ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Research Article

Clinical Outcomes of Lumbar Zygapophyseal Joint Fusion Using Hollow Titanium Facet Fusion Cages – Two Year Results

Robert D Labrom[1,2]* and Simon C Gatehouse[1,2]

[1]*The Wesley Hospital, Queensland, Australia*

[2]*University of Queensland, Australia*

***Corresponding Author:** Robert D Labrom, Associate Professor, Queensland Combined Orthopaedic Specialists, Auchenflower, Australia.

Received: May 13, 2017; **Published:** May 19, 2017

Abstract

Purpose: To evaluate the safety profile and fusion rates of hollow titanium lumbar zygophyseal fusion cages compared to traditional posterolateral onlay fusion.

Methods: In a prospective case controlled study, Group 1 consisted of 30 adult patients who received one or two level lumbar spinal zygapophyseal joint fusions using paired hollow titanium facet joint implants with adjunctive pedicle screw and rod fixation using a minimal posterior access technique. Group 2 consisted of 30 adult patients undergoing single level lumbar fusion using the same pedicle screw and rod construct but with traditional posterolateral on-lay autograft technique. Perioperative variables including blood loss and inpatient stay were recorded. Independent radiological comparison was completed for each patient using computerized axial tomography (CT scans) were performed at 12 and 24 months post surgery. End outcomes were compared using ANOVA analysis.

Results: Blood loss (145 mls vs 350 mls) and inpatient stay (3 days vs 6 days) were significantly lower in Group 1 ($p \leq 0.05$). Radiological fusion rates were 100% at 12 and 24 months for Group 1 compared to 89% and 96% respectively for Group 2 ($p = 0.20$) but this was not statistically significant. There were no signs of facet cage failure or loosening at 2 years.

Conclusions: Facet fusion cage insertion is a safe and reproducible technique that results in less patient morbidity through elimination of more extensive paraspinal muscle splitting and through more minimally invasive approaches for the technique.

***Keywords:** Posterior lumbar zygapophyseal joint fusion; facet fusion cages; posterolateral fusion; clinical outcomes*

Introduction

Advances in implants and surgical instrumentation have led to an increase in minimally invasive spine (MIS) surgery. The aim is to minimize soft tissue and muscle disruption by using a safe corridor to the spine with little dissection and retraction. Pedicle screw and rod fixation has dramatically increased posterior union rates using intertransverse process onlay fusion (posterolateral fusion). However, there are several disadvantages with such a technique, which may explain some of the variability in outcomes achieved [1]. Posterolateral fusion techniques require extensive soft tissue dissection and retraction to expose the transverse processes. This leads to increased post-operative scarring [2] with associated pain. Large amounts of graft are required due to the distance between the fusion surfaces, with a risk of migration of graft materials that may cause further neural compression. Frequently allograft or synthetic substitutes have to be employed to provide sufficient graft material volume. Finally, the graft is mobile and of variable quality.

Lumbar facet joint fusion has been well described and utilized in the past [3-5]. Similarly, Lumbar trans-facet joint solid screw placement is also a well reported technique that offers high levels of rotational stability to the lumbar functional spinal unit, yet has technical difficulties in the actual placement of the pair of screws that must cross the plane of the facet joint at a near perpendicular angle [6]. Solid facet screws also do not require a formal attempt at removing cartilage from the joint surfaces to enable the apposition of bleeding bone surfaces, which is the ideal condition for osseous fusion [3]. Lumbar facet fusion offers the advantage of a small gap between the fusion surfaces, which can be easily approached by opening the lateral multifidus compartment, ideal for MIS surgery. Furthermore, the two surfaces are in compression, which is biomechanically and biologically more favorable for fusion to occur.

The advent of the solid, hollow, lumbar interbody spinal fusion cages has also been well recorded and has been proven to offer high rates of anterior column spinal fusion with the advantage of offering a biomechanically superior structural graft block that can be packed with bone, unlike more traditional solid single piece iliac crest blocks which tend to be less strong in compression [7].

Utilizing the historical knowledge of facet joint fusion surgical techniques with the removal of cartilage and interposition of bone, the biomechanical advantage of a solid trans-articular facet screw pair, and the structural and grafting advantages of an anterior interbody fusion cage, we have proposed an implant that allows the best of these concepts to permit a fusion of the lumbar facet joints. It is proposed that the implant and technique can obviate the need for traditional posterolateral bone graft on-lay fusion between the transverse processes and the need for large volumes of bone morphogenic protein or other substitutes in the lumbar posterolateral gutter.

The aim of this study was to assess the radiological union rates and implant failure of a facet fusion cage, compared to the traditional posterolateral fusion.

Materials and Method

A prospective, non-randomized, comparison study was performed with 30 adult patients for one or two level lumbar fusions for degenerate pathologies including discogenic degenerate segmental collapse, associated central and sub-articular stenosis, and degenerate spondylolisthesis. Inclusion criteria were patients 18 - 80 years, symptomatic single or multiple level lumbar degenerative disease confirmed with plain radiography, CT and MRI scans. Patients had failed non-surgical management and all were able to give written informed consent for the procedure. Contraindications included bilateral pars intra-articular is defects or an associated isthmic spondylolisthesis, previous history of surgery or attempted fusion procedure anywhere in the lumbar spine, spine fracture, scoliosis, or spinal tumor. Patients with fixed sagittal imbalance were also excluded.

This group (Group 1) had lumbar spinal zygapophyseal joint fusion using paired hollow titanium facet joint implants with adjunctive pedicle screw and rod fixation using the standardized minimal access technique as described.

Data was also prospectively collected for 30 consecutive patients (Group 2) who underwent the same minimally invasive single level pedicle and rod instrumentation with posterolateral fusion. The transverse processes where decorticated and autograft (iliac crest) placed in an onlay fashion. A single surgeon (RDL) performed all procedures.

For both groups, demographic data was collected as was intraoperative blood loss and duration of inpatient hospital stay. Radiological assessment of union was made by an independent radiologist and spinal surgeon who were not associated with the index procedure by using Computed Tomography (CT) Scans taken at 12 and 24 months. Assessment for a positive fusion required direct evidence of a visible confluence of bone through the cage to each side of the articular processes of the facet joint [8].

Sample size was chosen based upon statistical power requirements and a minimum size to make a cautious study of this new implant. ANOVA testing was used in the statistical assessment of fusion rates between the two groups as well as intra-operative blood loss and length of hospital stay. Significance was defined as $p \leq 0.05$.

The Standardized Technique

The facet fusion cage material was titanium alloy (TiAl6V4) with an aluminum oxide blasted roughened external surface. This macro-texture allows bony on-growth and a "bone spot wielding" effect that has been proven with this surface treatment in other orthopaedic implants. The cages were tapered and were available in variable sizes, though all cages used in this study had a proximal core diameter of 11 mm and distal core diameter of 10mm, with a height of 11 mm. The wall thickness was 1.5 mm and a series of complete and incomplete circumferential reverse barbs existed around the external surface of the cage which acted as an anchor effect when the cage was pushed into the milled hole in the facet joint (Figure 1). Large open cage wall fenestrations were present to permit bone through-growth between the vascularized walls of the milled facet fusion hole. The implant had a solid cupped base that acts as a well like barrier for retention of bone marrow fluid and alike, so that ectopic bone formation is less likely. Moreover, the retention of the usually thickened anterior portion of the facet joint capsule acts as a further barrier to spillage of osteogenic fluid onto the underlying nerve root.

Figure 1: *Close up of solid facet fusion cages and end cutting high-speed burr.*

This surgical technique in all patients was performed by a single surgeon (RDL). Patients had a general anaesthetic, prone positioning and a minimally invasive surgical approach to either one or two spinal levels in the lumbar spine. This involved the adjunctive use of pedicle screws (7 mm diameter) and rods (5.5 mm diameter) over one or two levels. Fluoroscopic confirmation of screw placement was employed. All patients had a concomitant wide central or limited hemi-laminectomy to address issues of central or sub-articular recess neural stenosis.

Milling of each facet joint pair was performed using a cylindrical end-cutting burr bit with a diameter of 10.06 mm (Anspach®, Palm Beach Gardens, FL) using a high speed pneumatic drill (Figure 1). Irrigation and suction was essential during this process to avoid bone thermo-necrosis. Most trajectories approximated an angle that passed across the plane of the joint in a perpendicular direction more medial to lateral, away from the central neural canal (Figure 2). Minimally invasive techniques were used for screw placement and milling of the facet joints (Figure 3).

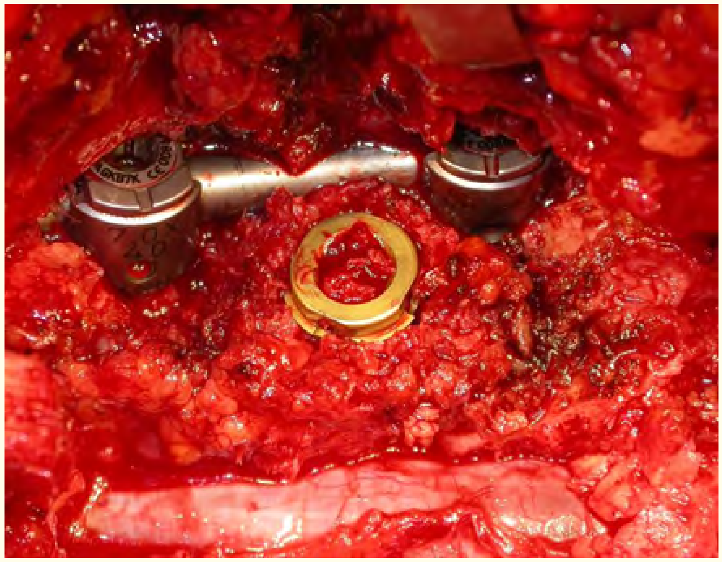

Figure 2: *Facet fusion cage in situ at L4/5 – note packed with autograft and wide central laminectomy.*

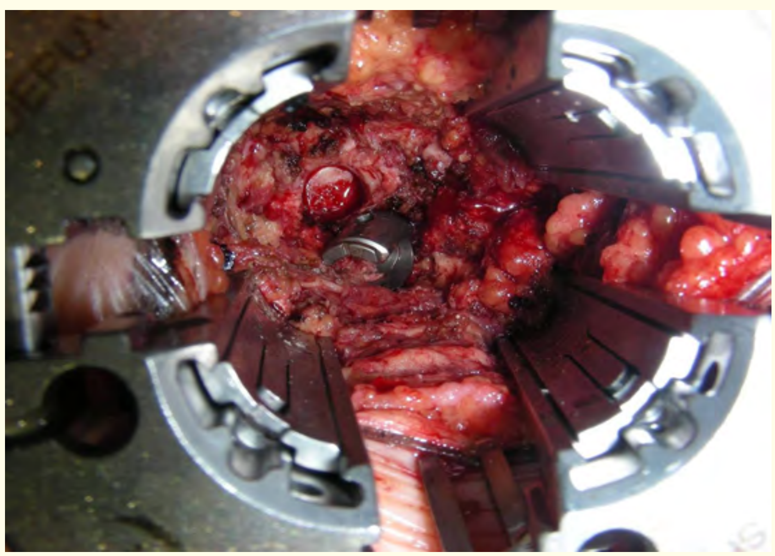

Figure 3: *Minimally invasive technique. Note milled facet hole, medial to pedicle screw head.*

In all cases, the facet fusion cages were packed with autograft taken either from local laminectomy bone or from a minimally invasive iliac crest core. An insertional tool was used to place the distal end of the cage into the milled hole. A final seating tamp tool was used to drive the facet cage into the hole such that the reverse barbs at three levels around the exterior of the cage became engaged with the bleeding, vascularized, bony walls of the milled facet joint hole (Figure 4).

Figure 4: *Facet fusion cage packed with bone graft before insertion.*

The final addition of titanium rods and locking of the screw heads was completed. The wounds were closed in a standard fashion and patients were mobilized early. No patient had a posterolateral on-lay bone graft fusion or interbody fusion technique applied at the same time as the facet fusion. No corset or brace was used.

Results

The demographics of both groups were similar. These are summarized in Table 1. All patients in Group 2 underwent single level fusion, whereas 27 patients in Group 1 underwent single level fusion. 3 patients in Group 1 had a two level fusion. In both groups, L4/5 was the commonest operated level. No fracturing of the facet joint articular processes was noted at the time of high speed milling or upon insertion of the facet joint fusion cages.

	Group 1 – Facet Fusion	Group 2 – Posterolateral Fusion	Statistical Analysis (ANOVA)
Number of Patients	30	30	
Age	69 (32 - 79) Years	67 (33-78) Years	
Gender F:M	18:12	16:14	
Single Level Fusion	27 patients	30 patients	
Double Level Fusion	3 patients	0 patients	
Blood Loss	145 ml (60 - 450)	350 ml (120 - 660)	$p \leq 0.05$
Mean Inpatient Stay	3 days	6 days	$p \leq 0.05$
Fusion at 12 months	100%	89%	$p = 0.20$
Fusion at 24 months	100%	96%	$p = 0.20$

Table 1: *Summary of patient demographics and results.*

Blood loss was significantly lower in the facet fusion group compared to the posterolateral group (145 mls vs 350 mls). This was statistically significant ($p \leq 0.05$). The inpatient hospital stay was also lower in Group 1 (3 days vs 6 days) and again this was statistically significant ($p \leq 0.05$).

CT analysis was performed at 12 and 24 months to assess facet and posterolateral fusion. Radiological fusion was found in all patients at 12 and 24 months in Group 1 with no signs of bone-facet cage or screw-bone interface loosening (Figures 5-7). The radiological fusion rate in Group 2 was 89% at 12 months and 96% at 24 months. This difference between the two groups was not statistically significant ($p = 0.20$).

Figure 5: *Sagittal CT scan of L5/S1 at 24 months showing solid trans-osseous fusion and no signs of screw loosening.*

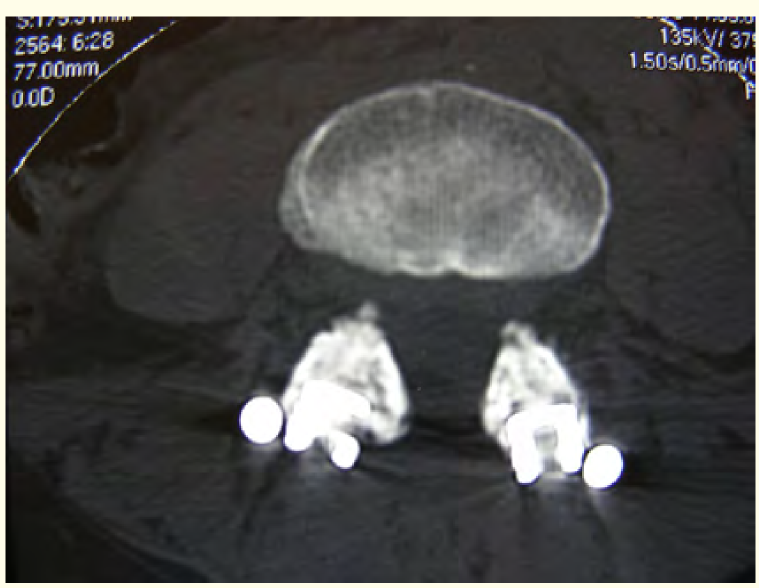

Figure 6: *Axial CT scan of L4/5 facet joint pair at 24 months showing solid facet arthrodesis.*

Figure 7: *Post-operative AP radiograph at 24 months showing solid facet fusion and no signs of screw loosening.*

Discussion

Posterior spinal fusion in the lumbar spine has received varied reports with regards to fusion rates and the degree of morbidity that is associated with deep paraspinal muscle stripping to permit inter-transverse process on-lay grafting. The harvesting of iliac crest grafting also adds a degree of morbidity which may be better addressed in the future with the advent of osteogenic materials such as bone morphogenic protein, albeit with a likely significant increase to health budgets.

Our results confirm that facet joint fusion with a cage provides fusion results that are comparable to the traditional posterolateral fusion technique. The results do suggest that fusion is achieved sooner with facet cages, but the results were not statistically significant.

The facet fusion cage utilizes the best features of biological bony fusion conditions. The technique involved removal of bone and cartilage via a cylindrical milled hole across the facet joint, and interposition of a load sharing structural cage device that bears load in compression, and permits insertion of graft material of the surgeon's choice. The safe and reproducible milling technique of the lumbar facet joint is made possible with a 10.06 mm end cutting high speed burr and the trajectory of the hole milled varies between a parallel and a perpendicular angle across the plane of the facet joint. The resultant hole with bleeding bony walls serves as an ideal environment for the incorporation of bone graft through the inserted facet fusion cage. The macro-textured external surface of the facet fusion cage permits bone on-growth to create a "bony spot weld" effect around the cage.

This novel method of facet joint fusion is proposed to obviate the need for posterolateral on-lay autograft inter-transverse process fusion, particularly in cases where a MIS technique is being utilized. Our data demonstrates higher blood loss and double the inpatient stay suggesting a slower recovery time after a more extensive soft tissue dissection following posterolateral fusion.

Addition of a graft material to the facet fusion cage is possible and can be at the discretion of the surgeon. Advantages of using local bone or small quantities of iliac crest autograft have been demonstrated in this clinical series with fusion noted in all cases. The additional usage of newer osteogenic materials may also be possible and it is likely that smaller volumes than are currently being suggested for posterolateral on-lay fusion would only be necessary permitting significant cost saving.

The technique and implantation of facet fusion cages may lend to further advances and the need for further study with regards to alternative adjunctive fixation devices such as down-sized pedicle screw and rods, and even the use of alternative fixation devices such as interspinous process tethering devices, such as an interspinous plate.

Limitations of the study include there being only one implanting surgeon which raises issues with reproducibility and bias, yet it offers a standardized surgical technique for comparison in this study. In this study patients were not randomized due to practical reasons, which possibly introduces selection bias. Other limitations include the sample size, though statistical powering of the study had been considered and achieved. Despite these limitations, the conclusions drawn from this prospective case-control study remain clinically valid and statistically significant.

Conclusions

We have reported the clinical results of the comparison of two clinical methods used to achieve posterior lumbar spinal fusion using concomitant conventional pedicle screws and rods over either one or two levels. The technique described of adding two facet fusion cages has been trialed using minimally invasive techniques without stripping muscle from the posterolateral spine, which lends to a smaller central midline mini-open surgical approach with less soft tissue disruption and post-operative scarring, less blood loss and shorter hospital stays. Facet cages also lend themselves to lower required graft volume and fusion rates at least comparable, if not better than posterolateral fusion.

Conflict of Interest

Neither author has a financial relationship to declare that relates to this implant study.

Bibliography

1 Kim KT., *et al*. "Clinical outcomes of 3 fusion methods through the posterior approach in the lumbar spine". *Spine* 2031.12 (2006): 1351-1358.

2 Motosuneya T., *et al*. "Postoperative change of the cross-sectional area of back musculature after 5 surgical procedures as assessed by magnetic resonance imaging". *Journal of Spinal Disorders and Techniques* 19.5 (2006): 318-322.

3 McBride ED. "A mortised transfacet bone block for lumbosacral fusion". *Journal of Bone and Joint Surgery (America)* 31.1 (1949): 385-393.

4 Ray CD. "Transfacet decompression with dowel fixation: a new technique for lumbar lateral spinal stenosis". *Acta Neurochirurgica Supplement (Wien)* 43 (1988): 48-54.

5 Stein M., *et al*. "Young Investigator Award. Percutaneous facet joint fusion: preliminary experience". *Journal of Vascular and Interventional Radiology* 4.1 (1993): 69-74.

6 Montesano PX., *et al*. "Translaminar facet joint screws". *Orthopedics* 11.10 (1988): 1393-1397.

7 McAfee PC., *et al*. "The indications for interbody fusion cages in the treatment of spondylolisthesis: analysis of 120 cases". *Spine* 30.6 (2005): S60-S65.

8 Cook SD., *et al*. "Comparison of methods for determining the presence and extent of anterior lumbar interbody fusion". *Spine* 29.10 (2004): 1118-1123.

Volume 6 Issue 4 May 2017