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Outcome of Tantalum Cage in Posterior Lumbar Interbody Fusion in Lumbar Degenerative Disc Disease and Low-grade Spondylolisthesis

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ABSTRACT

Background Data: Posterior lumbar interbody fusion (PLIF) provides better stability and fusion as a surgical treatment for degenerative disc disease (DDD) and spondylolisthesis. Different cage designs are available for interbody fusion. Tantalum cages are recent and appealing options in these techniques.

Purpose: To assess the clinical and radiological outcome of tantalum interbody cage in PLIF without autologous bone graft inside the cage.

Study Design: A retrospective case series study.

Patients and Methods: A total of 25 patients with single-level DDD (n = 16) or spondylolisthesis (n = 9) who underwent single-level PLIF surgeries with 1-year follow-up were recruited for this study. Clinical and functional assessment was done using the visual analogue scale (VAS) for low back pain and Oswestry Disability Index (ODI). Tantalum cage stability and fusion were assessed radiologically on static and dynamic lateral X-ray.

Results: VAS and ODI showed significant postoperative improvement at 6-week and 3-, 6-, and 12-month follow-up intervals. No significant migration or subsidence of tantalum cage was reported on static X-ray, no significant mobility was reported on dynamic X-ray, and the total sound bone fusion rate was 96% at 1-year follow-up.

Conclusion: Our data suggest that PLIF with tantalum interbody cage in lumbar DDD and low-grade spondylolisthesis showed good clinical and functional results in 1-year follow-up with high spinal stability and bone fusion rate (2020ESJ225).

Keywords: Posterior lumbar interbody fusion, Tantalum cage, Degenerative disc disease, Spondylolisthesis, Low back pain

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INTRODUCTION

Posterior lumbar interbody fusion (PLIF) is the standard and frequently used surgical treatment for DDD and spondylolisthesis causing chronic low back pain with or without radicular leg pain. It is indicated in patients not responding to conservative medical treatment. The lumbar interbody cage allows intervertebral height restoration, thus restoring segmental lordosis through adequate interbody fusion and maintained stability.[10]

The interbody cage is considered stable when it remains secured in place between the adjacent vertebral bodies with no migration or subsidence with adequate bony fusion, and this is usually secured by pedicle screw fixation.[7]

Different interbody cages are used like PEEK, titanium, and tantalum.[2,9,12] Tantalum cage is a highly porous interbody metal implant, very similar to cancellous bone, with high friction coefficient providing high stability and transmitting forces and stress to adjacent vertebral bodies bones. This allows bone ingrowth into the cage and strong bony fusion and decreases the stress shielding effect.[4,3] Osseointegration effect of tantalum has been shown in the acetabular revision of hip joint and knee replacement revision.[1,8] Tantalum use has shown significant success in many subspecialties as hip arthroplasty revision.[15] It is a promising metal intervertebral implant for achieving spinal fusion because of its biological characteristics and based on good results of the published clinical studies in the literature.[15]

This work aims to assess the clinical and radiological outcomes of pedicle screw augmented PLIF with tantalum cages in lumbar DDD and low-grade spondylolisthesis.

PATIENTS AND METHODS

A retrospective study was conducted on 25 patients with chronic low back pain and radicular leg pain not responding to medications for at least three months. Seven patients were females and 18 were males with mean age 42.68 ± 16.63 (range, 31–52) years. All data were collected from the neurosurgery department medical records of our university hospital after approval of our hospital ethical committee.

The clinical diagnosis of patients that have been approved with MRI of the lumbosacral spine was single-level lumbar DDD (16 cases) and low-grade spondylolisthesis (9 cases). They underwent 25 single-level PLIF surgeries between January 2018 and May 2019 in our institutional-hospital with a complete 1-year follow-up. Fifteen patients underwent operation for L4-L5, while L5-S1 was operated upon in 10 patients. Double-level surgery, PLIF with other cages, other fusion techniques, incomplete follow-up or data, and general contraindications to surgery were excluded from this study. A total of 25 patients were reported after excluding five patients due to incomplete data and follow-up. All patients routinely consented before the scheduled surgery. A summary of our patients' characteristics is shown in table 1.

Preoperative clinical assessment of all patients included visual analogue scale (VAS) for the low back pain and Oswestry disability index (ODI) for functional clinical outcome.[19,16] Preoperative radiological assessment has been conducted using AP and lateral X-ray flexion and extension dynamic views, MRI, and CT of the lumbosacral spine that revealed either lumbar DDD or low-grade spondylolisthesis.

Surgical Technique

Under general anesthesia, the patient was positioned prone with free abdomen and slightly flexed knees. Through the posterior approach, complete laminectomy and facetectomies were conducted to free the nerve roots and allow adequate space for cage insertion. Complete discectomy was done from both sides, followed by preparing the vertebral endplates using small curettes without violating them. Under fluoroscopic guidance, templates were used to assess the cage height and length. Two cages were inserted between the vertebral bodies (without autologous bone graft inside the

cage) away from the dural sac and the nerve roots shoulders, followed by posterior internal fixation of the vertebral bodies by polyaxial pedicle screws connected on each side by a curved lordotic rod. We used a trabecular metal tantalum cage (Figure 1).

Postoperative clinical assessment was done at 6 weeks and 3, 6, and 12 months after surgery at the outpatient's hospital clinic by the attendant physician. After that, the patients were discharged from the study. Clinical outcome was measured by reporting both back pain VAS and ODI. Perioperative data, such as operative time, blood loss, complications, and hospital stay, were reported. A 5-point subjective outcome scale survey for patients' satisfaction was reported at the last 12-month follow-up (excellent, good, fair, unchanged, and worse), and finally, return to work was subjectively reported.

The postoperative radiological assessment included AP and lateral lumbosacral spine X-ray at each follow-up visit and dynamic X-ray at 1-year follow-up. The following radiological parameters were reported: segmental stability, cage subsidence, and bone fusion. Assessment of the intersegmental mobility in flexion and extension has been conducted, measuring the angle between the adjacent endplates of the overlying and underlying vertebrae.[11] Tantalum cage was found to be stable when the movement of the two adjacent vertebrae at the index level was ≤5° on dynamic lateral X-rays (flexion and extension films) with no radiolucency between the cage and superior or inferior vertebral endplates. This finding was also considered a radiological sign of good bony fusion. Subsidence was considered when significant loss of postoperative disc height (>2 mm) with the migration of the cage within either of the adjacent cortical endplates on lateral X-rays. Minor subsidence with no evident dislocation was regarded as normal.[14]

Statistical Analysis

Clinical and radiological results were analyzed using Student's *t*-test. The significance threshold was set at $p < 0.05$. Analyses were performed by a statistician, using SAS software, 9.2.

RESULTS

A total of 25 patients completed one-year follow-up. The mean operative time was 183 ± 26.19 (range, 150–240) minutes, the mean blood loss was 399 ± 145.79 (range, 250–750) ml, and the mean hospital stay was 2 ± 0.88 (range, 1–4) days. Postoperative VAS and ODI showed highly statistically significant improvement (p value < 0.001) at 6-week and 3-, 6-, and 12-month follow-up compared to preoperative values (Table 2; Figures 2 and 3).

At 1-year follow-up, 23 patients (92%) were satisfied and returned to their original work, while two patients were able to manage their daily routine with mild intermittent axial back pain.

The radiological assessment showed no segmental mobility space around the pedicle screws; no cage misplacement, screw breakage, cage migration, or subsidence was also found. Minor cage subsidence in 2 patients was reported with no significant or symptomatic low back pain. All patients showed no mobility on dynamic X-ray at 1-year follow-up, as shown in follow-up dynamic X-ray (Figures 4 and 5)

Bony fusion rate was 96% as only one patient showed a radiolucent line between the cage and superior vertebral endplate with no significant mobility around the cage or symptomatic low back pain. Two dural tears (8%) were encountered in two patients and were directly sutured with 4-0 Vicryl sutures with a small muscle graft with no postoperative CSF leak. There was no reported infection, neural deficit, postoperative radiculopathy, metal breakage, or pseudoarthrosis.

Table 1. Patients' characteristics (n = 25).

Data	n (%)
Mean age/years	42.68 (31–52)
Gender	
Female	7 (28%)
Male	18 (72%)
Level	
L4-L5	15 (60%)
L5-S1	10 (40%)
BMI (KG/M2)	29.76 (22-40)
Smoker	11 (44%)
Diagnosis	
Degenerative disc disease	16 (64%)
Spondylolistheses grade 1	9 (36%)
Presentation	
Right sciatica	8 (32%)
Left sciatica	12 (48%)
Bilateral sciatica	5 (20%)
Low back pain	25 (100)

Table 2. Clinical outcomes parameters (VAS, ODI) at different postoperative follow-up intervals.

	Preoperative		Postoperative							
			6 weeks		3 months		6 months		12 months	
	DDD	Spondy	DDD	Spondy	DDD	Spondy	DDD	Spondy	DDD	Spondy
N	16	9	16	9	16	9	16	9	16	9
VAS	8.88 ± 0.89	8.89 ± 0.60	3.94 ± 0.85	3.78 ± 0.67	2.56 ± 0.73	2.11 ± 0.33	1.75 ± 0.86	1.44 ± 0.53	1.63 ± 0.81	1.33 ± 0.50
ODI	69 ± 12	71 ± 14	42 ± 13	44 ± 14	36 ± 14	38 ± 14	28 ± 13	29 ± 15	22 ± 14	21 ± 16

N: number; DDD: degenerative disc disease; Spondy: spondylolisthesis.

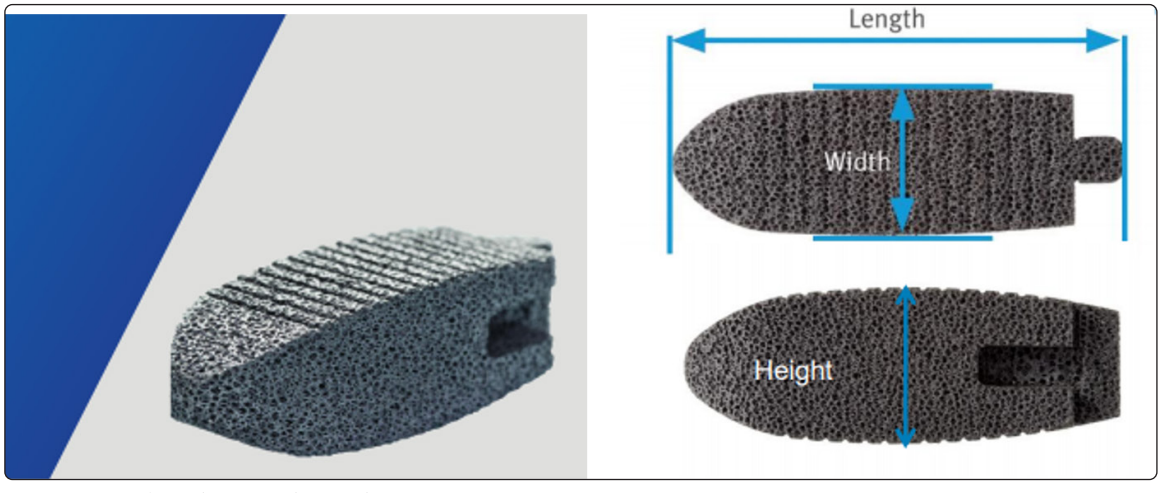

Figure 1. Trabecular metal tantalum cage.

Table 3. Outcomes of other studies using tantalum interbody cage in lumbar spine surgery.

Study/N.	Type of study	Follow-up/ months	Follow-up loss	Procedure/levels N.	Clinical outcomes	Complications	Fusion rate	Subsidence	Revision for nonunion
Cuzzocrea5 2019 (n = 40)	Retrospective	12	None	TLIF with PEEK cage (n = 20) vs. metal (n = 20), titanium (n = 12) or tantalum (n = 8) cage, 1 or 2 levels	Significant improvement; no difference	None	PEEK: 69%; metal: 90%	-	0
Jalalpour[10] 2015 (n = 135)	Prospective, randomized	24	None	TLIF (n = 68) (titanium PF & tantalum interbody spacer with interbody & posterolateral autograft) vs. PLF with autograft (n = 67), 1 or 2 levels	Significant improvement; no difference	Tantalum TLIF: 2 battered nerve roots; 1 bone fragment in canal; 1 superficial wound infection; autograft PLF; 2 dural lesions; 1 bronchial pneumonia; 1 nerve root laceration	TLIF: 87%; PLF: 80%	-	0
Hoy[9] 2013 (n = 100)	Prospective, randomized	24	6	PLF (n = 49) vs. TLIF (n = 51), 1, 2, or 3 levels	Significant improvement; no difference	Neural lesion (0 vs. 1); Dural breach (0 vs. 2); pneumothorax (0 vs. 1); hematoma (2 vs. 1); Infection (0 vs. 2)	PLF: 85.7% TLIF: 86.3%	-	PLF (n = 3); TLIF (n = 1)
Lebhar[11] 2020 (n = 52)	Retrospective	55	3	PLIF (n = 52) 1 level	Significant improvement	Dural breach (n = 2)	94.2%	-	0
Van de Kelft[17] 2015 (n = 80)	Prospective, randomized	24	None	PLIF (n = 40) vs. SA (n = 40), 1 level	Significant improvement; no difference	Dural breach (4 vs. 2); screw revision (1 vs. 0)	PLIF: 92.5% SA: 77.5%	Not present in either group	No data
Lequin[13] 2014 (n = 26)	Retrospective	15.3	None	SA (n = 26), 1 level	Significant improvement	Neural lesion (n = 4); dural breach (n = 2); hematoma (n = 2); infection (n = 1)	96.2%	7.5% ± 11.6%	1
Our study (n = 25)	Retrospective	12	None	PLIF (n = 25), 1 level	Significant improvement	Dural breach (n = 2)	96%	Not present	0

TLIF: transforaminal lumbar interbody fusion; PLIF: posterior lumbar interbody fusion; PSF: pedicle screw fixation; PLF: posterolateral fusion; n: number; vs.: versus.

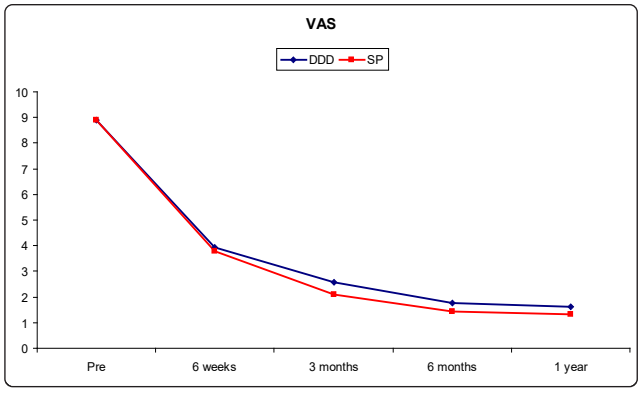

Figure 2. Clinical outcome (VAS) at different postoperative follow-up intervals.

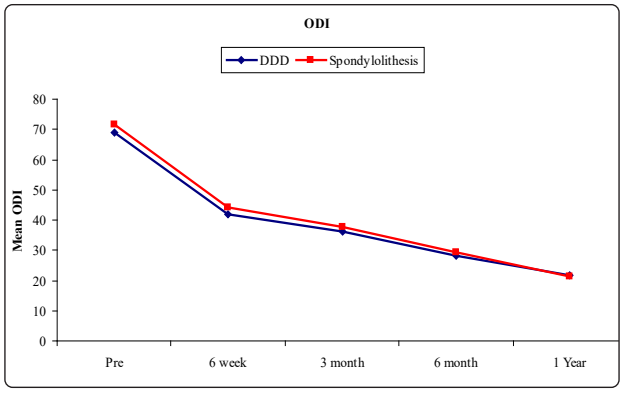

Figure 3. Functional outcome (ODI) at different postoperative follow-up intervals.

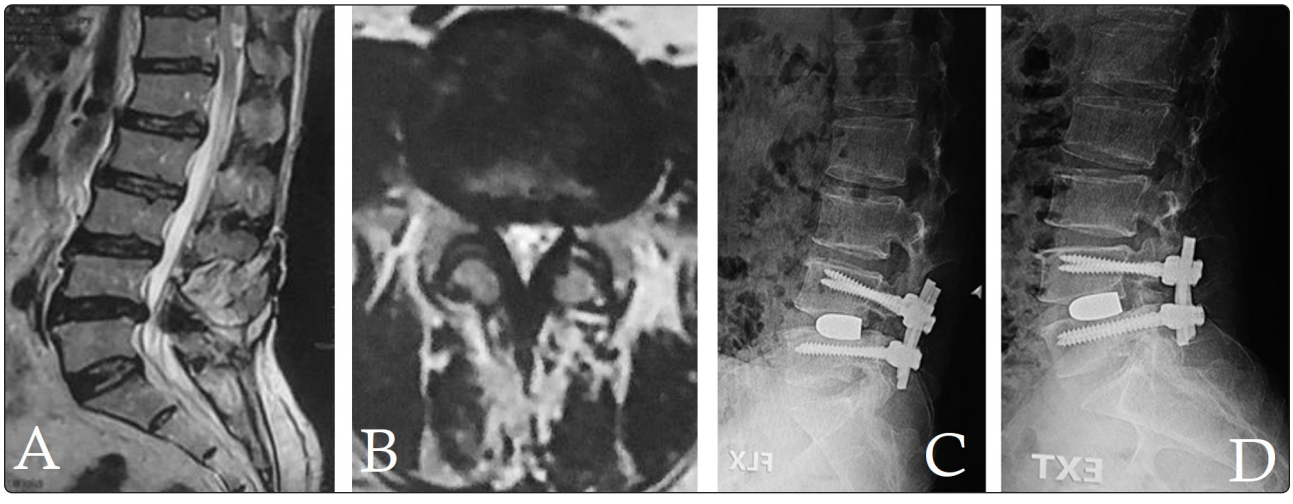

Figure 4. Preoperative MRI LSS (A, B) axial and sagittal images showing L4-L5 lumbar canal stenosis. Lateral plain X-ray in extension (C) and flexion (D) with the calculation of intersegment mobility (28◦ in extension and 27.8◦ in flexion).

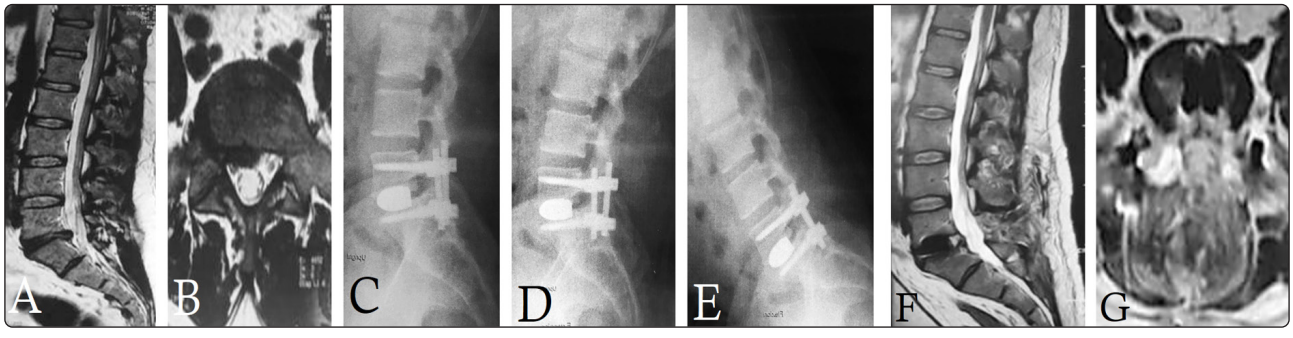

Figure 5. Preoperative MRI LSS (A,B) axial and sagittal images showing L4-L5 degenerated disc, diminished disc height, prolapsed disc, subtle retrolisthesis grade 1, facet hypertrophy, and lateral canal stenosis (partially sacralized L5). (C) Lateral plain X-ray showing L4-L5 interbody 2 PLIF trabecular tantalum cages. (D,E) Lateral plain X-ray in extension (A) and flexion (B) with the calculation of intersegment mobility (16◦ in extension and 15 ◦ in flexion). (F,G) Postoperative MRI LSS showing 2 PLIF trabecular tantalum cages.

DISCUSSION

In this retrospective study, we assessed the clinical and radiological outcomes of tantalum cage in series of 25 patients who underwent single-level PLIF for single-level lumbar DDD or low-grade spondylolisthesis pathology. PLIF with tantalum interbody cage showed satisfactory clinical and radiological outcome at 1-year follow-up. It showed high stability and bone fusion rate and a very low rate of migration or subsidence. There was no need to fill the cage with autologous bone graft due to its osseointegration property. One of its drawbacks is that bone fusion could be assessed only on static and dynamic X-rays rather than other images due to its metal artifacts.

Reviewing the literature revealed six relevant studies that assessed the outcome of tantalum cage in lumbar fusion procedures (Table 3).[5,9,10,11,13,18] Cuzzocrea et al.[5], Jalalpour et al.[10], and Hoy et al.[9] studied transforaminal lumbar interbody fusion (TLIF), while Lebhar et al.[11], Van de Kelft et al.[18], and Lequin et al.[13] studied PLIF. All studies utilizing tantalum cage in lumbar fusion surgery, either TILF or PILF, showed statistically significant improvement of VAS of back pain and ODI at all postoperative follow-up points.[5,9,10,11,13,18] Moreover, our study found highly statistically significant improvement of VAS of back pain and ODI as functional outcome assessment at different postoperative intervals (p value < 0.001).

In their comparative study, Jalalpour et al.[10] reported complications in 2 patients with battered nerve roots, one patient with bone fragment in the canal, and one patient with superficial wound infection in the TILF group with the use of tantalum cage. Hoy et al.[9] found the following complications in the TILF group: one neural injury, two dural breaches, one hematoma, two superficial infections, and one intraoperative pneumothorax treated with drainage.

Lebhar et al.[11] utilized tantalum cage in the PILF approach and reported two dural breaches. Van de Kleft et al.[17] reported four dural tears and one screw revision in the PILF group. Lequin et al.[13] mentioned four neural injuries, two hematomas, two dural tears, and one superficial infection. In our study, we had two patients with dural tear treated with direct suturing with muscle graft with no postoperative CSF leak or pseudomeningocele.

CT assessment of tantalum cage fusion is not applicable because of metal artifacts.[6,14] Radiological assessment of tantalum cage stability and fusion was done on dynamic X-ray flexion and extension films on the last follow-up (1 year after surgery) and showed <5° mobility around tantalum cage in all patients. This was comparable with the results of PLIF studies using tantalum cage.[11,13,18]

Cuzzocrea et al.[5] reported a higher fusion rate (90%) in the metal (titanium or tantalum) than that in the PEEK group (69%) and referred this to high osteointegrative properties of the metal cages and lower incidence of periprosthetic osteolysis, thus giving stable interbody fusion; however, they did not differentiate titanium from tantalum cage. Jalalpour et al.[10] found a similar fusion rate (87%) in the TILF group. Jonathan et al. reported a 94% fusion rate. Van de Kleft et al. and Lequin et al.[13] reported 92.5% (PILF group) and 96% fusion rates, respectively. Our fusion rate was due to the osseointegration effect and high friction coefficient of tantalum cage, which allow high primary stability[4,3] unlike PEEK.[19] Jonathan et al.[11] noticed a low risk of secondary mobilization. Due to being a highly porous cage, it provides a bigger contact surface with the vertebral endplates than between the bone and autologous graft in the center of the PEEK cage. Thus, there was no need in our study to fill tantalum cage with bone autograft

This study has some limitations, including the retrospective study design, the small number of recruited patients for this study, the short period of follow-up, lack of control group, and the lack of postoperative multislice CT scan or MRI due to the metal nature of the tantalum cage to assess the details of bone fusion thoroughly. A randomized

control large sample size with long-term follow-up prospective study is highly recommended.

CONCLUSION

Our data suggest that PLIF with tantalum interbody cage in lumbar DDD and low-grade spondylolisthesis showed good clinical and functional results at 1-year follow-up with high spinal stability and bone fusion rate.

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الملخص العربي

نتيجة قفص التنتالوم في الانصهار الخلفي بين الفقرات القطنية في مرض القرص التنكسي القطني والانزلاق الفقاري منخفض الدرجة

البيانات الخلفية: يوفر الانصهار الخلفي القطني الخلفي (PLIF) استقرارًا واندماجًا أفضل كعلاج جراحي لمرض القرص التنكسي (DDD) والانزلاق الفقاري. تتوفر تصميمات مختلفة للأقفاص للانصهار بين الأجسام. أقفاص التنتالوم هي خيارات حديثة وجذابة في هذه التقنيات.

الغرض: تقييم النتيجة السريرية والإشعاعية للقفص التنتالوم بين الفقرات في PLIF بدون طعم عظمي ذاتي داخل القفص.

تصميم الدراسة: دراسة سلسلة حالة بأثر رجعي.

المرضى والطرق: تم تجنيد ما مجموعه 25 مريضًا لديهم مستوى واحد من DDD (ن = 16) أو انزلاق الفقار (ن = 9) جراحات PLIF ذات مستوى واحد مع متابعة لمدة عام واحد لهذه الدراسة. تم إجراء التقييم السريري والوظيفي باستخدام المقياس التناظري البصري (VAS) لآلام أسفل الظهر ومؤشر الإعاقة ODI) Oswestry). تم تقييم ثبات وانصهار قفص التنتالوم إشعاعيًا على الأشعة السينية الجانبية الثابتة والديناميكية.

النتائج: أظهر VAS و ODI تحسنًا ملحوظًا بعد الجراحة في فترات متابعة 6 أسابيع و 3 و 6 و 12 شهرًا. لم يتم الإبلاغ عن هجرة أو هبوط معنوي لقفص التنتالوم على الأشعة السينية الثابتة ، ولم يتم الإبلاغ عن تنقل كبير على الأشعة السينية الديناميكية ، وكان إجمالي معدل اندماج العظم الصوتي 96 ٪. في متابعة لمدة سنة واحدة.

الخلاصة: تشير بياناتنا إلى أن PLIF مع قفص التنتالوم بين الأجسام في الفقرات القطنية DDD والانزلاق الفقاري منخفض الدرجة أظهر نتائج إكلينيكية ووظيفية جيدة في متابعة لمدة عام واحد مع استقرار عالي في العمود الفقري ومعدل اندماج العظام.