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ORIGINAL STUDY

Treatment of thoracolumbar burst fractures : short-segment pedicle instrumentation versus kyphoplasty

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The management of amyelic thoracolumbar burst fractures remains controversial. In this study, we compared the clinical efficacy of percutaneous kyphoplasty (PKP) and short-segment pedicle instrumentation (SSPI).

Twenty-three patients were treated with PKP, and 25 patients with SSPI. They all presented with Type A3 amyelic thoracolumbar fractures. Clinical outcomes were evaluated by a Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) preoperatively, postoperatively, and at two years follow-up. Radiographic data including the anterior and posterior vertebral body height, kyphotic angle, as well as spinal canal compromise was also evaluated.

The patients in both groups were similar regarding age, bone mineral density (BMD), follow-up period, severity of the deformity and fracture. Blood loss, operation time, and bed-rest time were less in the PKP group. VAS, ODI score improved more rapidly after surgery in the PKP group. No significant difference was found in VAS and ODI scores between the two groups at final follow-up ($p > 0.05$). Meanwhile, the height of anterior vertebrae (Ha), the height of posterior vertebrae (Hp) and the kyphosis angle showed significant improvement in each group ($p < 0.05$). The postoperative improvement in spinal canal compromise was not statistically significant in the PKP group ($p > 0.05$) ; there was a significant improvement in the SSPI group ($p < 0.05$). Moreover, these postoperative radiographic assessments showed significant differences between the two groups regarding the improvement of canal compromise ($p < 0.05$). At final follow-up, remodeling of spinal canal compromise was detected in both groups.

Conclusion : Both PKP and SSPI appeared as effective and reliable operative techniques for selected amyelic thoracolumbar fractures in the short-term. PKP had a significantly smaller blood loss and shorter bed-rest time, but SSPI provided a better reduction. Long-time studies should be conducted to support these clinical outcomes.

Keywords : type-A3 amyelic thoracolumbar fractures ; kyphoplasty ; short-segment pedicle instrumentation ; clinical outcomes.

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INTRODUCTION

The annual incidence of spinal fractures was reportedly about 64 per 100,000 population in a Canadian study made 30 years ago (*11*). Traumatic injuries are leading causes of spinal fractures. In more than half of the cases, spinal fractures affect the thoracolumbar junction (*11,22*). Magerl *et al* (*16*) classified vertebral fractures into three types : Type A (vertebral compression fractures), Type B (anterior and posterior element injuries with distraction), and Type C (anterior and posterior element injuries with rotation). The most common thoracolumbar fractures are type A fractures, which are distinguished into three subgroups : A3.1 (incomplete), A3.2 (complete), and A3.3 (burst/split fracture).

Nowadays, many techniques are available for managing unstable burst fractures in patients without any neurological deficit. Short segment pedicle instrumentation (SSPI) exhibits satisfactory results, instrumenting only one vertebra above and one vertebra below the fracture ; it is still popular for these lesions (*27*). In recent days, percutaneous kyphoplasty (PKP) has been widely used in the treatment of vertebral compression fractures. Several studies have suggested that PKP could be used in the treatment of burst fractures without any neurological deficits (*2,15*). The purpose of this study is to compare the clinical effectiveness of percutaneous kyphoplasty (PKP) and short-segment pedicle instrumentation (SSPI) in the treatment of painful thoracolumbar burst fractures without neurological deficit.

MATERIALS AND METHODS

From January 2008 to January 2009, a retrospective study was conducted on 48 patients who had type-A3 amyelic thoracolumbar fractures and were treated by PKP or SSPI. Twenty-three patients (16 women and 7 men, aged 58 to 72 years, mean age 63.7 years) underwent PKP, and 25 patients (18 women and 7 men, aged 60 to 78 years, mean age 65.2 years) underwent SSPI. All patients had fresh primary burst fractures, and they did not exhibit any neurological symptoms. Plain radiographs and computed tomography (CT) scans showed posterior column fractures with spinal compression.

Surgical techniques

All surgeries were performed in the prone position under general anaesthesia.

Kyphoplasty

Procedures were performed with the Kypho system (Kyphon Inc, Sunnyvale, USA) and bone filler (polymethylmethacrylate, PMMA). A bilateral transpedicular approach was used in all PKP cases. After achieving satisfactory inflation of the balloon, the latter was removed. PMMA was subsequently filled into the intra-vertebral cavity. The average PMMA volume was 4.6 ml (range : 2.3-6.9 ml).

Short-segment pedicle instrumentation (SSPI)

The approach was midline posterior in all patients. Pedicle screws were used bilaterally. These screws were fixed at the superior and inferior levels of the fracture. After performing successful screws placement, indirect reduction was achieved by inserting a contoured rod. The reduction procedure included the following steps : correction of kyphosis, lordotic distraction for further reduction of the vertebral height and intra-canal fragment, and rigid locking of all the nuts. The pedicle screws were removed by the same surgeon after 1 to 1.5 years.

Statistical analysis

Using SPSS 16.0 software, we compared the following parameters : VAS scores, ODI, Ha, Hp, the kyphosis angle, and spinal canal compromise of patients treated with PKP and SSPI, respectively. The comparisons included the data compiled at the preoperative and postoperative stages. Clinical parameters were also compared during the 2-year follow-up period. In addition, the preoperative general condition, blood loss, operation time, and bed-rest time were compared. Student's t test was used for statistical analyses ; the significance level was set at $p < 0.05$.

RESULTS

There was no statistically significant difference between the two groups regarding the following parameters : age, bone mineral density, preoperative VAS, ODI, Ha, Hp, kyphotic angle, and spinal canal compromise (Table I).

Table I. — Preoperative general conditions

Items	PKP (n = 23)	SSPI (n = 25)	*P*-value
Age	63.7 ± 5.8	65.2 ± 7.7	0.071
BMD	– 1.3 ± 0.9	– 1.2 ± 1.2	0.701
VAS	8.0 ± 1.0	7.8 ± 0.9	0.472
ODI (%)	68.4 ± 8.9	66.1 ± 9	0.392
Ha (%)	64.1 ± 14.8	62 ± 10.5	0.578
Hp (%)	87 ± 8.7	85.2 ± 8.8	0.466
Kyphotic angle	16.9 ± 9.1	17.1 ± 7.1	0.903
Spinal canal compromise (%)	26.1 ± 4.2	25 ± 5.8	0.471

Table II. — Operation time, blood loss, and bed-rest time

Items	PKP (n = 23)	SSPI (n = 25)	*P*-value
Op time (min)	47.8 ± 5.8	84.2 ± 13.9	< 0.05
Blood loss (ml)	10.8 ± 5.6	245.2 ± 74.1	< 0.05
Bed-rest time (d)	1.7 ± 0.7	45.6 ± 10	< 0.05

All procedures were performed uneventfully. The estimated blood loss (10.8 ± 5.6 ml vs 245.2 ± 74.1 ml, $p < 0.05$), operation time (47.8 ± 5.8 min vs 84.2 ± 13.9 min, $p < 0.05$), and bed-rest time (1.7 ± 0.7d vs 45.6 ± 10 d, $p < 0.05$) were less in patients treated with the PKP technique (Table II).

In the PKP group, the preoperative VAS improved from 8 ± 1 to 2.8 ± 0.7 ($p < 0.05$) after surgery ; it remained at 2.3 ± 0.6 at final follow-up. In the SSPI group, preoperative VAS improved from 7.8 ± 0.9 to 5.8 ± 1.2 after surgery and at 2 ± 0.7within the 2-year period of follow-up ($p < 0.05$). In the PKP group, the preoperative ODI score improved from 68.4 ± 8.9% to 34.2 ± 3.2% postoperatively ($p < 0.05$) ; it remained at 33.9 ± 5.1% during the 2-year period of follow-up. In the SSPI group, the ODI score changed from 66.1 ± 9% preoperatively to 58.2 ± 5.9% postoperatively ($p < 0.05$), and decreased to 34 ± 4% at the final follow-up ($p < 0.05$). While comparing the two groups, it was found that there were significant differences in the early postoperative VAS and ODI scores ($p < 0.05$). However, there were no significant differences at final follow-up ($p > 0.05$) (Table III).

Preoperative, postoperative, and 2-years follow-up radiographic data were assessed (Fig. 1 & 2, Table IV) The mean Ha increased from 64.1 ± 14.8% preoperatively to 80.7 ± 12% postoperatively in the PKP group ($p < 0.05$), and from 62 ± 10.5% preoperatively to 97.1 ± 4.3% ($p < 0.05$) in the SSPI group. The mean Hp increased from 87 ± 8.7% preoperatively to 92.2 ± 6.0% postoperatively in the PKP group ($p < 0.05$), and from 85.2 ± 8.8% preoperatively to 98.7 ± 3.8% in the SSPI group ($p < 0.05$). The kyphosis angle was restored from 16.9 ± 9.1° preoperatively to 11.9 ± 7.9° postoperatively in the PKP group ($p < 0.05$), and from 17.1 ± 7.1° preoperatively to 4.2 ± 3° operatively in the SSPI group ($p < 0.05$). The spinal canal compromise was restored from 26.1 ± 4.2% preoperatively to 25.8 ± 4.0% postoperatively in the PKP group ($p > 0.05$) and from 25 ± 5.8% to 11.9 ± 1.9% in the SSPI group ($p < 0.05$). The difference between the two groups was significant ($p < 0.05$). At final follow-up, loss of vertebra height was detected to some extent. Remodeling of the spinal canal compromise was also detected in both groups.

Complications

In both groups, no neurological deficit occurred after surgery. In the PKP group, cement leakage occurred in 4 cases ; the cement leak was into the pre-vertebral soft tissue of 1 patient, the epidural

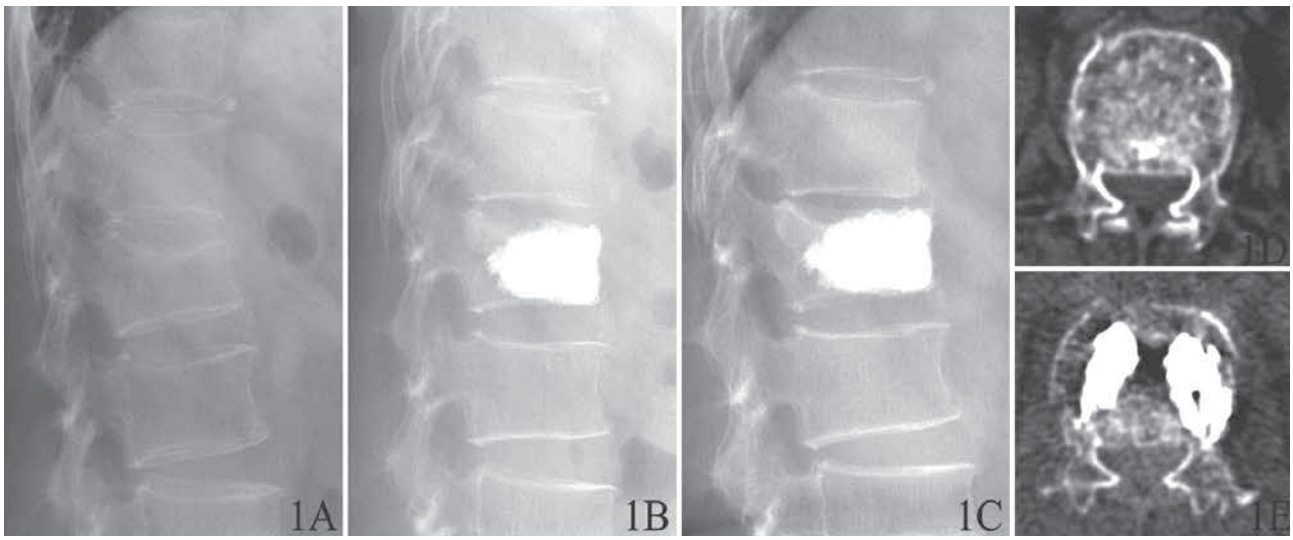

Fig. 1. — A 64-year-old man was managed by PKP after sustaining a L1 burst fracture after a fall from a height. Preoperative lateral radiograph (1A) showed loss of Ha, Hp, and kyphosis angle, and CT showed spinal canal compromise (1D). Postoperative lateral radiograph (1B) showed restoration of Ha, Hp, and kyphosis angle, and CT after PKP (1E) showed the improvement in spinal canal compromise. The final follow-up lateral radiograph (1C) showed a small loss of correction.

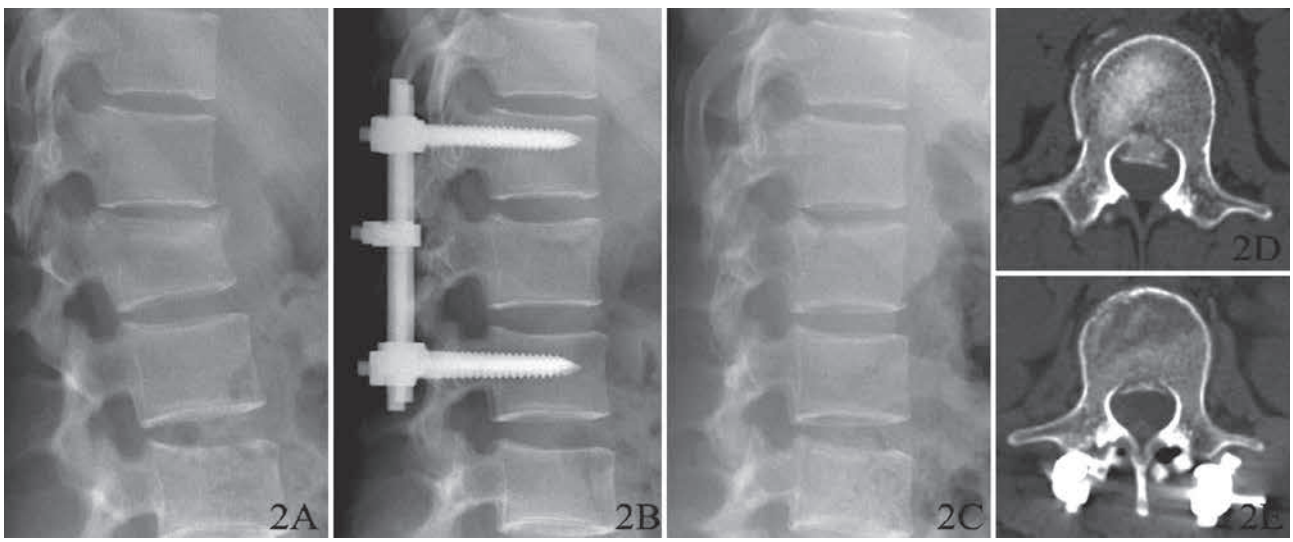

Fig. 2. — A 62-year-old man was managed by SSPI after he sustained a burst fracture of L2 vertebral body after a fall from a height. Preoperative lateral radiograph (2A) showed loss of Ha, Hp, and kyphosis angle, and CT showed spinal canal compromise (2D). Postoperative lateral radiograph (2B) showed restoration of Ha, Hp, and kyphotic angle, and CT after SSPI (2D) showed restoration of spinal canal compromise. The final follow-up lateral radiograph (2C) after removal of pedicle screws showed a small loss of correction.

space in 1 patient and into disk space in the other patients. However, no clinical symptoms were observed in the postoperative period and 2-year period of follow-up. In the SSPI group, we did not come across any complication in patients.

DISCUSSION

The main objectives in treating vertebral fractures are as follows : early neurological restoration, anatomical repair of damaged spinal segments, and

Table III. — Improvement of VAS and ODI postoperatively and 2-years follow-up (FU)

	VAS			ODI		
	Preop	Postop	2-years FU	Preop	Postop	2-years FU
PKP	8 ± 1	2.8 ± 0.7[a]	2.3 ± 0.6[b]	68.4 ± 8.9	34.2 ± 3.2[a]	33.9 ± 5.1[b]
SSPI	7.8 ± 0.9	5.8 ± 1.2[c]	2 ± 0.7[d]	66.1 ± 9	58.2 ± 5.9[c]	34 ± 4[d]

[a]P, [b]P, [c]P, [d]P < 0.05, *in comparison to preoperative scores*.
[a]P vs [b]P > 0.05, [c]P vs [d]P < 0.05.
[a]P vs [c]P < 0.05; [b]P vs [d]P > 0.05.

Table IV. — Restoration of Ha, Hp, kyphotic angle, spinal canal compromise postoperatively and at final follow-up

Items	PKP			SSPI		
	Pre-op	Post-op	2-years FU	Pre-op	Post-op	2-years FU
Ha (%)	64.1 ± 14.8	80.7 ± 12[a]	80.2 ± 12.3[a]	62 ± 10.5	97.1 ± 4.3[b]	94.3 ± 3.2[b]
Hp (%)	87 ± 8.7	92.2 ± 6[a]	91.7 ± 6.1[a]	85.2 ± 8.8	98.7 ± 3.8[b]	96.7 ± 3.4[b]
Kyphotic angle (°)	16.9 ± 9.1	11.9 ± 7.9[a]	12.6 ± 10[a]	17.1 ± 7.1	4.2 ± 3[b]	5.3 ± 3.7[b]
Spinal canal compromise (%)	26.1 ± 4.2	25.8 ± 4.0[c]	19 ± 3.4[a]	25 ± 5.8	11.9 ± 1.9[b]	9.6 ± 2.3[b]

[a]P, [b]P < 0.05, *in comparison to preoperative scores*.
[c]P > 0.05, *in comparison to preoperative scores*.
[a]P vs [b]P < 0.05, [c]P vs [b]P < 0.05.

stable fixation. Attaining these objectives helps in rehabilitating patients at an early stage (*13*). However, the treatment of thoracolumbar burst fractures is still controversial. Many authors recommended conservative management (*5,21,24*), such as bed-rest, braces, or physical therapy ; however, this is not likely to restore the original vertebral height. Moreover, it is difficult to achieve pain relief immediately. What is even more worrying is that patients will lose much more bone mass owing to cessation of normal activities. Another vertebral fracture can also be triggered with this loss in bone mass. Besides, Tropiano *et al* (*26*) suggested that prolonged bed rest increases the risk of thromboembolism, decubitus ulcers, pulmonary complications, and deconditioning.

Posterior short-segment pedicle instrumentation is a widely used technique in the treatment of unstable thoracolumbar fractures. It not only provides distraction and compression forces that facilitate three-dimensional correction and firm fixation, but it also preserves motion segments. It can offer several advantages : immediate stability, restoration of the vertebral height and deformity angle, and prevention of late neurological injury. However, short segment pedicle instrumentation has been associated with a high rate of failure (*4,17,18*). The latter is usually associated with implant failure and loss of reduction of kyphosis. Nevertheless, it is still considered as a superior method for treating thoracolumbar burst fractures (*23*).

Vertebroplasty and kyphoplasty are novel techniques used in the treatment of osteoporotic thoracolumbar burst fractures. Galibert *et al* (*10*) at first treated vertebral haemangioma by percutaneous vertebroplasty. Thereafter, vertebroplasty has been widely used to treat vertebral haemangiomas, osteolytic vertebral metastases, and vertebral compression fractures. Kyphoplasty was derived from vertebroplasty ; it can reduce the rate of cement leakage and achieve better kyphosis reduction. However, in patients with thoracolumbar burst fractures, there are many clefts in the posterior wall of the vertebral body. Therefore, physicians continue to consider the vertebroplasty technique as relatively contraindicated in the treatment of thoracolumbar burst fracture (*2,15,20*). During the PKP procedure, inflation of the balloon may compress the cancellous bone and thus cover the clefts to some extent. The ligament and soft tissue around the vertebrae have the ability to prevent cement leakage. In this study, although 4 patients had cement leakage, no clinical symptoms

were observed. Some authors also reported that PKP is a safe and effective technique which can be used in the treatment of thoracolumbar burst fractures (*3,6*). It is noteworthy that we have not come across any cases, where the symptoms have worsened after performing a PKP procedure.

Does the displaced fragment worsen spinal canal compromise without decompression and fragment removal ? In case of patients treated with PKP, the cement may leak into the spinal canal. Furthermore, owing to the pressure exerted by the balloon for creating the cavity, the leaked cement might compress the fragment into the spinal canal in the presence of an unstable posterior vertebral wall. Compared with PKP, after indirect posterior reduction and instrumentation without fusion (*28*), SSPI provides better restoration of spinal canal compromise. SSPI makes the partially displaced fragment return toward the vertebral column. This minimizes the possibility of deterioration in spinal canal compromise. However, some authors (*9,19*) have reported spontaneous remodeling of the spinal canal in thoracolumbar burst fractures. Limb *et al* (*14*) concluded that there is no correlation between bony or canal disruption and the degree of neurological compromise. According to another study conducted in our hospital, individual surgical techniques can decrease the risk of bone cement leakage with the help of dynamic C-arm X-ray monitoring. The leakage of cement has been associated with compression and thermal injury to the spinal cord and nerve root (*29*). Therefore, we propound that it is unnecessary to remove the displaced fragment from the spinal canal while treating thoracolumbar burst fractures without neurological deficit.

The values of Ha, Hp, and kyphotic angle improved significantly postoperatively in each group. However, when comparing patients treated with PKP and SSPI techniques, we found that there were significant differences in the post-operative values of these parameters between the two groups. The results suggest that SSPI is better in restoring these radiological parameters. SSPI achieves remarkable reduction by restoring the tension of the posterior longitudinal ligament with the help of contoured rods. Thus, SSPI is helpful in returning the displaced fragment to the vertebrae. When imaging of the posterior vertebral body wall showed a continuous and smooth "one-line sign" under lateral fluoroscopy during operation, we considered it to be reduced. Huilin Yang *et al* (*28*) made a prospective study of 25 patients with thoracolumbar burst fractures, who underwent fluoroscopically-guided indirect posterior reduction and fixation without fusion. These patients achieved satisfactory reduction, wherein the vertebral height was almost restored to its original height after operation. PKP creates a cavity, elevates the endplates, and fills the cavity with bone cement to increase the solidity of the fractured vertebra. When the bone cement reached the lateral margin, the filling process was stopped immediately. Because of the danger of cement leakage and limited reduction through balloon inflation, PKP cannot achieve the same reduction effect as SSPI.

In this study, all patients showed loss of correction to a certain extent. This was more pronounced in case of regional kyphosis, which could be attributed to disc degeneration. Disc degeneration is often encountered in patients diagnosed with this type of fracture. Screw misplacement can also decrease the original spinal stability provided by the instrumentation, thereby leading to a loss of correction (*1*). According to some authors, both bone and implant failure are the mechanisms of correction loss (*7*). In such fractures, the process of degeneration is accelerated owing to various factors, such as the injury of the intervertebral disk and change in intravertebral pressure after fixation. These factors have the potential to alter the mechanical environment associated with disk nutrition (*8*). However, several research studies (*12,25*) did not find any correlation between radiological assessments of kyphosis and functional results. Our findings also suggest that patients showed satisfactory functional evaluation and pain relief at final follow-up. However, we also noted a slight loss of vertebral height at progressive stages of the follow-up. Regardless of the type of surgical operation, anti-osteoporosis measures and functional exercise should be implemented to ensure healthy bone mass density. Research studies have proved that these measures are effective in increasing bone mass. They also help in strengthening the low back muscles to prevent the loss of correction.

It has been reported that PKP provides quick relief from back pain in patients with vertebral fractures. In this study, compared with the patients of the SSPI group, the postoperative VAS and ODI score of PKP patients improved significantly more ($p < 0.05$) ; however, after the follow-up period, there was no significant difference in the VAS and ODI scores of both groups ($p > 0.05$). After the final follow-up, all the patients resumed their normal life. PKP is a minimally invasive technique. In this technique, injected bone cement stabilizes the fractured vertebra ; it also reduces the movement of minute fractures. Moreover, it can also damage sensory nerve endings, thus contributing to pain relief. The PKP technique thus has a potential to provide immediate functional restoration. SSPI is a conventional open surgery, and it may damage vertebrae and soft tissue to a certain extent. Moreover, patients treated with SSPI have to undergo prolonged bed-rest. Thus, patients recover and return to their normal life after a longer period of time. While treating type-A3 amyelic thoracolumbar fractures, physicians often prefer PKP to SSPI as it provides pain relief more rapidly.

CONCLUSION

The study showed that both PKP and SSPI are effective and reliable operative techniques to treat selected thoracolumbar fractures. PKP can relieve pain and help patients return back to normal within a short time. Although SSPI provides better reduction outcome, there is no significant difference between PKP and SSPI techniques, when comparing the clinical outcomes after 2 years follow-up. PKP can be used to treat thoracolumbar fractures. It is preferentially used in patients with contraindications to open surgery. However, to evaluate the clinical efficacy of both techniques, the patients should be subjected to a longer follow-up period.

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