Original Article

Instrumented lumbar fusion in patients over 75 years of age: is it worthwhile?—a comparative study of the improvement in quality of life between elderly and young patients

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Background: Surgical treatment of degenerative lumbar disease in the elderly is controversial. Elderly patients have an increased risk for medical and surgical complications commensurate with their comorbidities, and concerns over complications have led to frequent cases of insufficient decompression to avoid the need for instrumentation. The purpose of this study was to evaluate clinical outcome between older and younger patients undergoing lumbar instrumented arthrodesis.

Methods: This is a retrospective, comparative study of prospectively collected outcomes. One hundred and fifty-four patients underwent 1- or 2-level posterolateral lumbar fusion. Patients were divided into two groups. Group 1: 87 patients ≤65 years of age who underwent decompression and posterolateral instrumented fusion; Group 2: 67 patients ≥75 years of age who underwent the same procedures with polymethylmethacrylate (PMMA) pedicle-screw augmentation. Mean follow-up 27.47 months (range, 76–24 months).

Results: Mean age was 49.1 years old (range, 24–65) for the younger group and 77.8 (range, 75–86) in the elderly group. Patients ≥75 years of age showed higher preoperative comorbidity (American Society of Anesthesiology, ASA: 1.7 *vs.* 2.4), and ≥2 systemic diseases with greater frequency (12.5% *vs.* 44.7%). No significant differences were found between the two groups in terms of postoperative complications, fusion, or revision rate. During follow-up, adjacent disc disease and adjacent fracture occurred significantly more in Group 2 (P<0.05). At the end of follow-up, there were no significant differences between the two groups in any of the clinical and health-related quality of life scores or satisfaction with treatment received.

Conclusions: Osteoporosis represents a major consideration before performing spine surgery. Despite an obvious increased risk of complications in elderly patients, PMMA-augmented fenestrated pedicle screw

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instrumentation in spine fusion represents a safe and effective surgical treatment option to elderly patients with poor bone quality. Age itself should not be considered a contraindication in otherwise appropriately selected patients.

Keywords: Elderly; degenerative lumbar surgery; pedicle screw augmentation; polymethylmethacrylate (PMMA); osteoporosis

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Introduction

Lumbar degenerative disease in the elderly population has long been a concern among spine surgeons. As part of the natural aging process, a series of degenerative changes occur in the lumbar spine, potentially producing structural disorders that may cause pain and limit activities of daily life. An increase in global life expectancy and quality of life has led to a growing demand for medical care (1-3). Conservative treatments have been shown to improve symptoms only over the short term (4,5). Too often, back pain and neurogenic claudication cause progressive disability, prompting both care providers and patients to weigh the risks and benefits of surgery.

Studies comparing clinical outcomes after hip and knee replacement operations (considered the most successful procedures in orthopedics) against those of lumbar surgery (6-9) reveal similar degrees of improvement in quality of life after surgery for degenerative lumbar disease and hip or knee arthroplasty. Unlike hip and knee surgery, however, surgical management for degenerative lumbar disease in the elderly population remains a matter of controversy.

Degenerative lumbar disease treatment in the elderly patient must be individualized, taking into consideration a wide range of clinical factors. Elderly patients have an increased risk for medical and surgical complications commensurate with their comorbidities, and concerns over complications have led to frequent cases of insufficient decompression to avoid the need for instrumentation (10-16). Osteoporosis is the most prevalent musculoskeletal condition in this population. It has been estimated that the age-adjusted prevalence of osteoporosis among female patients over 70 years of age undergoing a spine operation is 72%. Technical challenges related to surgery as well as the complications associated with screw fixation in the osteoporotic bone are well documented in the literature (9,17).

Cemented polymethylmethacrylate (PMMA) pedicle screw augmentation has demonstrated good clinical results and appears to be the safest and most efficient system for strengthening pedicle screws and achieving stable fixation (1). PMMA augmentation has been shown to increase pedicle screw pull-out force by up to 348%, and it has demonstrated effectiveness in both *in vitro* and *in vivo* clinical studies that examined the management of bone degenerative diseases and fractures (18).

Most authors have chosen 65 years of age as the lower limit to classify patients as elderly, this despite the increase in patients who continue to lead active lives beyond age 75 years (17,19). The present study describes the clinical and radiological outcomes, quality of life and functional improvement, as well as the surgically related complications

Highlight box

Key findings

- The study demonstrated the efficacy and safety of cement-augmented screws for the treatment of degenerative spine in patients with low bone mineral density.
- No differences were found in the clinical and functional outcome, fusion rate, surgical risks, major complications, or satisfaction with the treatment received between patients ≤65 and ≥75 years when the appropriate instrumentation was used.

What is known and what is new?

- Instrumented spinal fusion in elderly patients has been problematized due to the risk of age, screw loosening and comorbidity. Osteoporosis represents a major consideration before performing spine surgery.

What is the implication, and what should change now?

- The results of this study demonstrate the efficacy and safety of cemented instrumented fusion in degenerative lumbar disease in the elderly patient ≥75 years of age.
- Age itself should not be considered a contraindication in otherwise appropriately selected patients.

in a group of elderly patients (≥75 years of age) who underwent posterior decompression and fusion with cemented PMMA pedicle screw augmentation. We then compare these results with data from a similar procedure carried out in a younger population (≤65 years of age) with uncemented instrumentation. We hypothesize that there are no significant differences in clinical and health-related quality of life scores between both groups with the use of implants appropriate for their bone density. We present this article in accordance with the STROBE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-22-115/rc).

Methods

We retrospectively reviewed 154 patients who underwent 1- or 2-level instrumented lumbar fusion at our institution. The study population consisted of patients with painful degenerative lumbar disease and failure of appropriate conservative treatment. All data were collected prospectively and analyzed retrospectively. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research Ethics Committee of Jimenez Diaz Foundation (IRB No. EO 62/2016_FJD) and informed consent was taken from all the patients.

Surgical indications

Inclusion criteria were patients diagnosed with lumbar degenerative disease including lumbar canal stenosis, degenerative disc disease, and degenerative spondylolisthesis treated with 1- or 2-level posterior decompression and fusion after unsuccessful conservative treatment over a period of at least 6 months. To correlate clinical symptoms, all patients had plain anteroposterior, lateral, and flexion/extension radiographs of the lumbar spine, and preoperative magnetic resonance imaging (MRI) scans were performed to confirm the diagnosis and determine the level/s of surgery.

Exclusion criteria were patients under 18 years of age and patients in whom lumbar back pain was attributable to a diagnosis other than degenerative disease (i.e., tumors, congenital, rheumatoid disease, or infection). The primary indications for surgery were neurogenic claudication, significant radicular pain with or without neurologic deficit, and persistent back pain severe enough to limit activities of daily living plus radiologic instability. Except for patients showing a progressive neurologic deficit, our standard conservative treatment included oral analgesics, physiotherapy, rhizotomy, epidural blocks, and intradiscal injections.

Patients and surgical procedures

The 154 patients were divided into two groups according to their age at the time of the operation. Group 1 included 87 patients who were 65 years of age or younger (mean, 49.1 years; range, 24–65 years) and Group 2 included 67 patients who were 75 years of age or older (mean, 77.8 years; range, 75–86 years). All patients in Group 2 (age ≥75 years) underwent decompression and one- or two-level posterolateral (PL) instrumented fusion with cemented PMMA pedicle screw augmentation (Omega-21-LP pedicle screw, 6.35 - Zimmer Biomet. Warsaw, Indiana, US; Biomet bone cement V, Biomet Orthopaedics, Dietikon, Switzerland). Patients in Group 1 (age ≤65 years) underwent decompression and instrumented posterolateral instrumented fusion (PLIF) as indicated by the responsible surgeon (Polaris™ LP pedicle screw - Zimmer Biomet. Warsaw, Indiana, US) Fresh-frozen allograft bone was used in all cases for posterolateral fusion (*Figure 1*).

Bone mineral density (BMD) measurement by dual energy X-ray absorptiometry (DEXA), fenestrated screws, PMMA cement augmentation

As part of the authors' routine practice, DEXA scans were requested for female patients >65 years old, male patients >70 years old, and those between 60 and 75 years old with osteoporosis risk factors (20). We routinely used fenestrated screws in all patients >70 years of age, and in those patients between 60 and 70 years of age with positive DEXA scan for osteoporosis, or in the presence of risk factors for osteoporosis despite negative DEXA scans due to the possibility of a false negative. The decision to augment was based on the combination of patient's age (≥75 years old), preoperative positive DEXA scans for patients between 60 and 75 years old, confirmed by the intraoperative tactile feel resistance of the vertebral body to the pedicle probe, or suboptimal grip feel upon insertion of the fenestrated transpedicular screw.

Clinical assessment

Data regarding age, etiology, Visual Analogue Scale (VAS)

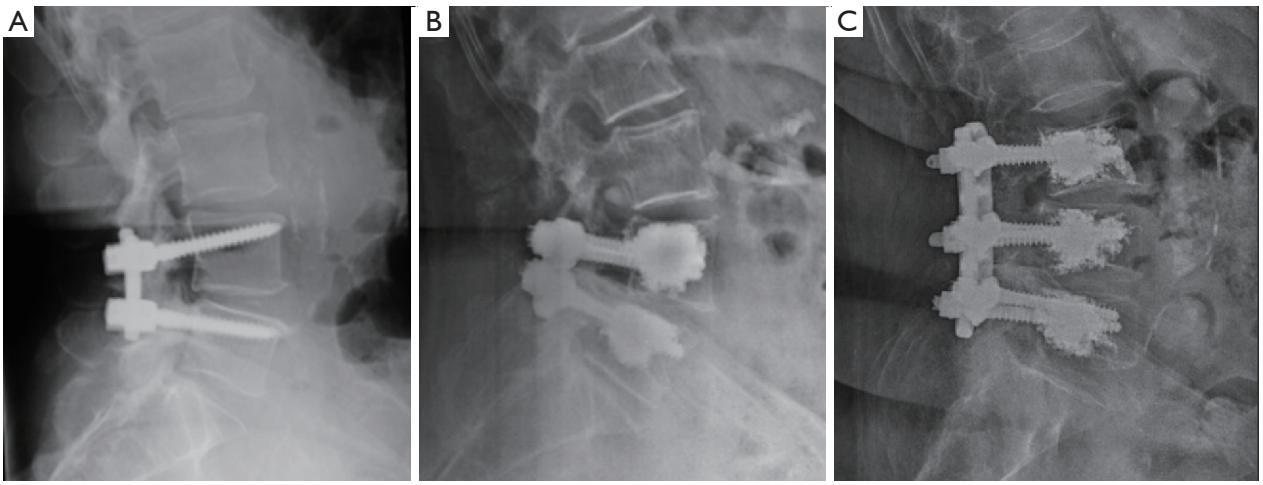

Figure 1 The 154 patients were divided into two groups. (A) Group 1, patients ≤65 years underwent decompression and 1- or 2-level posterolateral instrumented fusion; (B,C) Group 2 patients ≥75 years of age underwent decompression and 1- or 2-level posterolateral instrumented fusion with cemented PMMA pedicle screw augmentation and intertransverse bone allograft. PMMA, polymethylmethacrylate.

for back and leg pain, Oswestry disability index (ODI), and the Core Outcome Measure Index (COMI) questionnaires were collected as part of the authors' standard clinical practice. The ODI is a functional assessment questionnaire designed to assess disability associated with lumbar problems, i.e., to analyze the effects of low back pain on patients' functional status. It is the gold standard of low back pain scales (21). The Core Outcome Measures Index for the back (COMI-back) is an instrument that allows for rapid assessment of the main outcomes of relevance to patients with back problems (22) (i.e., pain, function, symptom-specific well-being, quality of life, disability).

Perioperative surgical data consisted of the degree of co-morbidity assessed using the scale of the American Society of Anesthesiology (ASA), levels treated, operative time, estimated blood loss, and length of hospital stay. The occurrence of any complication, postoperative reoperation, or revision procedure was also noted. Complications were classified into two categories: general complications (such as cardiopulmonary complications or respiratory or urinary infections) and surgical complications, which included infection, neurological deficits, epidural tears, etc. Outcome measures were performed at three, six, and twelve months postoperatively, and annually thereafter. Evaluation was based on a minimum follow-up of 2 years (range, 2–6.3 years). Mean follow-up was 27.47 months (range, 76–24 months).

Fusion success was defined as osseous trabecular bridging evidenced on plain radiographs with <3 mm of translation, <5° of angulation difference between the flexion and extension views, and the absence of cracking as evidenced by radiolucent lines through the fusion mass (23). Computed tomography (CT) scans were used as a secondary measure when bridging trabecular bone was not observed on plain radiographs. We defined adjacent segment degeneration to the postoperative radiographic progression of adjacent disc degeneration. In this context, a second operation was indicated only when nonoperative treatment such as medication and epidural steroid injection was not effective.

Statistical analysis

The results of the above measurements were analyzed statistically. Continuous variables were expressed as average, range, standard deviation (SD), and median where appropriate, and categorical variables as absolute value and/or percentages of the total sample for that variable. Comparison was made by obtaining a contingency table with its corresponding chi-square test of independence and of related or paired samples. The null hypothesis ("variables are independent") was rejected in cases in which P values were under 0.05. Statistical analysis was performed by an independent team of statisticians specifically engaged for this purpose.

Results

Surgical diagnoses included spinal stenosis (n=46), spondylolisthesis (n=41), degenerative disc disease (n=50),

Table 1 Demographic characteristics and diagnosis

Characteristic	Group 1 (age ≤65 years), n=87	Group 2 (age ≥75 years), n=67
Age, mean (range), year	49.1 (24 to 65)	77.8 (75 to 86)
Surgical diagnosis (both groups), n		
Spinal stenosis	46	
Spondylolisthesis	41	
Degenerative disc disease	50	
Revision surgery	17	
Most common diagnosis, %		
Degenerative disc disease	35.7	–
Spinal stenosis	–	49.2
No. levels fused, n		
One level	61	42
Two levels	26	25

Table 2 Patient pre/intraoperative comorbidities

Pre/intra operative comorbidity	Group 1 (on average) (age ≤65 years)	Group 2 (on average) (age ≥75 years)
ASA scale	1.7	2.4
% patients >2 systemic diseases	9.7%	44.7%
Mean operative time, min	110.2	146.4
Intraoperative blood loss (difference in preop-postop Hb), g/dL	1.8	3.1
Mean hospital stay, days	5.6	7.5

ASA, American Society of Anaesthesiologists; Hb, haemoglobin.

and revision surgery (n=17). Spinal stenosis (49.2%) was the most common diagnosis in Group 2 (age ≥75 years old) and degenerative disc disease (35.7%) was the most frequent in Group 1 (age ≤65 years old) (*Table 1*).

Preoperative health status and comorbidities

As expected, patients with age ≥75 years old had a more compromised baseline general state of health according to their preoperative comorbidity status, which was based on the ASA scale (2.4 in Group 2 and 1.7 in Group 1, on average), and especially evidenced by the number of patients with two or more systemic diseases (44.7% in Group 2 and 9.7% in Group 1). The mean operative time (146.48 minutes in Group 2 and 110.2 in Group 1) and average intraoperative blood loss (difference in preop-postop Hb 3.1 g/dL in Group 2, and 1.8 g/dL in Group 1) were almost the same in both age groups. The mean hospital stay was slightly longer in the older group (7.5 *vs.* 5.6 days). However, neither of these differences was significant (*Table 2*).

Postoperative complications

Postoperative complications occurred in 18 patients (26.8%) in Group 2, 5 of which were general complications (3 respiratory infections, 1 urinary infection, and 1 paralytic ileus), and 15 patients (17.2%) in Group 1. The most common surgical complications observed in both groups were wound infection and transient postoperative radicular pain, and no motor deficits occurred in either group. Three patients (4.4%) in Group 2 sustained dura tears during the procedure. One patient in Group 2 died secondary to a respiratory infection. Though the percentage of general complications was higher in Group 2, there was no statistically significant difference in the overall occurrence of complications between both groups (P=0.704). Ten revision surgeries were needed in Group 2 (14.9%): 2 repeat decompressions, 1 due to adjacent level disease, 6 resulting from deep wound infections, and 1 from pseudarthrosis at 1 year follow-up with breakage of a pedicle screw, which made revision surgery necessary for the addition of an anterior cage and bone graft. In Group 1, revision surgery was needed in 8 cases (9.1%) due to 3 wound infections, 3 cases of pseudarthrosis, 1 misplaced screw, 1 case of adjacent level disease. No significant difference between the two groups was found for the prevalence of revision surgery (P>0.05). None of the postoperative complications observed were related to cement leakage (*Table 3*).

Radiographic findings

The fusion rate was similar in both groups. In Group 1, six patients underwent CT evaluation to determine the presence of a solid fusion mass, while in Group 2 there were 4 patients, because the determination of the presence of a solid fusion mass in posterolateral arthodesis may be hampered by overlapping metallic implants. Finally, of the 5 patients in whom pseudarthrosis was detected, 2 were in Group 2 (2.9%) and 3 in Group 1 (3.4%). No significant difference in the rate of pseudarthrosis was observed

Table 3 Surgical, general, and follow-up complications by age group

Complications	Group 1 (age ≤65 yr)	Group 2 (age ≥75 yr)
Postop complications (P=0.704)	15 (17.2%); 1 general complication (1 resp infection)	18 (26.8%); 5 general complications (3 resp infection; 1 urinary infection; 1 paralytic ileus)
Revision surgeries (P>0.05)	8 (9.1%); 1 screw misplacement, 1 adjacent level disease, 3 deep wound infection, 3 pseudarthrosis	10 (14.9%): 2 repeat decompression, 1 adjacent level disease, 6 deep wound infection, 1 pseudarthrosis
Deaths	0	1 (respiratory infection)
Adjacent level fracture	0	2 as a result of falls (2.9%)
Degener adjacent disc (P<0.05)	7 (8%)	15 (22.3%)

resp, respiratory; Degener, degenerative; yr, year.

Table 4 Clinical outcomes

Clinical outcomes	Group 1 (age ≤65 yr)		Group 2 (age ≥75 yr)	
	Preoperative	Final follow-up	Preoperative	Final follow-up
Pain (VAS)	7.8	3.4	8.2	3.5
Oswestry (ODI)	63.8	30.7	52.7	22.9
COMI 6b (satisfaction with treatment received)	–	77.2%	–	72.4%

VAS, Visual Analogue Scale; ODI, Oswestry Disability Index; COMI, Core Outcome Measure Index; yr, year.

between the groups. No bone-cement radiolucency was observed. Cement leakage was observed in 11 (16.4%) of cemented vertebrae. We found type B leakage (epidural leakage) in 5 vertebrae (7.4%), type S leakage (lateral venous leakage) in 8 vertebrae (11.9%), and type C leakage in 1 vertebra. There were no instances of disc leakage. Adjacent level fracture occurred in 2 patients, both in Group 2 (2.9%) and resulting from falls. Degeneration of the adjacent disc was detected in 15 patients (22.3%) in Group 2 and in 7 patients (8%) in Group 1. The rate of adjacent disc degeneration in Group 2 was significantly higher than that observed in Group 1 (P<0.05) (*Table 3*).

Clinical results

At the final follow-up visit, the patients in both groups demonstrated significant improvements in VAS and ODI scores as compared to preoperative scores.

Group 1: the mean VAS score was 7.8 before surgery and 3.4 at final follow-up, showing a 56.4% improvement. The mean ODI score was 63.8 before surgery and 30.7 at final follow-up, indicating an average recovery rate of 51.8%. Group 2: the mean VAS score was 8.2 before surgery and 3.5 at final follow-up, which represents a 56.6% improvement. The mean ODI score was 52.7 before surgery and 22.9 at final follow-up, showing an average recovery rate of 56.5%. A reduction of >50% in VAS and ODI scores was observed in both groups. Overall, there were no significant differences between the two groups regarding outcome assessment using VAS and ODI.

At final follow-up, the rate of satisfaction with the treatment received (COMI 6b: satisfaction with the treatment received) was highly similar in both groups: 77.2% of the patients in Group 1 and 72.4% in Group 2 expressed satisfaction with the treatment received (P>0.05) (*Table 4*).

Discussion

The aim of the current study was to compare patients 75 years of age or older who underwent spinal fusion for degenerative lumbar disease against patients who were 65 years of age or younger who received the same procedure (old *vs.* young). No differences were found in clinical and functional outcome, fusion rate, surgical risks, major complications, or satisfaction with the treatment received after a minimum follow-up of 2 years (range, 2–6.3 years). The good clinical results obtained in this study are due to the

direct decompression of neural elements and the immediate stabilization of the spine with the most appropriate instrumentation.

With the progressive aging of the population and the increase in the expectations of older patients, the demand for treatment in older patients with degenerative diseases of the spine becomes more and more frequent. Since conservative management is usually effective only in the short-term, surgical treatment is considered the only remaining option for preserving or improving the quality of life and health status in many cases (5,11). Recent reports have shown good outcomes related to functional scores and fusion rates in patients between 65 and 75 years of age (2,24-28).

Nowadays, advanced age cannot be considered an absolute contraindication to surgical treatment. However, spinal fusion in elderly patients may be a major concern because of medical comorbidities and associated risks including osteoporosis. Although decompression alone is often sufficient, fusion is generally recommended when patients present preoperative mechanical instability or when laminectomy is accompanied by an extensive facet resection. Bouloussa *et al.* (29), in their study of 49 patients over the age of 85 with lumbar spinal stenosis who underwent decompression surgery with or without fusion, reported that fusion did not significantly affect the incidence of complications or the average number of complications per patient.

Osteoporosis is likely a major consideration before performing spine surgery. The lack of bone mineralization and presence of highly porous trabecular bone are responsible for decreased pullout strength, offering poor purchase for the instrumentation (19). Pedicle-screw fixation is the gold standard for surgically stabilizing the spine to achieve 3-column fixation in the lumbar and thoracic spine. However, the use of pedicle screws is controversial in patients with osteoporosis, since studies have demonstrated that insertional torque, pullout strength, and fatigue failure correlate linearly with bone mineral density, demonstrating that the weakest link in fixation of the osteoporotic spine is the bone-screw interface (30). In addition, damage caused by such pullouts can complicate revision surgeries. Several biomechanical studies have indicated that augmenting pedicle screws with PMMA significantly increases screw axial pullout strength (18,31-33). PMMA augmentation can be achieved using distally fenestrated pedicle screws specifically designed for cement injection. Once the cement has been extruded though the screw holes, it sets due to polymerization, creating a continuous mass between the core of the screw and the cancellous bone in the vertebral body. As a result, the cement provides immediate restoration of strength and stiffness and significantly increases pullout strength in osteoporotic vertebrae compared with nonaugmented low-to-normal BMD levels in the vertebrae (30,34). These studies have also shown that PMMA augmentation increases mean stiffness, energy absorbed to failure, and initial fixation and fatigue strength of pedicle screws (33,34).

DEXA scan is considered the gold standard for evaluating bone mineral density (35). However, the authors do not base cement augmentation solely and exclusively on the result of the DEXA scan due to the possibility of false results. Degenerative changes of the spine or hip, healed fractures, avascular necrosis, benign or metastatic bone-forming lesions may represent a false negative risk on DEXA scan. Whereas defects from a previous laminectomy and lytic lesions can result in a false positive result. Additionally, DEXA scores depend on age, gender, and race (36), and the validity of BMD as the only criterion in decision-making is relative and its use as a screening tool for osteoporosis would be doubtful, especially considering that the increase in age is 7 times more important than the densitometric decrease (37). We used fenestrated screws in all patients >70 years of age, and in those patients between 60 and 70 years of age with positive DEXA scans, or in the presence of risk factors for osteoporosis despite normal DEXA scans. The final decision to augment with PMMA cement is based on the combination of the preoperative finding of osteoporosis in DEXA scans, confirmed by the intraoperative tactile feel resistance of the vertebral body to the pedicle probe, or suboptimal grip feel upon insertion of the fenestrated transpedicular screw.

The main risk of using PMMA is the possibility of cement leakage. The reported incidence of cement leakage in augmentation techniques varies from 5% to 80% (38-40). Even though the incidence of cement leakage is very high, it is not necessarily clinically relevant. Widespread use of vertebroplasty has enabled surgeons to gain experience with the technique and has provided consistent data on the low risk of cement leakage when cement injection is performed in a controlled fashion (41-43). Cannulated pedicular screws make it possible to perform screw augmentation once the screws are inserted as well as to precisely control the consistency, rhythm, and volume of the cement injected into each screw. Cement is injected during the "toothpaste-like" phase to minimize the risks of extravasation. To

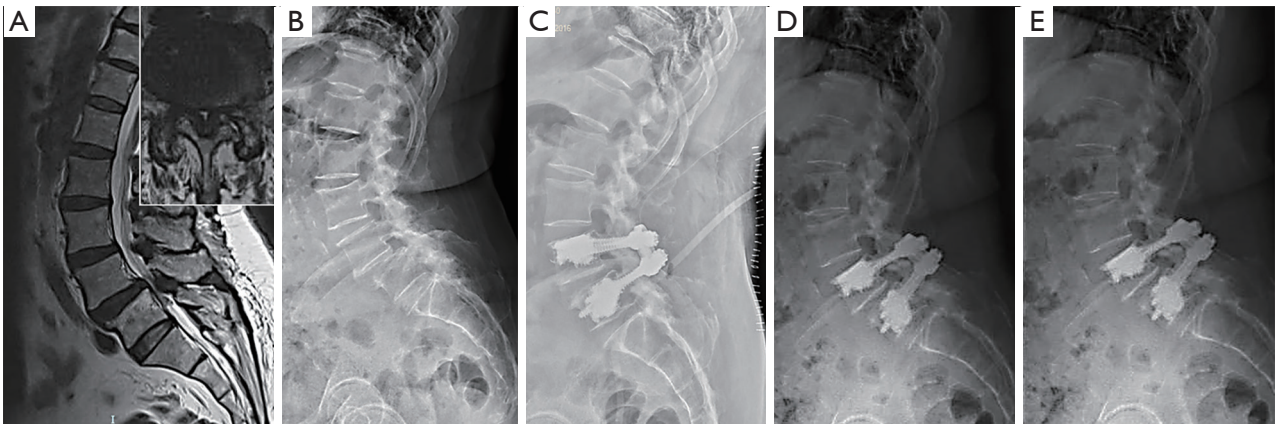

Figure 2 Sequential MRI and X-rays of a 78-year-old woman undergoing surgical treatment. (A,B) Preoperative MRI scan and lateral radiograph of a 78-year-old female who underwent decompression and 1-level posterolateral instrumented fusion with cemented PMMA pedicle screw augmentation; (C) immediate postoperative lateral radiograph at 24 hours; (D) postoperative lateral radiograph at 6 months showing stable reduction; (E) 4-year postoperative lateral radiograph evidencing preserved spinal alignment and implant placement. MRI, magnetic resonance imaging; PMMA, polymethylmethacrylate.

decrease the cement leakage rate, some recommend the use of high-viscosity cement (44,45). We mostly use 55- and 50-mm screws in the lumbar spine, attempting to insert the tip of the screw as far as possible in all cases (46). Distal fenestration allows the delivery of the entire volume of cement into the vertebral body around the distal third of the screw, far ventral to the neurocentral canal. This distal concentration of cement for screw augmentation promotes a higher force to failure and diminishes the risk of cement extrusion into the spinal canal owing to an accidental pedicle breach (1,47-49). Intraoperative live fluoroscopic images demonstrate progressive symmetrical filling of the vertebral body. Based on the experience of the authors, 3 cc of cement per screw is injected in the lumbar spine and 2 cc in the thoracic spine, depending on the size of the vertebrae. None of the clinical complications observed in this study were related to cement leakage (*Figure 2*).

Another major concern surrounding the use of PMMA-augmented screws is the likelihood of implant removal in case of infection, revision, or other problems. In a cadaveric study, Choma *et al.* (48) demonstrated that screws could be easily extracted after cement augmentation, with failure occurring at the screw-cement interface in all cases. Cho *et al.* (50) studied the torque required to back out the PMMA-augmented pedicle screws in an osteoporotic model. The results of their study showed that the torque required to remove the screws was generally higher than the insertion torque of the primary screws. However, the removal torque for screws that had been augmented was <1 N-m and did not cause any bone damage to the osteoporotic vertebrae, thus demonstrating that safe screw extraction is possible even after cement augmentation of a pedicle screw.

There is no consensus on the best radiographic way to evaluate the quality of lumbar vertebral fusion. Validity of simple radiography in determining the rate of fusion has been questioned, due to weak interobserver agreement and moderate degree of accuracy in determining intervertebral fusion. Concern with the quality of fusion is more relevant in those patients with an uncertain clinical result. CT scan is frequently used to verify the presence of solid fusion (51). In the present study, CT scans were used as a secondary measure when bridging trabecular bone was not observed on plain radiographs in those patients with a doubtful clinical result. The low rate of pseudoarthrosis found in both groups at the end of follow-up (2.9% in Group 2 *vs.* 3.4% in Group 1) confirms the solid degree of stability provided by the use of screws with cement augmentation in osteoporotic bone; indeed, osteoporotic bone in which pedicle screws with cement augmentation have been inserted shows comparable stability to that of conventional instrumentation in healthy bone. Two patients presented an adjacent vertebral fracture during follow-up, both of whom belonged to the group of patients older than 75 years (2.9%) and presented fracture related to a history of falling. Fifteen patients older than 75 years (22.3%) presented radiological signs of degenerative disc disease, compared

to only 7 patients (8%) in the group of younger patients. Vertebral arthrodesis produces an alteration of the dynamic physiological loading mechanisms, resulting in increased pressure on the disc and vertebral body in the adjacent segments. Hikata *et al.* (52) found that the length of follow-up was a risk factor for radiologic diagnosis of adjacent segment disease after posterior lumbar interbody fusion. The increase in the incidence of disc disease observed in adjacent levels among the patients over 75 years of age could be related to normal aging but could also be a direct consequence of the increase in dynamic load tension in the levels adjacent to the site of fusion in structures previously weakened by age (53).

Although statistically significant differences in preoperative ODI were found between the two groups, the clinical improvement in terms of pre- and postoperative score change was very similar. The older patients, therefore, demonstrated a greater limitation in ordinary activities with respect to the younger population, which was more attributable to their age and less to a lower surgical success rate (54-56).

Glassman *et al.* (57), reported the clinical outcome, stratified by diagnosis, among a series of patients with lumbar degenerative disease whose treatment included lumbar spine fusion. The mean age of patients diagnosed with stenosis was 63.3±13.1 years, while the mean age of patients with degenerative disc disease was 46.7±10.2 years. Assessment of the mean net change in ODI outcome score by diagnostic subgroup 1 year postoperatively revealed a substantial improvement for patients with disc pathology of 16.7±16.0 points and for patients diagnosed with spinal stenosis, 16.1±17.8 points at 1 year postoperatively. Assessment of the mean net change in back and leg pain outcome score by diagnostic subgroup 1 year postoperatively revealed an improvement for patients with disc pathology of 2.8±2.9 and 2.0±3.0 points respectively and patients diagnosed with spinal stenosis improved 3.1±2.9 and 3.1±3.2 points respectively. The incidence of major complications was 8.7% in the stenosis subgroup and 3.0% in the disc pathology subgroup. The findings regarding clinical improvement and occurrence of complications are in line with the present study.

Conclusions

Despite the increased risk of complications, elderly patients clearly benefit from surgical treatment of degenerative lumbar disease. The improvement experienced by individuals ≥75 years of age following surgical treatment of degenerative lumbar disease is clinically and statistically significant. Additional rigid stabilization/fusion is feasible even at more advanced ages without an obvious rise in surgical or general complications or complications at follow-up. Nowadays, given correct patient selection, use of appropriate instrumentation for bone fragility, and the choice of a safe surgical technique, it is possible to provide effective surgical treatment to elderly patients with lumbar degenerative disease. The results of this study demonstrate the efficacy and safety of instrumented arthrodesis in degenerative lumbar disease in the elderly patient ≥75 years of age.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research Ethics Committee of Jimenez Diaz Foundation (IRB No.

EO 62/2016_FJD) and informed consent was taken from all the patients.

References

1. Piñera AR, Duran C, Lopez B, et al. Instrumented lumbar arthrodesis in elderly patients: prospective study using cannulated cemented pedicle screw instrumentation. Eur Spine J 2011;20 Suppl 3:408-14.
2. Okuda S, Oda T, Miyauchi A, et al. Surgical outcomes of posterior lumbar interbody fusion in elderly patients. J Bone Joint Surg Am 2006;88:2714-20.
3. Sciubba DM, Scheer JK, Yurter A, et al. Patients with spinal deformity over the age of 75: a retrospective analysis of operative versus non-operative management. Eur Spine J 2016;25:2433-41.
4. Arden NK, Price C, Reading I, et al. A multicentre randomized controlled trial of epidural corticosteroid injections for sciatica: the WEST study. Rheumatology (Oxford) 2005;44:1399-406.
5. Tomé-Bermejo F, Barriga-Martín A, Martín JL. Identifying patients with chronic low back pain likely to benefit from lumbar facet radiofrequency denervation: a prospective study. J Spinal Disord Tech 2011;24:69-75.
6. Cervera Irimia J, Tomé-Bermejo F, Piñera-Parrilla AR, et al. Spinal fusion achieves similar two-year improvement in HRQoL as total hip and total knee replacement. A prospective, multicentric and observational study. SICOT J 2019;5:26.
7. Rampersaud YR, Ravi B, Lewis SJ, et al. Assessment of health-related quality of life after surgical treatment of focal symptomatic spinal stenosis compared with osteoarthritis of the hip or knee. Spine J 2008;8:296-304.
8. Rampersaud YR, Lewis SJ, Davey JR, et al. Comparative outcomes and cost-utility after surgical treatment of focal lumbar spinal stenosis compared with osteoarthritis of the hip or knee--part 1: long-term change in health-related quality of life. Spine J 2014;14:234-43.
9. Juul O, Sigmundsson FG, Ovesen O, et al. No difference in health-related quality of life in hip osteoarthritis compared to degenerative lumbar instability at pre- and 1-year postoperatively: a prospective study of 101 patients. Acta Orthop 2006;77:748-54.
10. Li G, Patil CG, Lad SP, et al. Effects of age and comorbidities on complication rates and adverse outcomes after lumbar laminectomy in elderly patients. Spine (Phila Pa 1976) 2008;33:1250-5.
11. Sobottke R, Aghayev E, Röder C, et al. Predictors of surgical, general and follow-up complications in lumbar spinal stenosis relative to patient age as emerged from the Spine Tango Registry. Eur Spine J 2012;21:411-7.
12. Lieber BA, Chiang V, Prabhu AV, et al. Postoperative Complications for Elderly Patients After Single-Level Lumbar Fusions for Spondylolisthesis. World Neurosurg 2016;91:149-53.
13. Lagman C, Ugiliweneza B, Boakye M, et al. Spine Surgery Outcomes in Elderly Patients Versus General Adult Patients in the United States: A MarketScan Analysis. World Neurosurg 2017;103:780-8.
14. Liang H, Lu S, Jiang D, Fei Q. Clinical outcomes of lumbar spinal surgery in patients 80 years or older with lumbar stenosis or spondylolisthesis: a systematic review and meta-analysis. Eur Spine J 2020;29:2129-42.
15. Shamji MF, Mroz T, Hsu W, et al. Management of Degenerative Lumbar Spinal Stenosis in the Elderly. Neurosurgery 2015;77 Suppl 4:S68-74.
16. Tomé-Bermejo F, Piñera AR, Alvarez L. Osteoporosis and the Management of Spinal Degenerative Disease (II). Arch Bone Jt Surg 2017;5:363-74.
17. Fehlings MG, Tetreault L, Nater A, et al. The Aging of the Global Population: The Changing Epidemiology of Disease and Spinal Disorders. Neurosurgery 2015;77 Suppl 4:S1-5.
18. Wittenberg RH, Lee KS, Shea M, et al. Effect of screw diameter, insertion technique, and bone cement augmentation of pedicular screw fixation strength. Clin Orthop Relat Res 1993;(296):278-87.
19. Bassewitz HL, Herkowitz HN. Osteoporosis of the spine: medical and surgical strategies. The University of Pennsylvania Orthopaedic Journal 2000;13:35-42.
20. Baim S, Binkley N, Bilezikian JP, et al. Official Positions of the International Society for Clinical Densitometry and executive summary of the 2007 ISCD Position Development Conference. J Clin Densitom 2008;11:75-91.
21. Fairbank JC, Couper J, Davies JB, et al. The Oswestry low back pain disability questionnaire. Physiotherapy

1980;66:271-3.
22. Mannion AF, Vila-Casademunt A, Domingo-Sàbat M, et al. The Core Outcome Measures Index (COMI) is a responsive instrument for assessing the outcome of treatment for adult spinal deformity. Eur Spine J 2016;25:2638-48.
23. Glassman SD, Polly DW, Bono CM, et al. Outcome of lumbar arthrodesis in patients sixty-five years of age or older. J Bone Joint Surg Am 2009;91:783-90.
24. Esses SI, Sachs BL, Dreyzin V. Complications associated with the technique of pedicle screw fixation. A selected survey of ABS members. Spine (Phila Pa 1976) 1993;18:2231-9.
25. Pérez-Prieto D, Lozano-Álvarez C, Saló G, et al. Should age be a contraindication for degenerative lumbar surgery? Eur Spine J 2014;23:1007-12.
26. Glassman SD, Carreon LY, Dimar JR, et al. Clinical outcomes in older patients after posterolateral lumbar fusion. Spine J 2007;7:547-51.
27. Cassinelli EH, Eubanks J, Vogt M, et al. Risk factors for the development of perioperative complications in elderly patients undergoing lumbar decompression and arthrodesis for spinal stenosis: an analysis of 166 patients. Spine (Phila Pa 1976) 2007;32:230-5.
28. Andersen T, Christensen FB, Niedermann B, et al. Impact of instrumentation in lumbar spinal fusion in elderly patients: 71 patients followed for 2-7 years. Acta Orthop 2009;80:445-50.
29. Bouloussa H, Alzakri A, Ghailane S, et al. Is it safe to perform lumbar spine surgery on patients over eighty five? Int Orthop 2017;41:2091-6.
30. Dodwad SM, Khan SN. Surgical stabilization of the spine in the osteoporotic patient. Orthop Clin North Am 2013;44:243-9.
31. Burval DJ, McLain RF, Milks R, et al. Primary pedicle screw augmentation in osteoporotic lumbar vertebrae: biomechanical analysis of pedicle fixation strength. Spine (Phila Pa 1976) 2007;32:1077-83.
32. Cook SD, Salkeld SL, Stanley T, et al. Biomechanical study of pedicle screw fixation in severely osteoporotic bone. Spine J 2004;4:402-8.
33. Schmoelz W, Heinrichs CH, Schmidt S, et al. Timing of PMMA cement application for pedicle screw augmentation affects screw anchorage. Eur Spine J 2017;26:2883-90.
34. Pfeifer BA, Krag MH, Johnson C. Repair of failed transpedicle screw fixation. A biomechanical study comparing polymethylmethacrylate, milled bone, and matchstick bone reconstruction. Spine (Phila Pa 1976) 1994;19:350-3.
35. Schousboe JT, Shepherd JA, Bilezikian JP, et al. Executive summary of the 2013 International Society for Clinical Densitometry Position Development Conference on bone densitometry. J Clin Densitom 2013;16:455-66.
36. Acharya S, Adsul N, Palukuri N, et al. Caveats in diagnosis of osteoporosis. Indian Journal of Medical Specialities 2017;8:169-74.
37. Kanis JA, Borgstrom F, De Laet C, et al. Assessment of fracture risk. Osteoporos Int 2005;16:581-9.
38. Hulme PA, Krebs J, Ferguson SJ, et al. Vertebroplasty and kyphoplasty: a systematic review of 69 clinical studies. Spine (Phila Pa 1976) 2006;31:1983-2001.
39. Schmidt R, Cakir B, Mattes T, et al. Cement leakage during vertebroplasty: an underestimated problem? Eur Spine J 2005;14:466-73.
40. Muijs SP, Akkermans PA, van Erkel AR, et al. The value of routinely performing a bone biopsy during percutaneous vertebroplasty in treatment of osteoporotic vertebral compression fractures. Spine (Phila Pa 1976) 2009;34:2395-9.
41. Alvarez L, Perez-Higueras A, Quiñones D, et al. Seven-year experience of percutaneous vertebroplasty for osteoporotic vertebral fractures: analysis of factors determining outcome in 212 patients. Spine J 2003;3:96.
42. Alvarez L, Alcaraz M, Pérez-Higueras A, et al. Percutaneous vertebroplasty: functional improvement in patients with osteoporotic compression fractures. Spine (Phila Pa 1976) 2006;31:1113-8.
43. Tomé-Bermejo F, Piñera AR, Duran-Álvarez C, et al. Identification of Risk Factors for the Occurrence of Cement Leakage During Percutaneous Vertebroplasty for Painful Osteoporotic or Malignant Vertebral Fracture. Spine (Phila Pa 1976) 2014;39:E693-E700.
44. Zhang L, Wang J, Feng X, et al. A comparison of high viscosity bone cement and low viscosity bone cement vertebroplasty for severe osteoporotic vertebral compression fractures. Clin Neurol Neurosurg 2015;129:10-6.
45. La Maida GA, Giarratana LS, Acerbi A, et al. Cement leakage: safety of minimally invasive surgical techniques in the treatment of multiple myeloma vertebral lesions. Eur Spine J 2012;21 Suppl 1:S61-8.
46. Martín-Fernández M, López-Herradón A, Piñera AR, et al. Potential risks of using cement-augmented screws for spinal fusion in patients with low bone quality. Spine J 2017;17:1192-9.
47. Chang MC, Liu CL, Chen TH. Polymethylmethacrylate

augmentation of pedicle screw for osteoporotic spinal surgery: a novel technique. Spine (Phila Pa 1976) 2008;33:E317-24.
48. Choma TJ, Pfeiffer FM, Swope RW, et al. Pedicle screw design and cement augmentation in osteoporotic vertebrae: effects of fenestrations and cement viscosity on fixation and extraction. Spine (Phila Pa 1976) 2012;37:E1628-32.
49. Sawakami K, Yamazaki A, Ishikawa S, et al. Polymethylmethacrylate augmentation of pedicle screws increases the initial fixation in osteoporotic spine patients. J Spinal Disord Tech 2012;25:E28-35.
50. Cho W, Wu C, Zheng X, et al. Is it safe to back out pedicle screws after augmentation with polymethyl methacrylate or calcium phosphate cement? A biomechanical study. J Spinal Disord Tech 2011;24:276-9.
51. Gotfryd AO, Pomar Fde M, Carneiro Neto NJ, et al. Reliability analysis of radiographic methods for determination of posterolateral lumbossacral fusion. Einstein (Sao Paulo) 2014;12:198-203.
52. Hikata T, Kamata M, Furukawa M. Risk factors for adjacent segment disease after posterior lumbar interbody fusion and efficacy of simultaneous decompression surgery for symptomatic adjacent segment disease. J Spinal Disord Tech 2014;27:70-5.
53. Giannadakis C, Solheim O, Jakola AS, et al. Surgery for Lumbar Spinal Stenosis in Individuals Aged 80 and Older: A Multicenter Observational Study. J Am Geriatr Soc 2016;64:2011-8.
54. Hayashi K, Matsumura A, Konishi S, et al. Clinical Outcomes of Posterior Lumbar Interbody Fusion for Patients 80 Years of Age and Older with Lumbar Degenerative Disease: Minimum 2 Years' Follow-Up. Global Spine J 2016;6:665-72.
55. Ulrich NH, Kleinstück F, Woernle CM, et al. Clinical outcome in lumbar decompression surgery for spinal canal stenosis in the aged population: a prospective Swiss multicenter cohort study. Spine (Phila Pa 1976) 2015;40:415-22.
56. Liao JC, Chen WJ. Surgical outcomes in the elderly with degenerative spondylolisthesis: comparative study between patients over 80 years of age and under 80 years-a gender-, diagnosis-, and surgical method-matched two-cohort analyses. Spine J 2018;18:734-9.
57. Glassman SD, Carreon LY, Djurasovic M, et al. Lumbar fusion outcomes stratified by specific diagnostic indication. Spine J 2009;9:13-21.

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