIF surgery to be a technique with a high fusion rate (95.8%).

Keywords: Extreme lateral interbody fusion, Fusion rate, Bone graft substitutions, Bone morphologic protein type 2

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Lumbar spinal fusion is a common procedure that is performed in a variety of diseases of the spine, and that can be performed using a variety of surgical approaches[1,2]. Compared to spinal fusion performed by open surgical method, Extreme Lateral Interbody Fusion (XLIF®) is less invasive, has significantly less intra-operative blood loss, and results in less postoperative pain. XLIF technique also facilitates avoidance of complications associated with the posterior approach, such as muscular damage, nerve root injury, and dural sac manipulation[3,4].

The success of spine fusion surgery often depends on successful bony fusion. Iliac crest bone graft (ICBG) is considered the gold standard bone graft for spinal fusion procedure; however, ICBG was reported to be associated with donor site morbidity[5]. Bone graft extenders, such as demineralized bone matrix (DBM) and tricalcium phosphate (β-TCP), were found to be helpful for increasing bone graft volume and promoting solid fusion mass[6]. Recombinant human bone morphogenetic protein type 2 (rhBMP-2) is gaining popularity as a substitute for ICBG with high fusion rates and highly favourable clinical outcomes. However, the use of rhBMP-2 is prohibitively expensive in resource limited settings like Thailand[7,8].

The aim of the present study was to determine the fusion rates of patients treated with ICBG, rhBMP-2, or ICBG combined with DBM or β-TCP in XLIF surgery.

Materials and Methods

This retrospective study included patients who underwent XLIF at the Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Bangkok, Thailand

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during the 2015 to 2018 study period. Patients with degenerative lumbar spondylolisthesis or lumbar spinal stenosis that were treated with XLIF surgery and that had complete pre-operative and postoperative radiography of the lumbar spine were enrolled. Each included patient underwent lumbar interbody fusion by lateral approach between L2-5 (XLIF®; NuVasive, Inc., San Diego, CA, USA) with supplemental posterior instrumentation (percutaneous pedicular screws). A single orthopedic surgeon operated on all patients. After enrollment, each patient's medical history was reviewed, and demographic data, surgical history, and radiographic finding (including plain radiography and computed tomography) were recorded and analyzed. The present study was reviewed and approved by the Siriraj Institutional Review Board (SIRB) (COA No. Si 410/2018). The requirement to obtain written informed consent was waived due to the retrospective, anonymous nature of the present study.

Surgical techniques

Under general anesthesia, patients were positioned left lateral decubitus on a radiolucent table. Antero-posterior and lateral radiography views were arranged by the surgeon using fluoroscopy until excellent images of the lumbar vertebral spine were achieved. The patient was then prepped and draped in the routine sterile manner. Standard XLIF procedure, which was previously described, was performed via the mini-open lateral approach[9]. All patient intervertebral disc spaces were inserted with a 10-degree lordotic intervertebral polyetheretherketone (PEEK) cage (CoRoent®; NuVasive, Inc., San Diego, USA). Interbody PEEK cages were filled with ICBG, rhBMP-2 (Infuse®; Medtronic Inc., Memphis, TN. USA), ICBG plus β-TCP (AttraX®; NuVasive), or ICBG plus DBM (Grafton®; Medtronic). Patients were then turned to prone position on the radiolucent table and supplemental posterior fixation was applied with percutaneous pedicle screws (either Apollo System; Orthopeasia Co., Ltd., Samut Prakan, Thailand, or Spherx PPS system; NuVasive). Patients were able to ambulate postoperatively, and they were discharged according to standard protocol after spine surgery.

Radiographic measurements

Dynamic lateral flexion and extension radiographs or CT scan of the lumbar spine after 1-year of follow-up were collected for evaluation by at least two spine surgeons at our center. All radiographic parameters were measured using an image viewer computer system (Sectra IDS7 version 15.1.28.6; Sectra AB., Linkoping, Sweden). Successful bony fusion was defined as a difference in Cobb angle between the flexion and extension views of less than 5 degrees[10-12] (Figure 1), or as the presence of bone bridging interbody trabecular bone in the coronal and sagittal views of CT scan[13,14] (Figure 2).

Data analysis

StatView for Windows version 5 (SAS Institute, Inc., Cary, NC, USA) was used to perform all statistical analyses. Categorical data are presented as number and

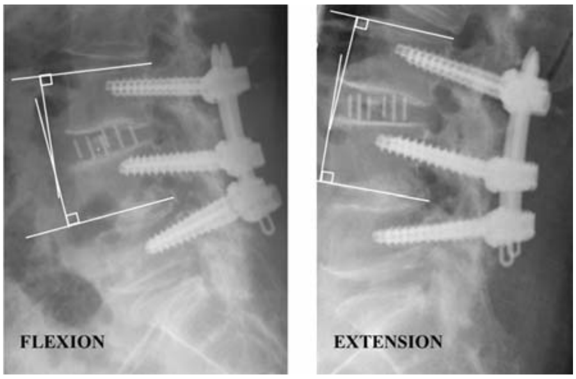

Figure 1. Radiographic images with lines drawn to measure the Cobb angle in flexion and extension of the lumbar spine. All of measurements were performed using a Sectra IDS7 image viewer computer system.

Figure 2. Computed tomography scan of the lumbar spine after Extreme Lateral Interbody Fusion (XLIF) surgery demonstrated the presence of bone bridging at the interbody between L4 and L5.

percentage, and continuous data are expressed as mean±standard deviation and range. Chi-square test was used to compare the fusion rates among the 4 evaluated bone graft materials. A p-value less than 0.05 was considered to be statistically significant.

Results

A total of 56 patients (total 71 levels of spinal fusion) were enrolled in the present study. The mean age of patients was 62.06±9.45 years (range: 41 to 81), and 67.9% were female. The most commonly treated segment was L4-5. ICBG was used in 11 levels; rhBMP-2 was used in 37 levels; ICBG with β-TCP was used in 18 levels; and ICBG with DBM was used in 5 levels. Demographic data, operative level, number of levels, and types of graft material are shown in Table 1. The 4 bone grafting material groups were evaluated for fusion status by plain radiography on lumbar spine flexion and extension or on computer tomography scan at the 1-year follow-up. The fusion rate was 100%, 97.3%, 94.4%, and 80.0% in the ICBG group, the rhBMP-2 group, the ICBG + β-TCP group, and the ICBG + DBM group, respectively. However, no statistically significant difference was observed among the 4 evaluated bone grafting materials ($p = 0.916$) (Table 2). No significant difference in fusion rate was observed between genders ($p = 0.751$). Non-fusion was found only in L4-5 segments (data not shown).

Table 1. Demographic data and operative details

Parameters	n = 56
Age (yrs), mean ± SD (range)	62.06±9.45 (41 to 81)
Gender, n (%)	
Male	18 (32.1)
Female	38 (67.9)
Level of surgery (n = 71), n (%)	
L2 to 3	7 (9.9)
L3 to 4	17 (23.9)
L4 to 5	47 (66.2)
Levels per operation (n = 56), n (%)	
One level	42 (75.0)
Two levels	12 (21.4)
Three levels	2 (3.6)
Type of graft material in PEEK, n (%)	
ICBG	11 (15.5)
rhBMP-2	37 (52.1)
ICBG + DBM	5 (7.0)
ICBG + β-TCP	18 (25.4)

L = lumbar; PEEK = polyetheretherketone; ICBG = iliac crest bone graft; rhBMP-2 = recombinant human bone morphogenetic protein type 2; DBM = demineralized bone matrix; β-TCP = β-tricalcium phosphate

Table 2. Fusion rate compared among evaluated graft materials at the 1-year postoperative follow-up

	Fusion	No fusion	% of fusion	*p*-value
ICBG (n = 11)	11	0	100	0.916
rhBMP-2 (n = 37)	36	1	97.3	
ICBG plus DBM (n = 5)	4	1	80.0	
ICBG plus β-TCP (n = 18)	17	1	94.4	
Total (n = 71)	68	3	95.8	

Discussion

Previously published studies in the fusion rate among different graft materials in the XLIF procedure focused on ICBG alone, rhBMP-2 alone, or β-TCP alone. Berjano, et al (2015) reported 75% fusion in the ICBG group compared to 89% among patients who used calcium triphosphate, and 83% among patients who used β-TCP (AttraX®)[15]. Recently, Parker, et al (2017) reported a fusion rate of 96% in the rhBMP-2 group compared to 80% in the β-TCP group (AttraX®)[16]. Similar to two previous studies, we found a high rate of spine fusion when using combination ICBG and rhBMP-2. This may be explained by the fact that rhBMP-2 is an osteoinductive substance that promotes bone healing. rhBMP was approved by the FDA for used in anterior lumbar spine fusion[17], for use when autograft was not available or the procedure was not desired. The use of rhBMP-2 in anterior lumbar fusion was a net cost-saving treatment from a societal perspective in Germany, France, and the UK[17,18]. Surprisingly, the authors found a 100% fusion rate in the ICBG group, which was in stark contrast to the 75% fusion rate reported by Berjano, et al. Therefore, the authors hypothesized that the combination of ICBG and bone extender should have a higher rate of fusion than bone extender alone.

Our result showed that ICBG plus β-TCP had a higher fusion rate (94.4%) than the previously reported 80% fusion rate when β-TCP was used alone[16]. Combination ICBG and β-TCP is lower cost compared to combination ICBG and rhBMP-2, and it has lower donor site morbidity due to less harvested bone graft compared to ICBG alone.

Demineralized bone matrix (DBM) is an acid extraction product of cadaver bone that was first described in 1965. Kim, et al (2016) reported similar fusion rates between DBM and autologous bone grafts as a bone void filler in lumbar interbody fusion[19]. Another study found that autologous bone grafts showed significantly greater bone growth compared to DBM on both coronal and sagittal images[20]. In the present study, the authors found inferior result from DBM combined with crest bone graft. However, this finding must be interpreted cautiously since only a small number of patients (n = 5) received this combination. The one case of non-union in this group yielded a 20% non-union rate, which may not reflect the true performance of this combination.

The limitations of the present study include its retrospective design and the relatively small number of included patients, especially in the ICBG plus DBM group. Further studies are needed to investigate association between the fusion rate and clinical improvement. The strengths of the present study include the 12-months postoperative follow-up, and the fact that all procedures were performed by the same surgeon.

Conclusion

ICBG with β-TCP can be used in XLIF surgery with a result similar to that found in ICBG and rhBMP-2. ICBG with β-TCP grafting is lower cost compared to ICBG and rhBMP-2, and has lower donor site morbidity due to less harvested bone graft compared to ICBG alone. The results of the present study confirmed XLIF surgery to be a technique with a high fusion rate (95.8%).

What is already known on this topic?

In XLIF surgery, the fusion rate for ICBG alone, rhBMP-2 alone, and β-TCP was previously reported to be 75%, 96%, and 80%, respectively. High fusion rate was achieved only when using rhBMP-2 (96%). To our knowledge, there are no reports on the fusion rates from ICBG combined with other bone extenders.

What this study adds?

β-TCP combined with ICBG showed a 94.4% fusion rate in XLIF surgery. This is the first study to report the fusion rate in this graft material combination (ICBG plus β-TCP) in XLIF.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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