Eur Spine J (2015) 24 (Suppl 3):S369–S371
DOI 10.1007/s00586-015-3929-7

ORIGINAL ARTICLE

Fusion rate following extreme lateral lumbar interbody fusion

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Received: 28 March 2015 / Revised: 3 April 2015 / Accepted: 3 April 2015 / Published online: 17 April 2015

Abstract
Introduction Lumbar fusion has been found to be a clinically effective procedure in adult patients. The lateral transpsoas approach allows for direct visualization of the intervertebral space, significant support of the vertebral anterior column, while avoiding the complications associated with the posterior procedures. The aim of this study is to determine the fusion rate of inter body fusion using computed tomography in patients treated by extreme lateral intersomatic fusion (XLIF) technique.
Materials and methods All patients intervened by XLIF procedure between 2009 and 2013 by a single operating team at a single institution were recruited for this study. A clinical evaluation and a CT scan of the involved spinal segments were then performed with at least 1-year follow-up following the standard clinical practice in the center.
Results A total of 77 patients met inclusion criteria, of which 53 were available for review with a mean follow-up of 34.5 (12–62) months. A total of 68 (87.1 %) of the 78 operated levels were considered as completely fused, 8 (10.2 %) were considered as stable, probably fused, and 2 (2.6 %) of the operated levels were diagnosed as pseudarthrosis. When stratified by type of graft material complete fusion was obtained in 75 % of patients in which autograft was used to fill the cages, compared to 89 % of patients in which calcium triphosphate was used, and 83 % of patients in which Attrax™ was used.
Discussion Reports of XLIF fusion rate in the literature vary from 85 to 93 % at 1-year follow-up. Fusion rate in our series corroborates data from previous publications. The results of this series confirm that anterior inter body fusion by means of XLIF approach is a technique that achieves high fusion rate and satisfactory clinical outcomes.

Keywords Anterior interbody fusion · Fusion rate · XLIF · DLIF · LLIF · Transpsoas · Minimally invasive spine surgery

Introduction

Lumbar fusion has been found to be a clinically effective procedure in adult patients with prolonged and invalidating symptoms due to degenerative spine disease, instability, spondylolisthesis and deformity. Conventional approaches, such as posterior fusion, or interbody fusions by posterior approach, have demonstrated variable fusion rates. In addition, biomechanical studies have corroborated that 80 % of weight is carried through the anterior spine, making posterior interbody fusion less favorable [1]. Less invasive approaches and instrumentation have been developed to decrease surgical morbidity and increase the biomechanical stability of anterior interbody fusion. The lateral, transpsoas interbody fusion procedure allows for direct visualization and access of the intervertebral space with low intraoperative blood loss, while avoiding the complications associated with the posterior procedures, which include muscular damage, nerve root complications, and dural sac manipulation [2–5].

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The aim of this study is to estimate the lateral transpsoas fusion rate using computed tomography. In addition, a clinical evaluation was performed to calculate the correlation between the final clinical status of the patient and the fusion status on CT.

Materials and methods

All patients included in the study signed an informed consent prior to being included in the study database. The subjects included in the study were all the patients undergoing anterior interbody fusion from 2009 to 2013 by lateral transpsoas access with triggered-EMG dilator technique and XLIF cages (Coroent-Nuvasive®, San Diego, CA, USA) filled with graft material (autologous bone, calcium triphosphate, Attrax™ or Nanostim), with or without posterior instrumentation, and with at least 1-year follow-up. A single surgical team operated on all patients. Patients with less than 12 months of follow-up or with severe disease that prevented compliance with the follow-up protocol were excluded from the study. The patients' clinical and radiological evaluation for this study follows a standard clinical protocol for degenerative spine disease published in our institution.

At the time of the last follow-up visit a comparative objective physical exam was carried out as well as a subjective evaluation including Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) for back and leg pain. The radiological study includes standard standing X-ray anteroposterior and lateral views and a CT scan with coronal and sagittal reconstructions limited to the operated segment, following the standard postoperative follow-up in our institution.

The main outcome measured was fusion rate. For each cage, fusion was considered as complete when a bone bridge was present in the interbody space connecting the lower endplate of the cranial vertebra with the upper endplate of the caudal vertebra. The fusion status was considered stable, probably fused when partial radiolucency was observed at only one interface of the graft-endplate contact but no bone resorption was present around the cage or screws. Pseudarthrosis was claimed when no graft material was visible in the cage, complete radiolucency was seen at both interfaces, or when radiolucency was observed in one interface with additional bone resorption surrounding the cage or the screws.

Secondary outcome was clinical status, measured by means of ODI and back and leg pain VAS.

Continuous variables following normal distribution were compared with student's *t* test for independent or paired (as appropriate) samples. Categorical variables were compared with the Chi-squared test.

Results

77 patients met the inclusion criteria. Of these, 53 (69 %) were evaluated at the end of follow-up. Twenty-four patients were lost to follow-up (31 %). In two cases patients were lost to follow-up due to death non-related to the surgery (oncologic disease). Twenty-two patients were not contactable. The baseline characteristics of the study population are shown in Table 1.

Following our fusion criteria 68 (87.1 %) of the 78 operated levels were considered as completely fused, 8 (10.2 %) as stable, probably fused and 2 (2.6 %) of the operated levels as pseudarthrosis.

Calcium triphosphate was used for 54 levels, Attrax™ (Nuvasive Inc., San Diego, CA, USA) in 18, autologous bone (laminar morzelised graft) in four, and Nanostim™ (Medtronic, Memphis, TN, USA) in two cases. When stratified by type of graft material, patients reached 75 % fusion with autograft, 89 % with calcium triphosphate, 83 % with Attrax™, and 100 % with other materials. The differences in fusion rate by graft material (Attrax™ vs. calcium triphosphate) were not statistically significant (Chi square 0.042, *p* value 0.837). Comparisons with autologous bone or Nanostim were not possible due to small numbers.

Clinical results stratified by the fusion status are presented in Table 2. Specific analysis of the pseudarthrosis group was not possible due to small numbers, and thus this category has been grouped for analysis with the probably fused.

Table 1 Baseline characteristics of the population

Number of patients	53
Age	64 (20–89)
Length of follow-up (months)	34.5 (12–62)
Number of fused levels per patient	1.52 (1–4)
Diagnosis	
Degenerative disc disease	23 (43.4 %)
Scoliosis	8 (15 %)
Sagittal imbalance	7 (13.2 %)
Stenosis	8 (15 %)
Spondylolisthesis	2 (3.7 %)
Revision	4 (7.5 %)
Other	1 (1.8 %)
Type of graft	
Calcium triphosphate granules	35 (66.2 %)
Autologous bone	4 (7.5 %)
Attrax™	13 (24.5 %)
Nanostim™	1 (1.8 %)
Supplemental fixation	
Anterior plate	3 (5.6 %)
Bilateral pedicle screws	39 (73.5 %)
Unilateral pedicle screws	10 (18.8 %)
Translaminar facet screws	1 (1.8 %)

Table 2 Comparison of clinical outcomes by fusion status

	Fused Mean (SD)	Probably or not fused Mean (SD)	*p* value
ODI	19.0 (17.3)	25.2 (16.2)	0.29
VAS leg	2.3 (2.2)	3.0 (2.0)	0.34
VAS back	2.2 (2.6)	2.7 (2.4)	0.55

Discussion

Few studies have established XLIF fusion rate by means of CT study. Rodgers et al. [6] report 93.2 % fusion at the time of follow-up (mean 17.3 months), with a reduction after 12 months of VAS for back pain from 8.2 ± 1.2 to 4.8 ± 3.1, VAS for leg pain from 7.9 ± 2.0 to 3.7 ± 3.1, and an ODI of 50.9 ± 15.2 % to 33.1 ± 19.6 %.

Malhalm reports fusion rate based on coronal views of 46 % at 6 months, 58 % at 9 months and 85 % at 12 months. There was an improvement of back pain with a reduction of VAS from 6.9 to 2.9 and leg pain from 6.6 to 2.9 (in patients with leg pain), and a reduction of ODI from 56.9 preoperatively to 33.5 at the last follow-up [7].

Criteria for fusion are based on the classifications for anterior interbody fusion proposed by various authors, although these are generally specific to allograft-based fusion. In 1995, Bridwell et al. [8] defined the grades of anterior and posterior fusion based on computed tomography in a study with allograft fusion.

Choudhri and Tan, however, recommend fine-cut computed tomography as a more sensitive means to evaluate interbody arthrodesis and proposed a classification with four grades of fusion, being grade I and II considered as successful fusion and grades III and IV as pseudarthrosis [9, 10].

The fusion rate at last follow-up in our series lies within the range reported in the literature, although unified criteria for fusion evaluation specific to anterior intersomatic fusion is yet to be established. No statistically significant differences were found between the different types of graft used to fill the cages, with all types of graft providing high levels of fusion. Surprisingly, the apparent fusion rate with autologous bone is the lowest in the series (compared to bone substitutes). This finding cannot be considered as reflecting a true difference in favor of bone substitutes. Small numbers (4 cases) with the use of autologous bone made that only one case of nonunion accounts for a 25 % nonunion rate that does not probably reflect the reality. In fact, the differences are not statistically significant. Clinically, there was no statistically significant difference in the subjective scale results between patients declared fused and patients with incomplete fusion or pseudarthrosis. Interestingly, though autologous bone and BMP were not extensively utilized in this study (at all BMP), the fusion rate observed was high and comparable to other studies in the literature.

These limits of this study include the small sample size, although this is compensated by the homogenous treatment received with single technique carried out by a single surgical team in the same institution. The other significant limit is the loss to follow-up (31 %), which could be a significant source of bias that we were not able to overcome with our study design.

The results of this series corroborate that anterior inter body fusion by means of XLIF approach is a technique that achieves high fusion rate and satisfactory clinical outcomes.

Conflict of interest Pedro Berjano and Claudio Lamartina have received honorarium from Nuvasive, DePuy Synthes, Medacta, K2M as lecturers and for surgeon education activities.

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