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ORIGINAL RESEARCH

Is Removal of Implants Mandatory Following Minimally Invasive Percutaneous Screw-Rod Stabilization Without Fusion for Mono-Segmental Thoracolumbar Fractures in Elderly Patients?

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Purpose: Despite the lack of evidence, the current standard of care following posterior pedicle screw-rod stabilization for spinal trauma includes instrumentation removal. This retrospective cohort study aimed to assess the necessity of implant removal in patients aged ≥65 years who underwent minimally invasive pedicle screw-rod fixation for AO type A and B thoracolumbar fractures.

Methods: We evaluated the clinical and radiological outcomes of 57 patients aged ≥65 years with mono-segmental AO type A and B thoracolumbar fractures treated with percutaneous short-segment pedicle screw fixation, and compared the two groups with and without hardware removal. Clinical outcomes included the visual analog scale score for back pain (VAS), Oswestry Disability Index (ODI), residual chronic back pain (RCBP) and implant-related complications. Radiological parameters, such as the vertebral wedge angle (VWA), segmental kyphosis Cobb angle (SKCA), anterior edge height ratio (AEHR) and adjacent intervertebral height index (IHI), were measured.

Results: No significant differences were observed between the two groups in the mean VAS and ODI values at 12 months and final follow-up. The incidence of RCBP in the implant retention group (25.9%) was slightly higher than that in the implant removal group (20%). However, there were no significant differences between the two groups. Both groups showed correction loss over time. An increase in the segmental kyphosis Cobb angle only differed by 2.02° with no significant difference between the two groups at final follow-up (implant removal group A 4.15°, implant removal group 2.13°). However, whether the implant was removed or not, no statistically significant differences were found in the correction loss of SKCA, VWA, IHI, or AEHR between the two groups within the 12-month follow-up period.

Conclusion: Our results suggest that percutaneous short-segment pedicle screw fixation showed similar radiological and functional outcomes in patients aged ≥65 years, regardless of whether the implants were removed after fracture healing.

Keywords: spinal fractures, pedicle screws, instrumentation, minimally invasive surgery, implant removal

Introduction

Randomized trials have found that treating most thoracolumbar (TL) fractures with reduction and spinal stabilization is adequate without the use of bone grafting for definitive fusion.[1,2] In recent decades, surgical treatment of patients with AO type A and B TL fractures has shifted from conventional open procedures to minimally invasive surgery. Percutaneous pedicle screw-rod fixation (PPSF) has been developed to restore stability and alignment, while promoting early mobilization in patients with TL fractures.[3,4] The current standard of care following PPSF includes instrumentation removal once bony healing occurs and stability is restored because this is a non-fusion procedure. In clinical practice, our patients were informed about the necessity of a second operation for implant removal one year postoperatively, although

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evidence of the need for posterior implant removal remains inconclusive. Coronavirus disease 2019 (COVID-19) spread worldwide in the spring of 2020. The Chinese government introduced the Dynamic-Zero COVID-19 Prevention and Control Policy, which included heavy social restrictions and repeated lockdowns. China postponed non-emergent procedures to preserve hospital resources in an unprecedented situation during the lockdown period. Additionally, owing to the transmissibility of the SARS-CoV-2 virus and social measures, patients' willingness to return and undergo planned instrumentation removal surgery significantly declined during the waves of the pandemic. Patients scheduled for implant removal surgery required suspension or cancellation of the procedure, which provided an unexpected opportunity to observe the effect of prolonged implant retention after PPSF. In the present study, we conducted a retrospective observational study reviewing patients aged ≥65 years who underwent minimally invasive PPSF for TL fractures to evaluate the necessity of implant removal in elderly patients. Our null hypothesis was that hardware removal surgery may not be mandatory for elderly patients, which would lead to cost savings and the prevention of perioperative complications.

Materials and Methods

Patients/Inclusion-Exclusion Criteria

This retrospective study was conducted at the sixth medical center, PLA general hospital (a tertiary-level in China). The inclusion criteria were patients aged ≥65 years (WHO defines and addresses the health needs of older adults in developing country.) who underwent non-fusion minimally invasive PPSF for single-level type A or B TL fractures in terms of AO spine classification at our hospital between January 2017 and December 2021. Patients were not included if open decompression of neural elements was indicated or if they had multiple injured segments that needed surgery at multiple levels. We also excluded patients with upper or lower limb injuries or chronic physical conditions that negatively affected bone healing (eg, autoimmune disease, ankylosing spondylitis, and systemic corticosteroid treatment).

Surgical Procedures

All patients underwent PPSF under general anesthesia, and all operations were performed by the same group of surgeons. The patient was positioned prone on a radiolucent spine table, and the operating table was adjusted to provide sufficient reduction in vertebral height with routine hyperextension positioning and ligamentotaxis. Anteroposterior (AP) / lateral imaging capabilities were provided by C-arm fluoroscopy units, and a 1.5 cm incision was proposed and marked just lateral to the lateral border of each pedicle of interest. Standard antiseptic skin preparation and draping were completed and incisions were made in the fascia. The entry point is usually selected to be at or just lateral to the lateral border of the pedicle in the AP view. The cannulated trochar was tamped through the pedicle parallel to the disc space at adjacent vertebrae, ensuring that the tip of the trochar remained lateral to the medial pedicle wall until the tip of the trochar passed into the vertebral body. Trochar placement was guided and confirmed by AP and lateral C-arm imaging. Guidewires were placed at each pedicle to be instrumented through the trochar, followed by the removal of the trochar. The pedicles were then tapped and cannulated screws were manually placed through the guidewires. Therefore, it is necessary to maintain the guidewire in place without inadvertent withdrawal or advancement. All patients were treated with pure percutaneous six-screw short segment fixation, which involves conventional one-above- and one-below-injured level stabilization and additional augmentation at the fractured vertebrae using bilateral intermediate screws. Two extra screws with an appropriate length of 30 mm were placed toward the anteroinferior portion of the vertebral body, and care should be taken to prevent the screws in the injured vertebra from crossing the fracture line. The rods were introduced subfascially and advanced through pedicle screw slots. Fracture alignment was optimized using distraction maneuvers, and final tightening was performed with antitorque in place to prevent rod rotation in the coronal plane. Final AP and lateral C-arm imaging were used to verify the appropriate instrumentation placement and spinal alignment before incisions were cleaned and closed. We evaluated and compared the pre- and postoperative radiologic parameters, as well as instrumentation-related complications on CT and X-ray images after treatment. The patients were allowed full weight-bearing ambulation and rehabilitation on postoperative day one with protection of a thoracolumbosacral orthosis brace.

Study Cohort and Data Collection

All patients were followed up at 1, 3, 6, and 12 months postoperatively and annually thereafter. In our department, patients who had received percutaneous fixation were routinely recommended to have the hardware removed at least 10 months after surgery, when fracture healing was observed or when implant-related irritation occurred. However, The Coronavirus disease 2019 (COVID-19) pandemic has greatly affected medical practices worldwide. Heavy social restrictions and repeated lockdowns are associated with reduced access to healthcare services. In addition, the COVID-19 outbreak has resulted in a significant reluctance of elderly patients to consider elective implant removal surgery owing to infection concerns. Therefore, eligible patients were classified into two groups: group A, in which implants were removed and group B, in which implants were retained. The time interval between the primary operation and implant removal in Group A and the duration of implant retention in Group B were recorded.

Clinical Evaluation and Radiological Examinations

We evaluated the clinical outcomes at follow-up using the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS; 0 = no pain, 10 = maximum pain) scores for the intensity of back pain. Residual chronic back pain (RCBP) was defined as a visual analog scale score ≥ 3 at the latest follow-up. Radiological evaluation was performed using standing X-ray images, including the VWA (angle between the superior and inferior endplates of the fractured vertebra), segmental kyphosis Cobb angle (SKCA; angle between the superior endplate of the upper adjacent vertebra and the inferior endplate of the lower adjacent vertebra), and anterior edge height ratio of the injured vertebra (AEHR; anterior edge height ratio between the fractured vertebra and the average of two adjacent vertebrae). Implant-related complications, such as screw loosening or breakage, were noted. In this study, Postoperative radiographic adjacent segment degeneration (ASD) was evaluated based on the loss of intervertebral height index (IHI) adjacent to the stabilized segments. (intervertebral height index = (anterior disc height + posterior disc height)/(superior disc diameter + inferior disc diameter) × 100). In addition, anterior and posterior translations were used to detect instability. The PACS imaging software and embedded imaging tools (kyphosis angle and height ratio) were used for all measurements (Figure 1). Two authors independently performed all the measurements using the arithmetic mean.

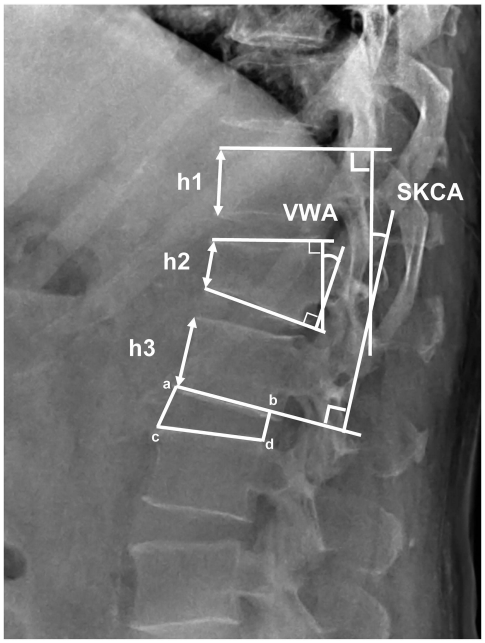

Figure 1 Schematic diagram regarding measurement of radiological parameters: 1. vertebral wedge angle (VWA), angle between the superior and inferior endplates of the fractured vertebra; 2. segmental kyphosis Cobb angle (SKCA), angle between the superior endplate of the upper adjacent vertebra and the inferior endplate of the lower adjacent vertebra; 3. anterior edge height ratio of injured vertebra (AEHR= 2 × h2/(h1 + h3) × 100%), anterior edge height ratios between the fractured vertebra and the average of two adjacent vertebrae; 4. intervertebral height index (IHI = (ac + bd)/(ab + cd) × 100%).

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Statistics

Descriptive statistics were summarized for all variables as means and standard deviations (SD) for continuous variables, and percentages for categorical variables. The Kolmogorov–Smirnov Test was performed to assess the normal distribution of the data. Inferential statistics for bivariate analyses were performed using t-tests and chi-squared tests. A confidence level of 95% was used for this study. Data were analyzed using SPSS (version 22.0; IBM, Armonk, NY, USA).

Ethics

This study complies with the Declaration of Helsinki ethical standards, and all of the study procedures were approved by the Ethics Committee of the PLA General Hospital. Written informed consent was obtained from all the patients before inclusion.

Results

Demographic and Fracture Characteristics

A total of 57 patients with a mean age of 68 years (range 65–78) were included in the study. We divided the patients into 2 groups based on whether they underwent implant removal after fracture healing. The implant removal group comprised 30 patients who had their spinal hardware removed between 10 and 15 months after the initial surgery and the implant retention group comprised 27 patients. The demographics, injury mechanisms, fracture levels, follow-up times, and AO spine fracture classification are shown in Table 1. Means and standard deviations (SDs) were calculated for each continuous variable, and proportions for each categorical variable. We then used the Kolmogorov–Smirnov test to test the normality of the distribution of each continuous variable. Both groups had similar demographic characteristics, as

Table 1 Demographic Characteristics and Spine Fracture Classification of the Implant Removal Group and the Implant Retention Group

	Implant Removal Group (n=30)	**Implant Retention Group (n=27)**	***P*-value**
Gender			0.84
Male	13 (43.3%)	11 (40.8%)	
Female	17 (56.7%)	16 (59.2%)	
Age	68.3±3.2	67.7±2.3	0.38
Body mass index	24.96±1.6	25.34±1.4	0.37
Fractured Level			0.98
T11	4 (13.3%)	3 (11.1%)	
T12	8 (26.7%)	8 (29.6%)	
L1	13 (43.3%)	11 (40.7%)	
L2	5 (16.7%)	5 (18.5%)	
Injury mechanism			0.95
Fall	20 (66.7%)	19 (70.3%)	
Fall from a height	4 (13.3%)	3 (11.1%)	
Others	6 (20%)	5 (18.5%)	

(*Continued*)

Table 1 (Continued).

	Implant Removal Group (n=30)	Implant Retention Group (n=27)	*P*-value
AO classification			0.92
A1	9 (30%)	8 (29.6%)	
A2	4 (13.3%)	2 (7.4%)	
A3	14 (46.7%)	15 (55.5%)	
B1	2 (6.7%)	1 (3.7%)	
B2	1 (3.3%)	1 (3.7%)	
Follow-up time (months)	53.6±8.6	33.7±7.8	<0.01*
Prior spine surgery	2 (6.7%)	1 (3.7%)	0.925

Notes: Data are expressed as n (%). *significant *P*-values were the results after comparison between the two groups.

well as comparable spine fracture patterns. However, the implant removal group a significantly longer duration of follow-up than implant retention group for the known reason (53.6±8.6 months versus 33.7±7.8 months, $p<0.01$).

Clinical Outcome Measures

Clinical outcome data (ODI and VAS) were collected at 1, 3, 6, 12, months postoperatively and latest follow-up. No significant differences were observed between the two groups in the mean VAS and ODI values at the 12-months postoperative follow-up (Table 2). The mean ODI values at the latest follow-up were 11.4±6.6 (implant removal group) versus 10.6±5.1 (implant retention group) ($p=0.59$), and the mean VAS scores were 1.23±1.55 (implant removal group) versus 1.37±1.60 (implant retention group) ($p=0.74$). The incidence of RCBP was slightly higher in the implant retention group (25.9%, 7/27) than that in the implant removal group (20%, 6/30). However, there were no significant differences in the postoperative RCBP between the two groups with respect to implant removal or retention ($p=0.59$). In the implant

Table 2 Clinical Outcomes in the Implant Removal Group and the Implant Retention Group

	Implant Removal Group (n=30)	Implant Retention Group (n=27)	*P*-value
Visual Analog Scale (VAS)			
Pre-operative	7.23±1.38	7.44±1.30	0.56
Post-operative	3.53±0.89	3.74±1.06	0.43
1 month	2.60±0.93	2.70±0.95	0.68
3 months	2.23±1.04	2.26±1.16	0.93
6 months	1.77±0.97	1.81±1.18	0.87
12 months	1.43±1.19	1.44±1.34	0.97
Latest follow-up	1.23±1.55	1.37±1.60	0.74

(*Continued*)

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Table 2 (Continued).

	Implant Removal Group (n=30)	Implant Retention Group (n=27)	*P*-value
Oswestry Disability Index(ODI)			0.95
Pre-operative	/	/	/
1 month	45.4±10.9	43.3±12.8	0.49
3 months	27.8±8.23	27.4±10.8	0.87
6 months	17.8±7.3	16.8±8.3	0.63
12 months	10.9±6.3	11.7±7.9	0.70
Latest follow-up	11.4±6.6	10.6±5.1	0.59
Residual chronic back pain	20% (6/30)	25.9% (7/27)	0.59
New fractures	2 (6.7%)	1 (3.7%)	0.93

Note: Data are expressed as median(SD) or n (%).
Abbreviations: ODI, Oswestry Disability Index; VAS, Visual Analog Scale.

removal group, 6.7% (2 cases) and 3.7% (1 case) of patients in the implant retention group presented a new fracture (non-significant). No patient experienced screw breakage or required reoperation for hardware repositioning or failure during the follow-up period, and none of the patients in either group required conversion to open surgery or additional subsequent surgery.

Radiological Outcome Measures

The preoperative vertebral wedge angle and segmental kyphosis Cobb angle were comparable between groups (p>0.05). All imaging parameters, such as kyphotic angles and anterior vertebral body height, were measured on standing lateral radiographs during follow-up, and all angles were measured using Cobb's technique. The postoperative SKCA, VWA, and AEHR were significantly corrected compared with these parameters preoperatively in both groups. Both the implant removal and retention groups showed correction loss over time. However, regardless of implant removal, no statistically significant differences were found in the correction loss of SKCA (Figure 2), VWA (Figure 3), or AEHR (Figure 4) between the two groups within the 12-month follow-up period (p> 0.05). We compared the intervertebral height index at

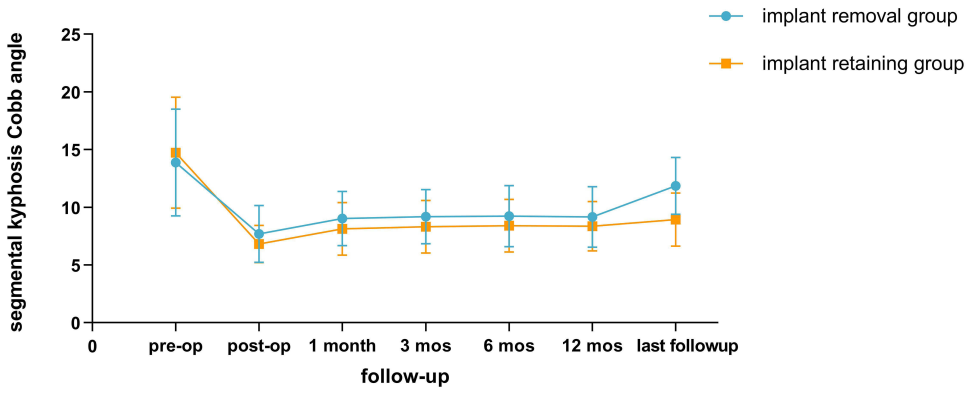

Figure 2 Serial change of the segmental kyphosis Cobb angle (SKCA) of the two groups at various follow-up times.

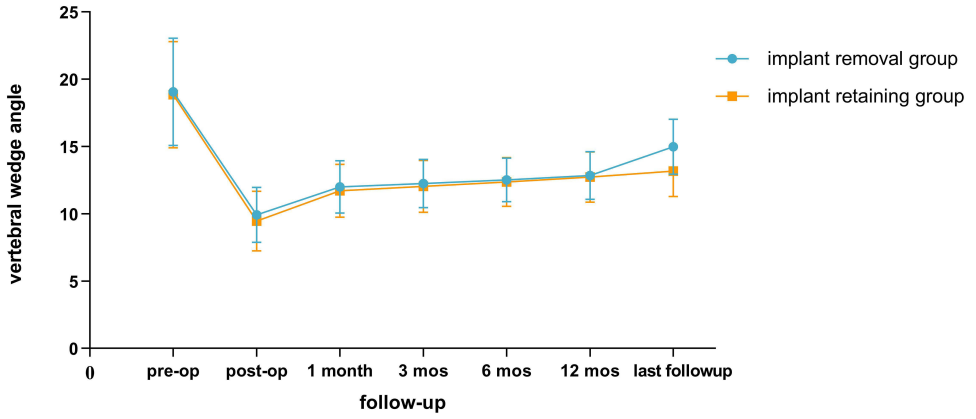

Figure 3 Serial change of the vertebral wedge angle (VWA) of the two groups at various follow-up times.

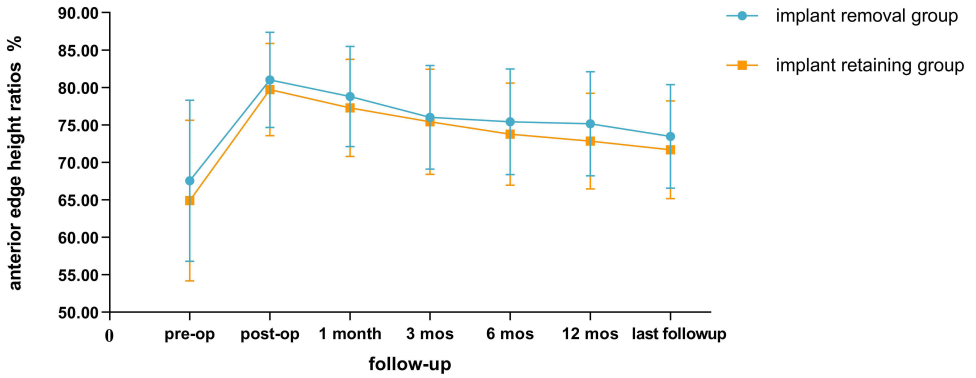

Figure 4 Serial change of the anterior edge height ratio of injured vertebra (AEHR) of the two groups at various follow-up times.

the cranial and caudal adjacent segments within and between the groups at 12 months and final follow-up versus 1 month postoperatively. Interestingly, a significant decline in IHI was observed by paired t-tests within each group during the follow-up period, whereas there were no significant differences between the groups (Table 3).

Table 3 Comparison of Intervertebral Height Index Adjacent to Stabilized Segments (Cranial and Caudal) in the Implant Removal Group and the Implant Retention Group

	Implant Removal Group (n=30)	**Implant Retention Group (n=27)**	***P*-value**
IHI of cranial adjacent segment (%)			
1 month	20.81±2.59	20.75±2.97	0.94
12 months	20.19±2.62	19.95±2.87	0.74
Latest follow-up	19.09±2.18	19.35±3.02	0.71
P-value (12mos vs 1month)	0.006**	<0.0001**	/
P-value (latest follow-up vs 1month)	<0.0001**	<0.0001**	/

(*Continued*)

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Table 3 (Continued).

	Implant Removal Group (n=30)	Implant Retention Group (n=27)	*P*-value
IHI of caudal adjacent segment (%)	45.4±10.9	43.3±12.8	
1 months	30.88±5.42	30.95±4.92	0.96
12 months	30.46±5.53	29.54±4.59	0.50
Latest follow-up	29.71±5.68	28.33±4.48	0.32
P-value (12mos vs 1month)	0.011*	<0.0001**	/
P-value (latest follow-up vs 1month)	<0.0001**	<0.0001**	/

Notes: Data are expressed as median(SD). *Significant difference ($p < 0.05$); **Significant difference ($p < 0.01$) between 12 months post-operatively/latest follow-up and 1 month in each group using the paired *t*-test.
Abbreviation: IHI, intervertebral height index.

Discussion

The surgical options for elderly patients with thoracolumbar fractures include posterior segmental fixation and percutaneous cement augmentation techniques.[5,6] The decision on whether vertebral augmentation or instrumented fixation should be performed depends on the patient's age, bone quality, fracture morphology, reduction success, and resulting stability. The literature suggests that osteoporotic burst fracture with posterior wall breach is contraindicated for vertebroplasty because pressurized application of polymethyl methacrylate (PMMA) can lead to cement extravasation into the spinal canal, causing radicular compression symptoms, neurological deficits, and pain.[7] Bone cement implantation syndrome (BCIS) may develop during surgical interventions that use PMMA, manifesting as hypoxemia, hypotension, and unexpected loss of consciousness.[8] Bone cement augmentation also changes the load transfer mechanism remarkably and permanently, with increased stresses and strains in the vicinity, leading to postoperative refractures.[9] Instrumented stabilization is advised for fractures with severe collapse that leads to increased kyphosis. Instrumentation surgeries for elderly patients can be difficult and controversial, mainly because of the poor pedicle screw hold between the screw thread and osteoporotic vertebral bone, which is associated with a high rate of hardware failure.[10] Clinicians should thus be cautious when using instrumented stabilization in elderly patients whose fractures occur following trivial daily activities with no significant trauma. In the present study, patients who fulfilled the eligibility criteria and underwent PPSF had relatively good bone quality, although osteoporotic bone loss is the most common aging phenomenon. All the patients in our series had a history of low-energy trauma, mostly caused by simple falls. Another concern is that conventional open spinal decompression and stabilization in elderly patients has significant morbidities related to age, surgical approach, and blood loss. However, open surgical procedures are progressively being replaced by minimally invasive procedures.[11] PPSF for treating thoracolumbar fractures is increasing in popularity owing to its numerous potential advantages, including reduced length of stay, blood loss, requirement for postoperative analgesia, and earlier return to full weight-bearing ambulation.

Treating monosegmental type A or B TL fractures with reduction and posterior fixation is adequate without the use of bone grafting for definitive fusion. The hardware functions as a temporary internal brace. Patients who have undergone percutaneous fixation and whose fracture has completely healed require scheduling a second hardware removal procedure in routine clinical practice. Most investigators suggest that the appropriate time for hardware removal is 10 months to 1 year after the injury and operative fixation. However, there is a lack of evidence regarding the necessity for implant removal in all age groups.

The main principle of hardware removal once a fracture has healed is to prevent implant failure secondary to stress shielding. Instrumentation itself can bear load, thereby shifting the load away from the anterior spinal column of the immobilized segments and increasing the risk of metal fatigue failure.[12] However, hardware failure is less likely in the trauma population than in patients with degenerative spine disease, given that the thoracolumbar spine is a transition

from a rigid and less mobile thoracic spine to a more flexible caudal lumbar spine. Sanderson et al[13] and Chou et al[14] reported a 14% and 36.3% incidence of screw breakage, respectively, in short-segment fixation of thoracolumbar burst fractures without fusion; however, both suggested that routine removal of the implants may not be necessary because functional and radiological outcomes were similar in the implant retention and removal groups. Contrary to their findings of high hardware failure rates, in our series, no mode of implant failure, including breakage, bending, or pulling out of screws, was encountered after a mean follow-up of 33.7 months. The variation in the respective outcomes can be explained by the variations in the patient samples. The mean age at the time of injury was 33.1 years and 45.3 years in Sanderson and Chou's studies, respectively, whereas the inclusion criteria included patients aged ≥65 years and a mean age of 68 years in our series. In elderly patients, a diminished pedicle screw is held between the screw thread and trabeculae of the vertebral bone. Impaired screw purchase leads to a weaker bone/metal interface, consequently reducing the stress-shielding effect. In addition, in younger patients, a more active lifestyle could lead to increased stress on the implants, which in turn may lead to higher failure rates. The elderly population had lower physical activity levels and intensities than the younger population. In the Chinese culture, elderly people who underwent spine surgery seemed more inclined to have decreased physical and socially active lifestyles, reducing vulnerability and the risk of falling. Similar to our findings, Neeley et al[4] reported 76 patients with a mean age of 60 years who were treated with percutaneous fixation for traumatic thoracolumbar fractures, with only twenty-five patients had instrumentation removed after the fracture had healed. None of the patients required reoperation for hardware repositioning or failure during the 2-year follow-up period. Xu et al[15] analyzed 50 patients with a mean age of 69.4, whose implants were retained after open or percutaneous posterior fixation for TL fractures. Only two patients experienced asymptomatic screw breakage, and no significant differences were found in the functional and radiological outcomes between the implant removal and retaining groups.

However, the potential development of adjacent segment pathology due to implant retention is concerning. Implant stiffness could shift the shear loads by one level above and below the instrumented segment, which is thought to accelerate degeneration at adjacent motion levels. Theoretically, if the hardware is kept in place perpetually, it could ultimately lead to an arthrodesis-like effect, thus also resulting in accelerated degeneration of the adjacent disc degeneration.[16,17] Instrumentation removal can minimize the risk of early adjacent segment degeneration. However, despite extensive research, the pathogenesis of adjacent segment degeneration/disease following spinal fusion is still unclear and tremendously challenged by its multifactorial etiology. Correlating singular variables and their potential impact on the development of this pathology is difficult. To date, the clinical evidence of adjacent disc degeneration and posterior fixation without fusion has been inconsistent.[18,19] Recent studies have emphasized that preexisting degenerative adjacent-level changes have a higher risk of subsequent deterioration after posterior fixation. There is a lack of consensus as to whether hardware removal helps prevent adjacent segment degeneration at the thoracolumbar spine, which has a comparatively lower incidence of natural degenerative disease than the cervical and lumbar spine. Long-term implant retention inevitably results in micromotion at the bone-implant interface during cyclic axial and torsional loading, subsequently decreasing hardware stiffness post-implantation. Compared with younger adults with relatively good bone quality, less load on the instrumented segments was transferred to the adjacent segment in elderly patients because of the weaker bone-metal interface. Reduced rigidity leads to topping-off effects, such as in dynamic stabilization devices, which can prevent the progression of degenerative changes at adjacent levels.[20] Several recent studies have shown that hardware retention does not lead to subsequent adjacent segment degeneration.[4,14,15] The results of our study are consistent with these studies.

Correction loss of kyphotic angle or vertebral body height is a common manifestation of TL fractures after posterior fixation. Kocanli et al[21] reported that for patients with a mean age of 30 years, a significant correction loss was found in late postoperative sagittal plane kyphosis and anterior wedge angle compared to the early postoperative period. Correction loss was usually observed before fracture healing was achieved and was negatively correlated with clinical outcomes. Chou et al[14] concluded that correction loss of the kyphotic angle and vertebral body height were unrelated to implant removal in 69 patients after a mean follow-up of 66.2 months. In our series, remarkable postoperative correction of global kyphosis and slight correction loss during follow-up were observed in both the implant removal and retention groups, with no significant difference. Another cause of implant removal is "implant-related" pain of unknown origin, which can be attributed to metal fretting, corrosion, or an allergic response to metalwork. However, there remains a lack

of consensus on the benefits and risks of removal of instrumentation for pain.[1,22,23] In the present study, there was no evidence that patients with hardware retention after PPSF were prone to residual back pain. Patients who suffer from RCBP should be informed that back pain might not be sufficiently relieved after the successful removal of their instruments.

Limitations

This study has some limitations. First, our data collection and analysis were retrospective, and the results were subject to recall and selection bias. In response to COVID-19, only elderly patients who declined implant removal surgery to decrease the risk of SARS-CoV-2 transmission were eligible to be included in the retention group. This retrospective study involving subgroups divided by surgery time may have selection bias. Second, spinal alignment and ASD occurrence were measured based on plain radiographs in this study, which would be beneficial for evaluating facet joint integrity or disc degeneration using additional MRI or CT scans. Third, the number of patients was limited and the follow-up time was short. Larger multicenter studies with longer follow-up periods and the inclusion of relevant confounding factors that could affect traumatic TL fracture measurements and management decisions are necessary.

Conclusion

Our findings support the hypothesis that PPSF and instrumentation retention for TL fractures result in high levels of satisfaction in elderly patients (>65 years old), contrary to what was previously anticipated, and are not associated with a higher rate of implant-related complications. Despite the limitations mentioned and given the reported patient outcomes, we would suggest that instrumentation removal is not always required following minimally invasive percutaneous screw-rod stabilization for thoracolumbar fractures, considering the relatively high risk of general anesthesia in the elderly and more medical expenses that are required in the second removal surgery. However, patients should be sufficiently informed about the potential occurrence of implant-related complications.

Author Contributions

CZ: All aspects of the work, including surgery, the conception, study design, radiostereometry, and interpretation of the results. CX: the conception, surgery, execution, study design, data collection, and statistical analyses. DR contributed to the study design, surgery, and data collection. All authors took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare no competing interests.

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