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ORIGINAL ARTICLE

PEEK versus metal cages in posterior lumbar interbody fusion: a clinical and radiological comparative study

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Abstract

Background Low back pain and sciatica represent a common disabling condition with a significant impact on the social, working and economic lives of patients. Transforaminal lumbar interbody fusion (TLIF) is a surgical procedure used in degenerative spine conditions. Several types of cages were used in the TLIF procedure.

Purpose To determine whether there is a difference in terms of symptomatology improvement, return to daily activities and fusion rate between metal cages and polyetheretherketone (PEEK) cages.

Methods We have retrospectively reviewed 40 patients who have undergone TLIF from October 2015 to May 2016. All patients were clinically evaluated with questionnaires and were assessed with CT scan and standing X-ray films of the full-length spine.

Results We found no significant functional differences in the two groups. At 1-year follow-up, osteolysis was present in 50% of cases of the PEEK cages and in 10% cases of the metal cages. The degree of fusion at 1 year was evaluated as complete in 40% cases of the metal cages and 15% cases of the PEEK cages.

Conclusions We have found a better fusion rate and prevalence of fusion in the group treated with metal cages, reflecting the well-known osteoinductive properties of titanium and tantalum.

Keywords TLIF · PEEK · Tantalum · Titanium · Cage

Introduction

Low back pain and sciatica represent a common disabling condition with a significant impact on the social, working and economic lives of patients [1]. Transforaminal lumbar interbody fusion (TLIF) is a surgical procedure used in degenerative spine conditions, such as lumbar stenosis, lysis and spondylolisthesis, and disk herniation. The need to use the cage in addition to posterior arthrodesis has arisen in the last four decades to solve bone graft-related problems such as donor site complications, poor fusion, a collapse of the graft and kyphotization of the motion segment [2]. Several types of cages were used in the TLIF procedure: the first to yield satisfactory results, as demonstrated by a wide range of studies, were the titanium cages.

However, despite their excellent degree of fusion, the higher elastic modulus of titanium cages [3] resulted in some disadvantages: primarily poorer clinical outcomes compared to the morcellized bone but also peri-prosthetic osteolysis leading to implant mobilization and the difficulty in determining the degree of fusion with standard imaging.

For this reason, more and more attention has been given to polyetheretherketone (PEEK) cages, a polymer biomechanically similar to cortical bone with advantages in loads distribution and potential higher fusion rate [4–7].

Despite the fact that several studies have compared the effectiveness of different types of cages in cervical stabilization, only in 2014 Nemoto et al. [8] analyzed the clinical and radiographic outcome of patients, who underwent a TLIF procedure, treated either with titanium cages or PEEK cage. However, despite the fact that the latter showed higher biocompatibility, the data did not prove a superiority of PEEK cages in fusion rate.

This study aims to determine if there is a difference in term of symptomatology improvement, return to daily activities and fusion rate between the two cages.

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Materials and methods

We have conducted an observational retrospective study on medical records of all patients who had undergone TLIF using cages (one or two levels), by the same senior surgeon, from October 2015 to May 2016. A total of 40 patients with a minimum 6-month follow-up were included in this study and all the patients with spinal deformities, previous operation on lumbar spine and an age greater than 70 years were excluded. Of those 40 patients, twenty were treated using a PEEK cage (group A), while a metal cage was used in the remaining twenty patients (group B). Of those twenty metal cages, 12 were made of titanium and eight tantalum.

All patients were clinically evaluated using the Visual Analog Scale (VAS), the Oswestry Low Back Pain Disability Questionnaire and were assessed with CT scan and standing X-ray films of the full-length spine.

They presented with chronic low back pain (LBP) and irradiated lower extremity symptoms after an unsuccessful conservative therapy, covering at least 6 months.

Patients were evaluated preoperatively (T0) and at 1(T1), 3(T2), 6(T3) and 12(T4) months after surgery using standardized clinical questionnaires (Oswestry Disability Index—ODI, Visual-Analogue-Scale for low back pain—VAS LBP and leg pain—VAS LEG, and EQ-VAS).

The radiological analysis was carried out with the execution of standing X-ray films of full-length spine at 3 months and CT scan at 6 and 12 months.

For the evaluation of the fusion rate on CT images, we used the system described by Christensen [9] with three possible degrees of fusion.

The degree of osteolysis was evaluated on CT images with the method reported by Knox [10].

Baseline characteristics were expressed as the mean (standard deviation). We examined the distribution of continuous variables through the Kolmorov–Smirnov test. The *t* test was used for normally distributed continuous variables, and the Wilcoxon test was used for continuous variables not normally distributed. A value of $p < 0.05$ was considered statistically significant. Data were statistically analyzed using IBM SPSS Statistics for Windows (Version 22.0; IBM, Armonk, NY, USA).

Surgical technique

Surgery is performed under general anesthesia with a minimally invasive approach and a dedicated retractor. After the pedicle screws are positioned, decompression is performed by laminartrectomy (symptomatic side) and discectomy. TLIF was performed on the side of sciatica, and in the case of recurrent disk herniation, it was performed on the contralateral side. After the cage positioning, the system was compressed.

Walking with full weight bearing was allowed with a low elastic lumbar brace the first day after surgery. The brace was kept in place for the first month, and antithrombotic therapy was prescribed for the first four weeks. From the second month, a gradual recovery of normal daily activities has been granted.

Results

The average follow-up was 12 months (range 6–24). The average age of patients in Group A was 48 years (range 39–57), and there were 11 females and nine males. Group B had an average age of 55 years (range 43–64), and the sample consisted of 12 women and eight men. No significant differences were found in age's distribution ($p = 0.127$).

Twenty patients had a disk herniation, 8 had spondylolisthesis and 12 had lumbar stenosis with disk degeneration, without significant difference of distribution in two group of treatment (Table 1).

The degree of fusion at 1 year in Group A was classified as grade 3 (absent fusion) in 31% of cases, grade 2 (dubious fusion) in 54% of cases and grade 1 (complete fusion) in 15% of cases, thus reaching fusion in 69% of cases. In Group B, a grade 3 of fusion was achieved in 10% of cases, grade 2 in 50% of cases and grade 1 in 40% of cases; therefore, a certain degree of fusion was present in 90% of cases (Fig. 1).

At 1-year follow-up, osteolysis evaluated on CT scan was present in 50% of cases in Group A, while in 10% cases in Group B (Fig. 2).

Evaluation of clinical and functional status in the preoperative phase shows statistically significant differences between the two treatment groups ($p < 0.05$) (Figs. 3, 4).

One month after surgery, there is no statistically significant difference between the two groups in any of the clinical and functional assessment ($p > 0.05$). However, at 3 and 6 months of follow-up, there were significant differences between the two treatment groups in all the scales used ($p < 0.05$), with worse values in Group B, although with a

Table 1 Baseline characteristics

	A—PEEK	B–Metal
N	20	20
Age (y.o.)	48 (range 39–57)	55 (range 43–64)
Sex	9 M/11 F	8 M/12 F
Diagnosis	12 disk herniation 3 spondylolisthesis 5 lumbar stenosis	8 disk herniation 5 spondylolisthesis 7 lumbar stenosis

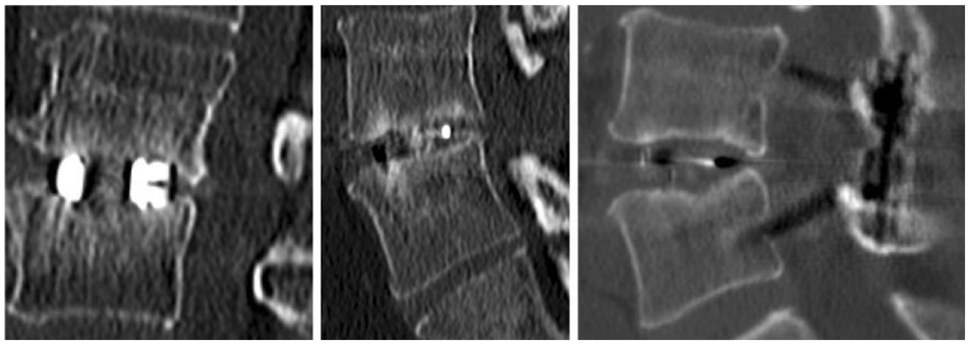

Fig. 1 Fusion rate in CT scan images: **a** grade 1, **b** grade 2 and **c** grade 3

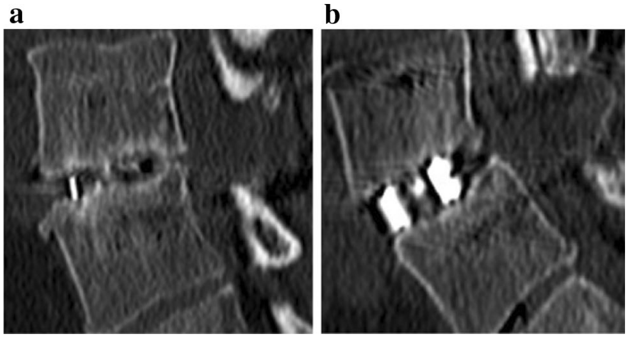

Fig. 2 Peri-prosthetic osteolysis: **a** PEEK and **b** metal

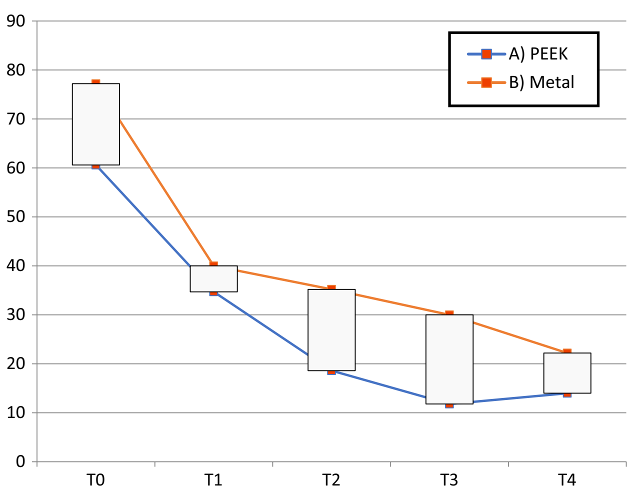

Fig. 3 ODI at T0, T1, T2, and T3

progressive reduction in differences in the 3 months. One year after surgery, we found no statistically significant difference between the groups (Table 2).

Therefore, for each clinical and functional variable, was calculated the difference between the value at the single observational time and the previous one (D1 = T1 − T0, D2 = T2 − T1, D3 = T3 − T2, D4 = T4 − T3) and the difference between the value at single observational time and the preoperative one (DD1 = D1, DD2 = T2 − T0, DD3 = T3 − T0, DD4 = T4 − T0). Statistically significant results ($p < 0.05$) there were in ODI D4 and VAS LBP DD4, with better values in Group B.

Discussion

We found no statistically significant clinical and functional differences in the two groups. Both groups showed scores that can be classified as good and excellent. However, it is worth pointing out the reduction of the score in clinical and functional scales, starting from 6 months after surgery in the PEEK-group. As matter of fact, from the analyzes carried out on the differences D and DD, in which for each subject are neutralized any covariate (characteristics) specific of the subject present since the first observation and which remain stable during the analysis period influencing the comparison between the groups, results are better in group B and partly statistically significant overall at 1 year postoperatively, underlining the best forecast for this group.

But even more noticeable and exciting is the presence of a higher percentage of peri-prosthetic osteolysis and a lower degree of interbody fusion in Group A compared to Group B. In those cases with osteolysis in group A, there was no increase in VAS or ODI. In no case at 1 year, a revision surgery was performed. The aim of the TLIF with cage and posterior instrumentation is to stabilize the affected motion segment and facilitate the fusion process by giving an anterior mechanical support.

The importance of a good spine alignment is underlined also in case of thoracolumbar spine fracture in adults, in which surgical procedure (posterior percutaneous stabilization) produces the best outcome in spine alignment, return to work, and reduction in complications compared to conservative treatment [11]. While in case of osteoporotic compressive fracture is possible to keep a good spine alignment also in conservative management, preventing progression of kyphosis with muscles strengthening. As matter of fact, patients treated with dynamic orthosis had better pain

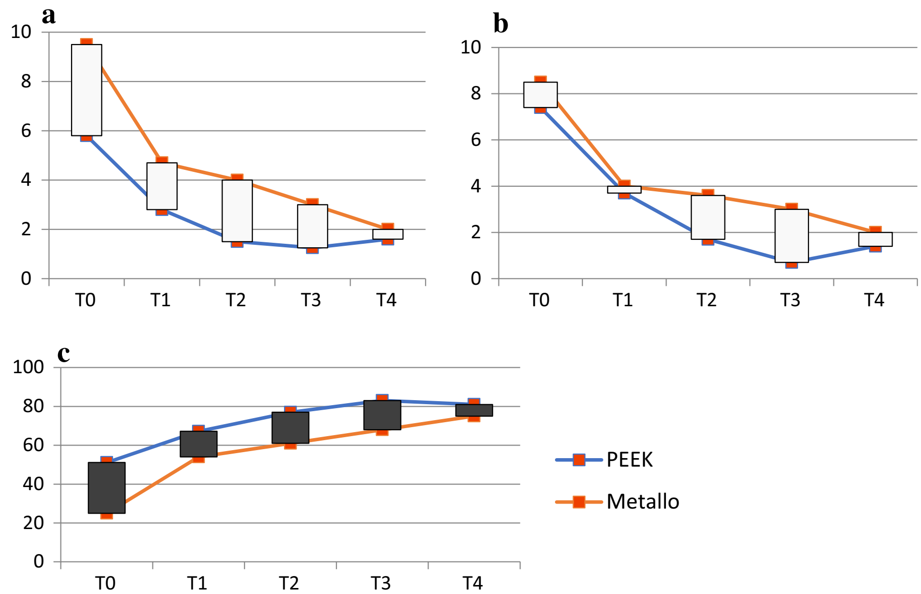

Fig. 4 VAS at T0, T1, T2, and T3: **a** low back pain VAS, **b** leg VAS and **c** EQ-VAS

Table 2 Average change in VAS scores and ODI scores at preoperative and follow-up in both groups

	A—PEEK	B—Metal	*P* value
ODI T0	60.6 ± 21.3	77.2 ± 9.2	0.008
ODI T1	34.7 ± 17.9	40.2 ± 23.0	0.521
ODI T2	18.6 ± 12.6	35.2 ± 22.5	0.052
ODI T3	11.8 ± 11.8	30.4 ± 21.4	0.026
ODI T4	14.1 ± 15.6	22.2 ± 21.0	0.307
VAS LBP T0	5.8 ± 2.9	9.5 ± 1.0	< 0.001
VAS LBP T1	2.8 ± 1.9	4.7 ± 3.5	0.134
VAS LBP T2	1.5 ± 1.4	4.2 ± 2.9	0.020
VAS LBP T3	1.2 ± 1.2	3.0 ± 2.5	0.097
VAS LBP T4	1.6 ± 2.9	2.1 ± 2.6	0.386
VAS LEG T0	7.4 ± 2.2	8.5 ± 3.2	0.031
VAS LEG T1	3.7 ± 2.6	4.0 ± 3.4	0.904
VAS LEG T2	1.7 ± 1.6	3.7 ± 3.0	0.079
VAS LEG T3	0.7 ± 0.9	3.1 ± 2.9	0.028
VAS LEG T4	1.4 ± 1.4	2.2 ± 2.6	0.372
EQ-VAS T0	51.1 ± 26.9	25.0 ± 16.5	0.004
EQ-VAS T1	67.2 ± 22.4	54.0 ± 29.1	0.232
EQ-VAS T2	76.9 ± 18.3	61.0 ± 23.8	0.086
EQ-VAS T3	82.7 ± 18.6	68.0 ± 19.3	0.038
EQ-VAS T4	80.9 ± 23.8	75.5 ± 16.7	0.231

Values are mean ± standard deviation

control and breathe function compared to patients treated with a 3-point orthosis. The so-called biofeedback may be an underlying principle of efficacy of dynamic orthosis [12].

It has always been described that PEEK cages have the advantage of a higher modulus of elasticity, much closer to that of cortical bone than metal [13]. Although recent studies on trabecular metal or porous titanium show much more favorable osseointegration than previous generation metal cages and in some cases with higher results than PEEK cages [14], it should be emphasized that the high fusion rate associated with the use of cages in PEEK in the past years may be related to a poor use of CT scan for the instrumental study, thus making it easier to identify the interbody fusion on plain X-ray studies given the radiolucency of the cages [15]. Indeed, in recent years, other authors have described unfavorable CT scan results in patients treated with interbody fusion with PEEK cages [14, 15]. Different reasons that may explain the low degree of fusion obtained using PEEK cages are to be found in their chemical structure, inert and less osteogenic than materials such as porous titanium [15] and in their prosthetic design [16]. There were no differences in costs between the two groups [17]. The limits of this study are mainly to be found in the retrospective design of the study based on a consecutive series of patients, as well as on the small number of patients enrolled and in the short follow-up.

Conclusion

We have found a better fusion rate and prevalence of fusion in the group treated with metal cages, reflecting the well-known osteointegrative properties of titanium and tantalum. This was resulting in a lower prevalence of peri-prosthetic osteolysis, hence a much more stable interbody fusion. Statistically significative clinical and functional differences were found 1 year after surgery in favor of group treated with titanium/tantalum intersomatic cages.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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