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ORIGINAL ARTICLE

Cement discoplasty for managing lumbar spine pseudarthrosis in elderly patients: a less invasive alternative approach for failed posterior lumbar spine interbody fusion

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Abstract

Purpose A retrospective cohort study was performed to evaluate pseudoarthrosis treatment results by injection of cement in disc space of failed fusion in posterior lumbar interbody fusion in patients above 65 years.

Methods Forty-five patients above 65 years with symptomatic pseudarthrosis after lumbar spine fusion were treated by cement injection in the affected disc space.

Results There were 30 females and 15 males. The mean age at the operation was 74 ± 6.5 years (range 65–89). Discoplasty was performed after the primary fusion operations after a mean of 14 ± 1.3 months (range 12–24). The mean preoperative VAS was 7.5 (range 6–9), and ODI was 36 (range 30–45). Cement injection was done at one level in most of the cases (35 patients). In seven cases, two injection levels were done, and in three cases, three levels. Twenty-three patients had discoplasty only, while 22 had discoplasty and screws change, including 14 cases of extension of the instrumentation. The mean postoperative follow-up was 32 ± 6.5 months. The VAS improved to 3.5 (range 2–5) ($p = 0.02$) and ODI to 12.3 (range 5–35) ($p = 0.001$). Reoperation was indicated in two (4%) patients by screws loosening. Asymptomatic cement leakage occurred in the paravertebral space in seven cases (15.5%).

Conclusion Cement discoplasty offers a less invasive reliable surgical solution in elderly patients with symptomatic lumbar pseudarthrosis in the elderly patients. In cases with screw loosening, discoplasty should be combined with screw revision.

Keywords Cement augmentation · Discoplasty · Pseudoarthrosis · Spine fusion · Elderly

Introduction

Posterior lumbar interbody fusion (PLIF) is one of the most frequently performed operations in spine surgery [1]. There have been rapid improvements in implants and surgical techniques in the last few decades. These improvements increased the fusion rates and improved the lumbar fusions' clinical results [2, 3]. Despite this improvement, failure of fusion is still frequent, with a range between 5 and 35% of the operated patients [1, 4, 5], with the predominance of the lowermost disc spaces.

Many risk factors are associated with failure of fusion after PLIF, including high body mass index (BMI), smoking, diabetes, multiple level fusion, and age of the patients [4, 6]. The clinical results after PLIF are significantly related to the fusion rate [7]. Revision surgery for pseudarthrosis remains costly and complicated. The diagnosis of pseudarthrosis depends on both clinical and radiological signs. Clinically, persistent pain and instability symptoms after spine fusion are indicators of failure of fusion. Radiologically, plain X-ray, or in the equivocal case, a CT scan is used to diagnose pseudarthrosis [7, 8]. Surgical revision for lumbar pseudarthrosis is indicated in patients suffering significant pain and instability symptoms.

Revision can be performed through an anterior, posterior, or a combined anterior and posterior approach. The classical surgical revision is associated with a relatively high rate of complications, especially in elderly patients [1, 7]. In the

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last few years, the injection of bone cement to treat some degenerative lumbar disc disease was introduced. The term discoplasty was used to define the injection of bone cement in the degenerated disc space [9–11].

In this work, we introduce a new application of bone cement injection in the disc space in elderly patients (above 65 years) suffering from symptomatic lumbar spine pseudarthrosis after failed posterior lumbar interbody fusion (PLIF) due to degenerative lumbar spine disease.

Materials and methods

Study design

In a single spine center, the data of the operated patients were prospectively collected. A retrospective analysis of the collected data between January 2011 and December 2017 was performed in this work. In this period, forty-five patients were operated on using cement injection in the lumbar pseudarthrosis after posterior lumbar interbody fusion (PLIF) for a degenerative lumbar spine disease in patients 65 years or older. The data analysis derived from these patients included the indication of surgery, the clinical presentation, the radiological workup, the surgical technique, and the postoperative follow-up to a minimum of 2 years (Table 1).

Inclusion and exclusion criteria

The inclusion criteria in this retrospective analysis were patients 65 years or older, the fusion surgery was primarily for degenerative lumbar spine disease, persistent pain (VAS 5 or more) after posterior lumbar fusion despite conservative treatment for 12 months or longer, radiological pseudarthrosis with the presence of gas in the fusion level (vacuum phenomena). Radiological signs of pseudarthrosis were first, absence of continuous bony trabeculation between adjacent vertebrae; second, a radiolucency around the screws; and third, a radiolucency around the cage. A motion on dynamic films was also considered a non-fusion sign. In all patients, routine preoperative investigations, including the inflammatory markers (CRP and leukocytic counts), were done. With any suspicion of infection using these investigations or imaging, cement was not used. The patient is subsequently not included in the study. Patients with diagnosed spondylodiscitis, spinal canal stenosis in the pseudarthrosis level, or the adjacent levels, and patients with neurological deficits requiring decompression were excluded from this study.

Preoperative diagnosis

Dynamic lumbar spine X-rays in flexion and extension were performed. The lumbar spine CT scan was performed to confirm the pseudarthrosis and evaluate the vacuum phenomena. The radiological assessment was performed by a radiologist from the radiology department in our hospital. Clinically, VAS and ODI were recorded. A neurologist examined all patients preoperatively to evaluate the presence of any neurological deficits. Multi-morbidity was defined as the presence of multiple diseases or conditions, often with a cut-off of two or more [12].

Operative technique

According to the screw loosening observed on both X-rays and CT scans, there were two groups of patients. Patients without a marked screw loosening are managed by percutaneous cement injection in the pseudarthrosis space (Discoplasty). In contrast, patients with a marked screw loosening are managed by re-instrumentation using thicker screws and

Table 1 The clinical and radiological parameters of the studied patients

45 Patients, mean of 74 years old, 30 females and 15 males mean follow-up was 32 ± 18 months				
	Preoperative	Intraoperative	Postoperative	Complications
VAS	7.5 ± 2.2		3.5 ± 2.3 ($p = 0.02$)	
NDI	36 ± 8		12.3 ± 4.8 ($p = 0.001$)	
Number of levels				
Single level		35		
Two levels		7		
Three levels		3		
Level	*Level*	*N*		
	L1/2			
	L2/3	3		
	L3/4	5		
	L4/5	17		
	L5/1	20		

cement augmentation of the vertebral body and discoplasty in the same setting (Table2).

Table 2 Intraoperative and postoperative data

Blood loss	
Discoplasty	30 ml
Discoplasty + screws	350 ml
Operation time	
Discoplasty	50 min
Discoplasty + screws	135 min
Cement augmentation of the end vertebrae	17 patients
Screw revision with extension of the fixation	14 patients
Cement leakage	Seven paravertebral leakages
Reoperations	Two patients due to screw loosening

Under general anaesthesia, the operation was performed in a prone position using two perpendicular X-ray devices. The affected levels were identified. In patients without screw loosening, the affected levels were approached percutaneously.

The disc space access was performed through the pedicle (transpedicular access) or parallel to the superior lateral pedicle edge to avoid the nerve root, which passes through the medial and inferior corner of the superior pedicle (extrapedicular access, like a discography technique).

In the extra-pedicular approach, the needle is inserted under two perpendicular X-ray devices through the Kambin's triangle [13] (Fig. 1).

The extra-pedicular access was suitable except for the L5–S1 level, in which the transpedicular S1 access was performed, with violation of the superior sacral endplate. Both anterior–posterior and lateral images were necessary to identify pedicles and vertebral endplates. For the L5/S1 level, the needle was inserted through the sacrum starting caudally to the screw with the needle directed cranially and

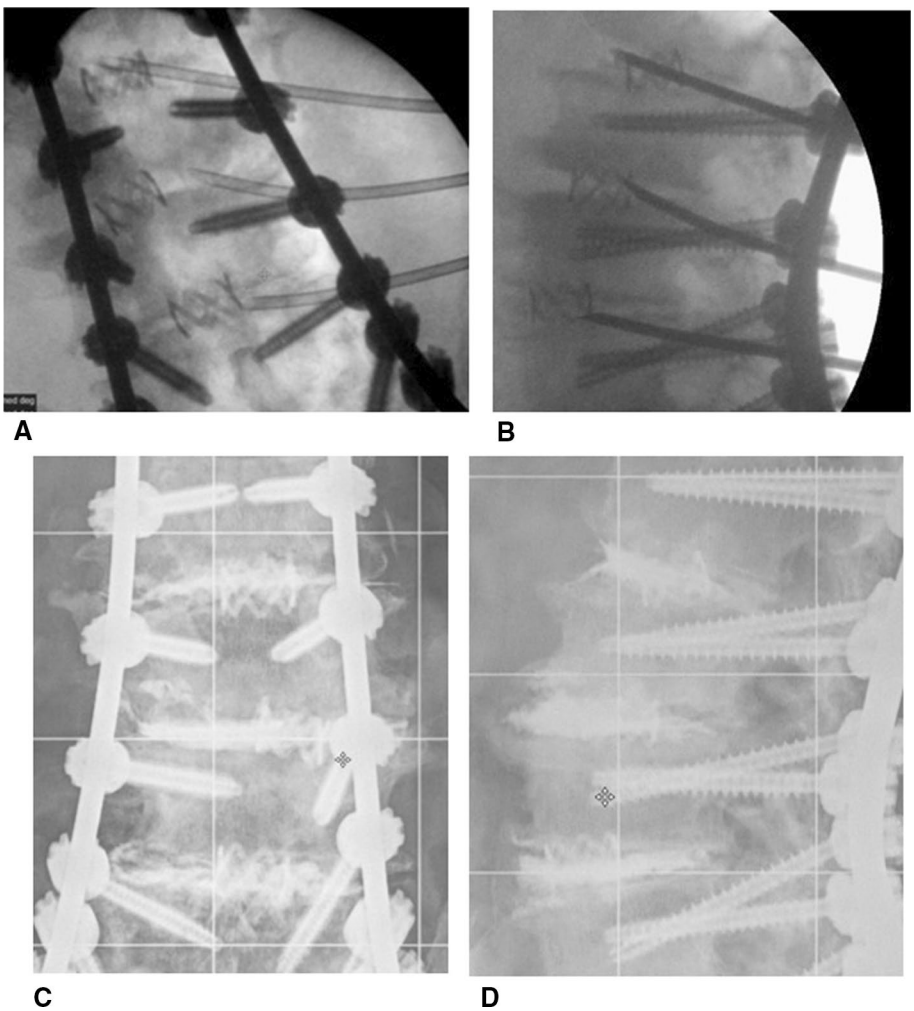

Fig. 1 Intraoperative and postoperative X-rays showing the extra-pedicular approach for the disc space. AP picture with the needle in the disc space (**A**), lateral picture (**B**), postoperative AP X-ray (**C**), and lateral X-ray (**D**)

medially, violating the superior endplate of the S1 vertebra into the disc space (Fig. 2).

In cases with screws loosening, the posterior approach was used for removal of the old screws and replacement using thicker screws with additional cement augmentation of the vertebral bodies. In the same setting, the affected disc spaces were filled with bone cement using the same technique under the guidance of two X-ray devices. The operative time, the blood losses, cement leakage, as well as any intraoperative complications were recorded.

High viscosity cement (VertaPlex HV Bone Cement®) was used in all cases. It is rapidly setting cement. According to the manufacturer, it reaches a thick viscosity as soon as it's mixed and keeps viscosity for an average of 18 min. For delivery, we used Stryker Autoplex® Mixing and delivery system. The amount of cement injection varied considerably depending on the volume of the void, osteoporosis, and type of cage used. The most amount was 7 ml, least amount was 3 ml. The amount was controlled by the intraoperative judgement of the surgeon using a biplanar image intensifier. End points were either good filling on the image or the occurrence of leakage.

Postoperative follow-up

Postoperative X-rays were performed on the first postoperative day. Clinical parameters, including neurological examination, VAS, and ODI, were regularly recorded. Regular postoperative visits for the clinical and radiological evaluations are scheduled after three months, six months, at one year, and yearly. Patients with any postoperative complications or patients requiring any further surgical interventions were analysed, and the data were recorded for the final evaluation.

Statistical analysis

Statistical analyses were performed using SPSS 20.0 software (IBM SPSS statistics software, Chicago, IL, USA). A p value of less than 0.05 was considered significant. The student t test was used for numerical values, and the X^2 test was used to compare the ordinal values.

Results

The study included 45 patients, 30 females and 15 males. The mean age at the operation was 74 ± 6.5 years (range 65–89). Most patients (40) had an ASA score of 3, and five patients were critically ill and had an ASA score of 4. All patients had at least one associated chronic medical disease; DM in 30 patients, high blood pressure in 27 patients, renal impairment in 18 patients, liver function impairment in 12 patients, and six patients had a history of malignant tumour therapy. Thirty-eight patients were multi-morbid.

L5/S1 was the most affected level in 20 cases, followed by L4/5 in 17 cases. Most patients had a fusion in two or

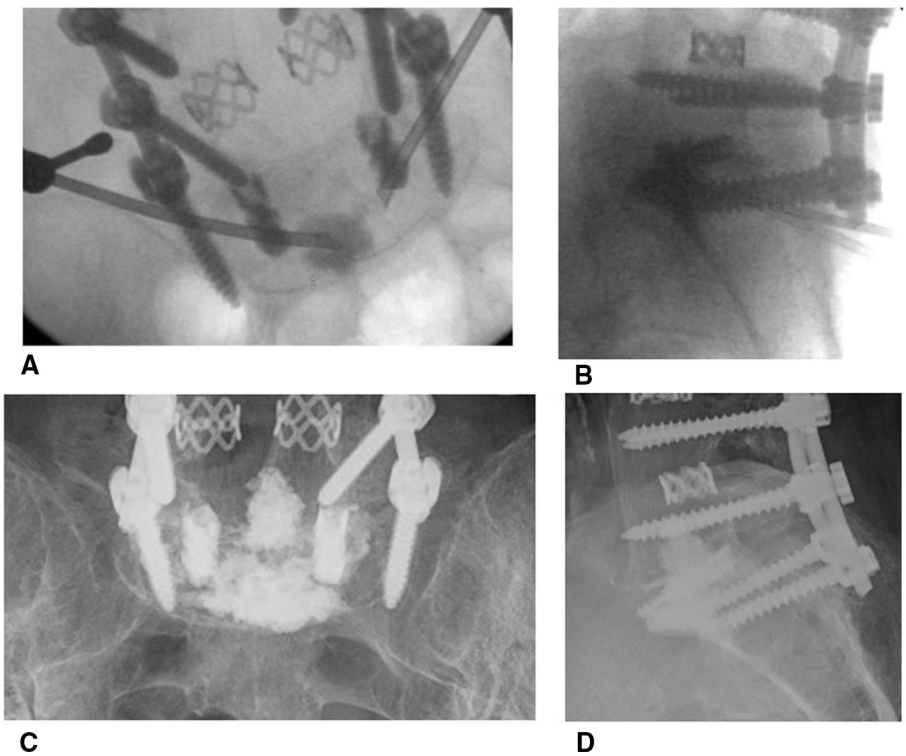

Fig. 2 Needle placement in the L5/S1 level with caudal entry point and direction cranio-medial to cross the endplate of s1 into the disc space. AP intra-operative view (**A**), lateral view (**B**), postoperative AP X-ray (**C**), and lateral X-ray (**D**)

more levels (36). Nine patients had a single-level fusion. Hypermobility was observed in 29 patients of the cohort.

The mean preoperative VAS was 7.5 ± 2.2 (range 6–9), and ODI was 36 ± 8 (range 30–45). Discoplasty was performed after the primary fusion operations after a mean of 14 ± 1.3 months (range 12–24).

The mean operative time was 50 min ± 43, and the mean blood loss was 30 ml ± 15 in cases managed by discoplasty alone, and a mean operative time of 135 min ± 35 and a mean blood loss of 350 ml ± 150 in cases of combined discoplasty and screw fixation. Additional percutaneous cement augmentation of the adjacent vertebrae was applied in 17 patients. Cement injection was done at one level in most of the cases (35 patients) (Fig. 3) In seven cases, two injection levels were done, and in three cases, three levels. Cement leakage occurred in the paravertebral space in seven cases (15.5%). This leakage was asymptomatic, and there was no need for revisions. Twenty-three patients had discoplasty only, while 22 had discoplasty and screws change. This second group included 14 (31%) cases with the extension of the instrumentation due to the loosening of the distal screws (Fig. 4) There were no intraoperative complications. The mean postoperative hospital stay was a mean of 8 ± 2.5 days (range 4–10).

Postoperative follow-up was to the mean 32 ± 6.5 months. The VAS at the end of follow-up improved significantly to 3.5 ± 2.3 (range 2–5) ($p = 0.02$) and ODI improved to 12.3 ± 4.8 (range 5–20) ($p = 0.001$). Reoperation was necessary for two patients. The revisions were after a mean of 6 months after the discoplasty due to the symptoms' persistence. X-ray and CT examinations showed loosening of the screws, and they were managed surgically by anterior fusion through a retroperitoneal approach and posterior revision and extension of the fixation to lower lumbar levels. The two patients were 65-year-old males.

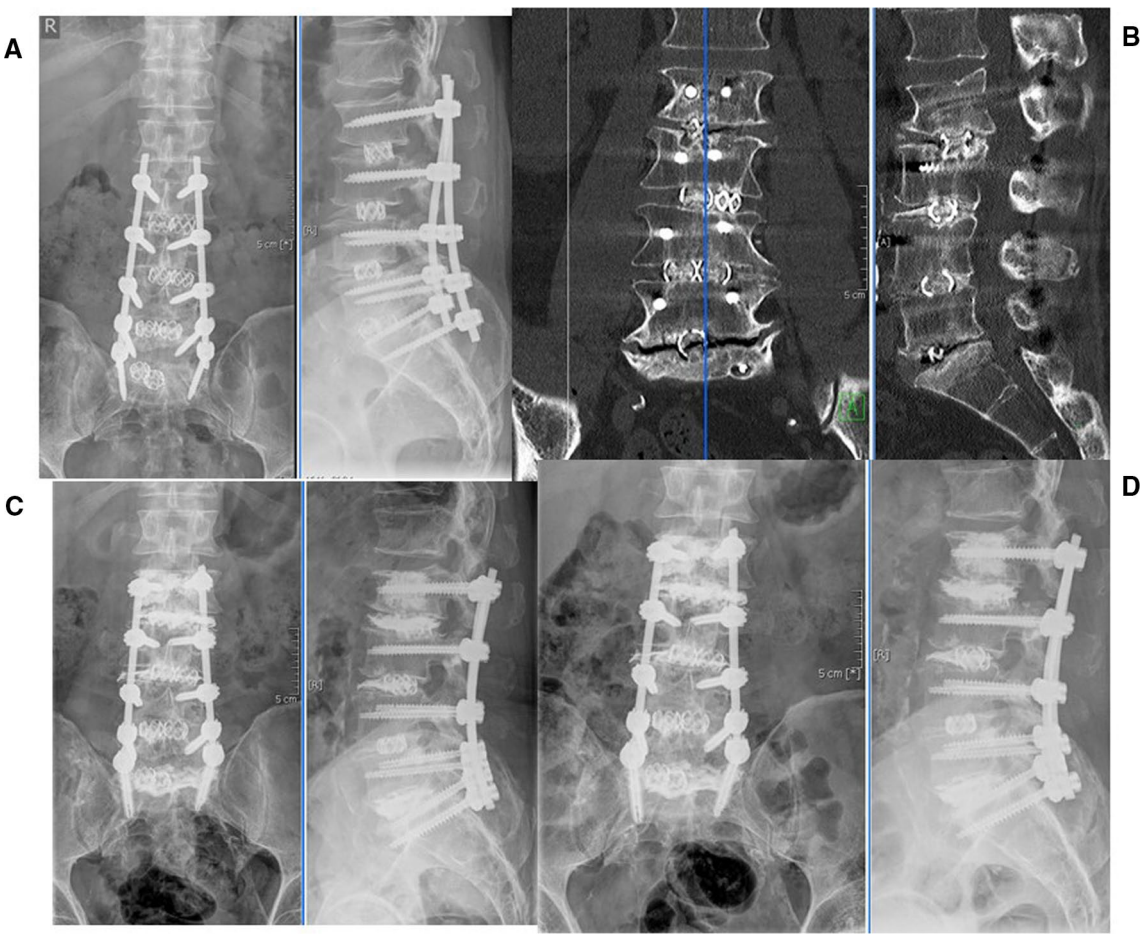

Fig. 3 Plains X-rays 14 months after posterior lumbar interbody fusion in 74-year-old female patients (**A**). CT scan was showing the vacuum phenomena with gas in the disc space in the fusion levels (**B**). postoperative X-rays were showing cement in the disc space and the vertebral body bone cement augmentation (**C**). X-rays 24 months after the procedure showing a stable situation (**D**). The patient had VAS of 2 and ODI of 8

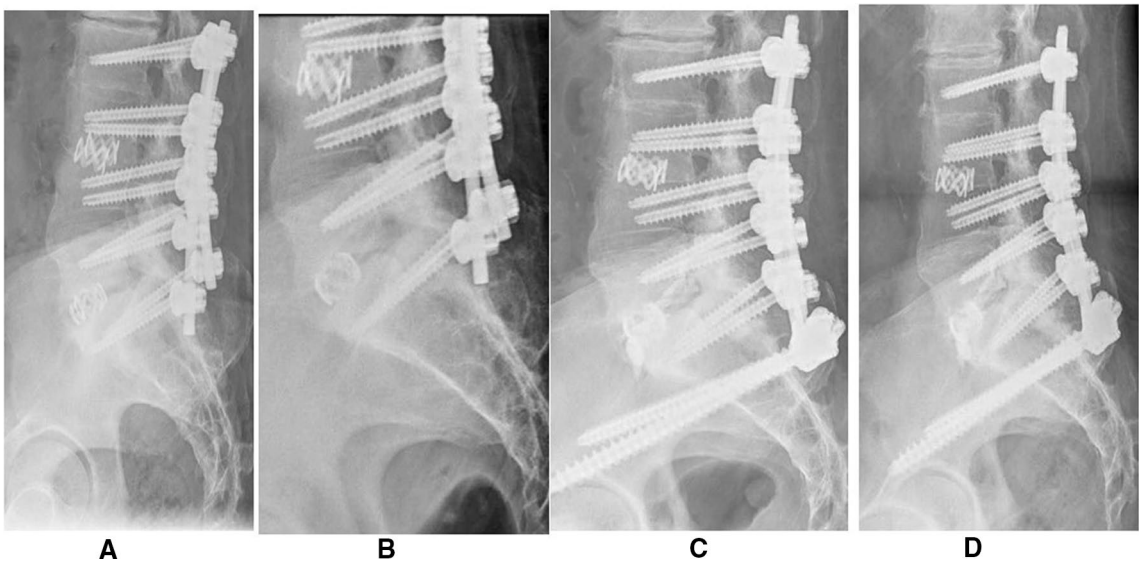

Fig. 4 Postoperative plain X-ray of a 75-year-old male after long-segment fusion ending at S1 (**A**), X-ray 24 months postoperative showing failure of fusion at L5/S1 level with a loosening of the screws (**B**), X-ray after discoplasty L5/S1 and stabilization to iliac screws (**C**), and a follow-up X-ray 36 months postoperatively with the stable construct (**D**)

Discussion

Bony fusion is correlated with better postoperative clinical results after PLIF operations. Many studies confirmed the degree of postoperative patients' clinical satisfaction with the solid bony fusion after the posterior lumbar fusion [14–16]. The micro-instability associated with the failure of fusion results in pain and reduces patient's satisfaction.

Revision surgeries for the symptomatic pseudarthrosis after lumbar spine fusion are surgically demanding and cause a significant increase in costs and operative risks. Careful evaluation is mandatory, and patients' expectations should be addressed adequately by the surgeon before undertaking any surgical procedure [16].

In a series of 2320 patients, Saleh et al. concluded that elderly patients undergoing lumbar spinal surgery have high complications and postoperative readmission rates. Risk factors for complications and readmissions include longer operative time and extensive instrumentation and fusion procedures [17]. These risks stimulated the introduction of a less invasive approach to managing the symptoms associated with the failure of fusion after the lumbar spine fusion and, at the same time to minimize the risks associated with the conventional surgical interventions. To the best of our knowledge, the current study is the first to introduce the concept of cement injection in the pseudarthrosis space to reduce the micro-instability and hence the pain associated with the failure of Fusion after PLIF operations.

In the present study, the clinical results were evaluated using VAS and ODI. The improvement of the clinical situation in the operated patients was significant, and these results were in coherence with the published studies regarding the surgical revisions in patients with pseudarthrosis after PLIF operations using the standard surgical techniques [18, 19], on the other hand, the complication rates in these studies were significantly higher; iliac vein lacerations requiring repair, a ureteral injury requiring subsequent nephrectomy, two infections, one radiculopathy, and two patients with prolonged ileus were recorded in a series of 47 patients [18].

The operative time and blood loss are significant factors for the rapid recovery after the surgical procedure, especially in elderly patients with associated medical comorbidities. In the current study, the mean operative time was 50 min, and the mean blood loss was 30 ml in cases managed by discoplasty alone, and 135 min and blood loss of a mean 350 ml in case of combined discoplasty and screw fixation. These values are superior to the standard surgical techniques used for the management of pseudarthrosis after failed PLIF procedures [17–20].

In the recently published literature, there is increasing evidence that filling the defects in the disc space in degenerative lumbar spine disease reduces the symptoms and improves the quality of life of the affected patients [9, 10]. Reducing the micro-movement caused by the pseudarthrosis and diagnosed by the presence of gas in the disc space leads to the alleviation of the symptoms. This stability leads to the improvement of the functional situation of the lumbar spine. These results explain the significant improvement of the clinical situation in our patients after filling the pseudarthrosis defects with bone cement since we considered that the cause of pain in cases of pseudoarthrosis was probably attributed to mechanical

instability micromotion between spinal segments. So in this study, fusion was not assessed postoperatively. Postoperative routine X-ray follow-up was done. In cases with persistent pain, a CT was performed to assess the fusion and the screws.

The safety of the procedure is essential, especially in fragile elderly patients. Observing the superior and inferior endplates parallel to the intensifier in the lateral view and the pedicles in the anterior–posterior view is essential. Inaccurate images may complicate the needle placement and increase the risk of neurovascular injury.

There were no intraoperative complications or technical difficulties in the present study. The reoperation was necessary in two patients who showed an increased pain intensity due to loosening of the screws and instability. Both revision cases were relatively younger and active patients (65 years). This result indicates the further refining of the indication and the patients' proper selection for this minimally invasive procedure.

In this work, we analysed the results of discoplasty retrospectively in elderly patients with pseudarthrosis after lumbar fusion. Compared with published results in the literature using the classical open surgical approach, this technique showed lower and less dangerous complications [16–22]. The most common complication by cement augmentation is cement leakage, which occurs on paravertebral soft tissue, into the intervertebral disc, spinal canal, and paravertebral veins [23]. In the case of cement injection after PLIF, the instrumentation could interfere with visualization during cement injection. To reduce the risk of cement leakage, multidirectional and multiple fluoroscopic images should be used for proper visualization, and cement injection was stopped immediately in the event of cement reaching the posterior vertebral wall. There were leakages in seven cases in the paravertebral space without any symptoms in the current study. Leakage was mostly due to degenerative clefts and ruptures of the annulus.

The study had limitations; the study's retrospective nature and the wide range of fusion levels (between one and several level fusion). However, the data are prospectively collected, and the selection criteria were clear. A prospective multicenter study is needed to further verify the obtained results in this work. Another limitation is that chronic infection is one of the risk factors of pseudarthrosis, which is a contraindication for cement discoplasty. The exclusion of infection has depended only on preoperative laboratory investigation and radiological findings. Also, bone mineral density was not evaluated in this study to exclude osteoporosis, which is a relative contraindication for cement discoplasty [9]. Furthermore, the study included two groups of patients: discoplasty only and discoplasty with re-instrumentation and, in some cases, with the extension of the construct may be considered a limitation of the statistical significance of the study results, which necessitate future research to compare both groups.

Conclusions

Cement discoplasty offers a less invasive reliable surgical solution in elderly patients with symptomatic lumbar pseudarthrosis. Indications are the failure of conservative treatment and documentation of void (vacuum phenomena) in the disc space. Discoplasty significantly reduces the symptoms in the treated patients, reduces the need for anterior revision, and improves life quality. In cases with marked screw loosening, combining the discoplasty with screw revision is an effective method for pseudoarthrosis therapy in the elderly and multi-morbid patients.

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Data availability Sharing is possible only after approval from Research Committee of our hospital.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Patients signed informed consent regarding publishing non-identifying data and photographs.

Ethical approval This research study was conducted retrospectively from data obtained for clinical purposes. We consulted extensively with the Research Ethics Committee of our hospital who determined that our study did not need ethical approval.

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