Vertebropexy as a Ligamentous Stabilization for Degenerative Low-Grade Spondylolisthesis

A Report of 3 Cases

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Abstract

Case: Three patients with low-grade spondylolisthesis were treated with vertebropexy, a new surgical technique that replaces rigid fusion with ligamentous stabilization. Clinical outcomes, functional radiographs, and magnetic resonance imaging were used to document the early clinical results of this biomechanically established and promising new surgical method.

Conclusion: Vertebropexy may be a valuable alternative to rigid fusion in the treatment of low-grade degenerative spondylolisthesis.

Degenerative lumbar spondylolisthesis is a common pathology with an incidence of up to 6% in the general population[1]. If surgical treatment is needed, decompression alone or decompression with posterior fusion is the commonly used techniques. Decompression alone, while less-invasive and morbid, does not resolve mechanical instability and may predispose patients to further segmental degeneration, worsening back pain and the need for reoperation[2]. By contrast, spinal fusion, which involves internal rigid fixation with pedicle screws and rods with the ultimate goal of bony fusion, positively affects patient outcomes in the short term[3]. However, in the medium to long term, up to 33% of patients require revision surgery in the following years[4] because load redistribution can lead to adverse mechanical consequences within the spine, such as implant-related complications (screw loosening, implant failure), painful pseudoarthrosis, and adjacent segment degeneration[5-7].

Alternative techniques for stabilizing the lumbar spine that do not reduce segmental mobility to a minimum, such as dynamic systems, have not been able to gain acceptance[8]. In search for the optimal surgical technique, a new method (vertebropexy) has been developed based on principles of ligamentous stabilization well known in orthopaedic surgery. In 1999, a first attempt at such ligamentous stabilization using an artificial ligament for degenerative spondylolisthesis was successfully performed[9]. The technique presented here has been biomechanically tested on cadavers before clinical application with promising results[10]: It placed lumbar vertebral body segments in a more stable state than the native baseline.

To the best of the authors' knowledge, there has been no clinical application of a motion-restricting, semirigid fixation method that uses the orthopaedic principle of ligamentous reinforcement to stabilize the lumbar spine hitherto. In this case report, we present the outcome of the first 3 patients who underwent fusionless stabilization of the lumbar spine with a tendon allograft loop, after microsurgical decompression, to counteract the destabilization caused by decompression.

The patients were informed that data concerning their cases would be submitted for publication, and they provided consent. All patients were aware of the experimental nature of the procedure and gave informed consent.

Case Reports

Case 1. A 76-year-old man presented with bilateral gluteal pain and left L4 radiculopathy. After epidural infiltration, the symptoms subsided for 24 hours. Radiographs documented age-related degenerative changes, including low-grade spondylolisthesis (Meyerding[11] grade I) at L4/5, with no apparent instability on functional radiographs (Fig. 1). Magnetic resonance imaging (MRI) of the lumbar spine showed spinal stenosis at L4/5 with pronounced facet arthropathy and additional foraminal stenosis on the left side (Fig. 2).

With increasing symptoms and no response to conservative measures, the patient sought a definitive solution. Decompression surgery without vs. with dorsal fusion was discussed with the patient. Considering the disadvantages of

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Keywords vertebropexy; ligamentous stabilization; fusion; spine

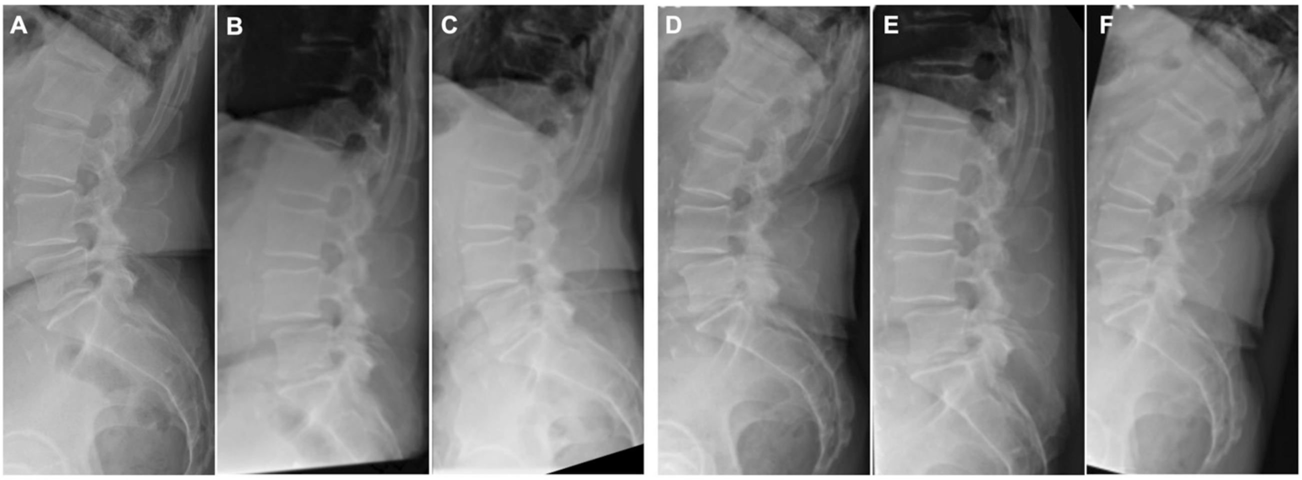

Fig. 1
Case 1: preoperative functional radiographs: upright (**Fig. 1-A**), inclined (**Fig. 1-B**), and reclined (**Fig. 1-C**). Six-month postoperative functional radiographs: upright (**Fig. 1-D**), inclined (**Fig. 1-E**), and reclined (**Fig. 1-F**).

dorsal fusion and the risk of destabilization of the segment by decompression and further advancing the degenerative cascade[12-14], an interspinous vertebropexy was performed. Its principle is based on a ligamentous reinforcement of vertebral bodies using autografts, allografts, or synthetic grafts to restore stability after decompression surgery[15,16].

Case 2 and 3. The second case was a 68-year-old woman with bilateral L5 radiculopathy with recessal stenosis L4/5 due to degenerative spondylolisthesis (Meyerding grade I).

The third case was a 71-year-old woman with right lumboglutalgia due to degenerative spondylolisthesis (Meyerding grade I) L4/5 with resulting spinal stenosis.

After exhaustion of conservative therapy and for the reasons mentioned above, decompression with simultaneous ligamentous interspinous vertebropexy was indicated in both cases.

Surgical Technique

The patients were positioned prone. A midline posterior skin incision was used to expose the spinous processes and laminae of L4 and L5. A bilateral sparing laminotomy (Lamina L5 caudal, L4 cranial) was performed, starting with the symptomatic side and sparing the midline structures. A cranial to caudal flavectomy was performed followed by a standard recessotomy on both sides. After decompression, the descending nerve roots were bilaterally exposed to secure full decompression (Figs. 3-A and 4-B).

The spinous processes were prepared for passage of the allograft by carefully exposing them with a Cobb and drilling a

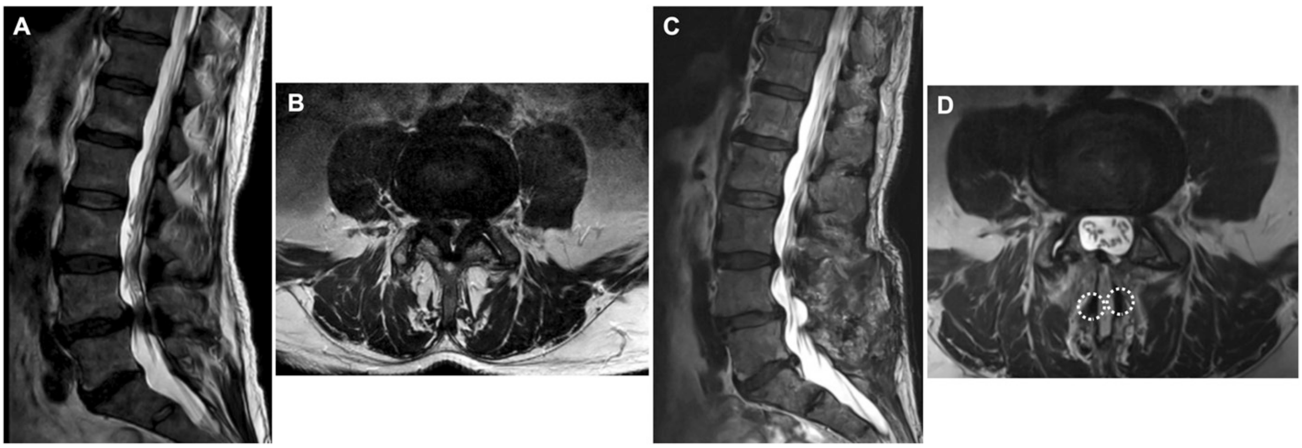

Fig. 2
Case 1: preoperative MRI (T2-weighted) (**Figs. 2-A and 2-B**) showing L4/5 spinal stenosis in the sagittal view (**Fig. 2-A**) and axial view (**Fig. 2-B**). MRI 6 months postoperatively: sagittal view (**Fig. 2-C**) and axial view (**Fig. 2-D**) without residual compression or progression of segmental degeneration with tendon allograft in the spinosus process (white dashed circles). MRI = magnetic resonance imaging.

4 mm hole from side to side through the center of the spinous process with a diamond ball burr. The holes were carefully joined from both sides, taking care to avoid iatrogenic fracture (Figs. 3-A and 4-C). A semitendinosus tendon allograft (AlloSource) was prepared: The allograft was thinned to a maximum diameter of 4 mm to allow for safe passage. The required length of the tendon was measured by passing a suture through the holes in the spinous processes and looping it. The distance on the suture for a loop was measured (Figs. 3-C and 4-C). This distance corresponded to the unreinforced central portion of the tendon graft (Fig. 3-D). The graft was then reinforced: One end of the tendon was reinforced with Fiberwire No. 2 (Arthrex, Naples, Florida) over a length of 2 cm with a Krackow suture[17] (Figs. 3-D and 4-D). The other end of the tendon was similarly reinforced with a Fiberwire No. 2, with the allograft not yet shortened and with a loop in addition to the Krackow suture[17] (Figs. 3-D and 4-D). The allograft was then pulled through the previously drilled holes using a double-loop technique (Figs. 3-E and 4-E). The Fiberwire suture was knotted using the cow hitch technique[18] (Figs. 3-F and 4-F): a double-strand knot configuration with a loop on 1 side secured by 4 half loops. The knot was tightened using a needle holder. Finally, the existing overhang of the tendon was sutured to the looped tendon, and the excess tendon material was removed (Figs. 3-F and 4-G).

The operative time of 90 to 112 minutes was shorter than the average time for dorsal fusion with cage insertion. Blood loss was minimal with a maximum of 150 mL (range: 100-150 mL).

Postoperative Course

All 3 cases showed an unremarkable postoperative course. During the first 4 weeks postoperatively, the patients were carefully mobilized and lifting heavy weights (>5 kg) was limited. Subsequently, physiotherapy exercises were prescribed to gently strengthen the paraspinal muscles with full range of motion. Six months postoperatively, all patients were subjectively highly satisfied. One patient (case 2) reported minimal residual back and leg pain, the other 2 patients were pain-free at the 6-month mark. Radiologic functional imaging showed that the decompressed segment was stable in all cases (Figs. 1-D, 1-E, and 1-F), and MRI excluded residual stenosis or progression of segmental degeneration (Figs. 2-C and 2-D).

Clinical examination included assessment of the Oswestry Disability Index (ODI)[19] and visual analog scale (VAS) for back and leg pain. Figure 5 shows the preoperative baseline values for ODI and VAS, as well as the improvement in ODI, back and leg pain at 4 weeks and 6 months postoperatively.

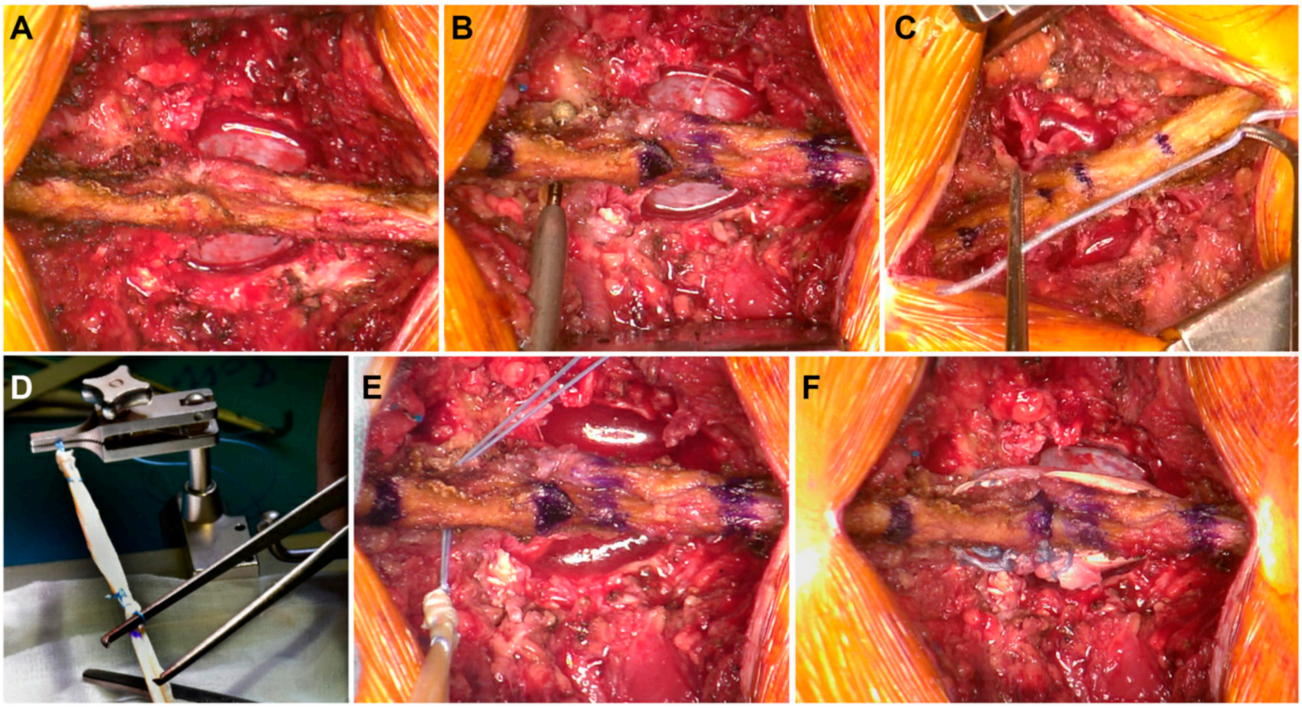

Fig. 3

Intraoperative photographs. **Fig. 3-A** View of the L4/5 segment after decompression. **Fig. 3-B** Diamond burr used to drill a hole in each of the 2 spinous processes. **Fig. 3-C** The required length of tendon allograft was measured by passing a suture through the holes in the spinous process and forming a loop. This distance was measured and corresponded to the unreinforced central portion of the graft. **Fig. 3-D** Reinforcement of the tendon with no. 2 fiberwire. **Fig. 3-E** Passing the graft through the holes. **Fig. 3-F** Final result after looping the graft and tying the sutures.

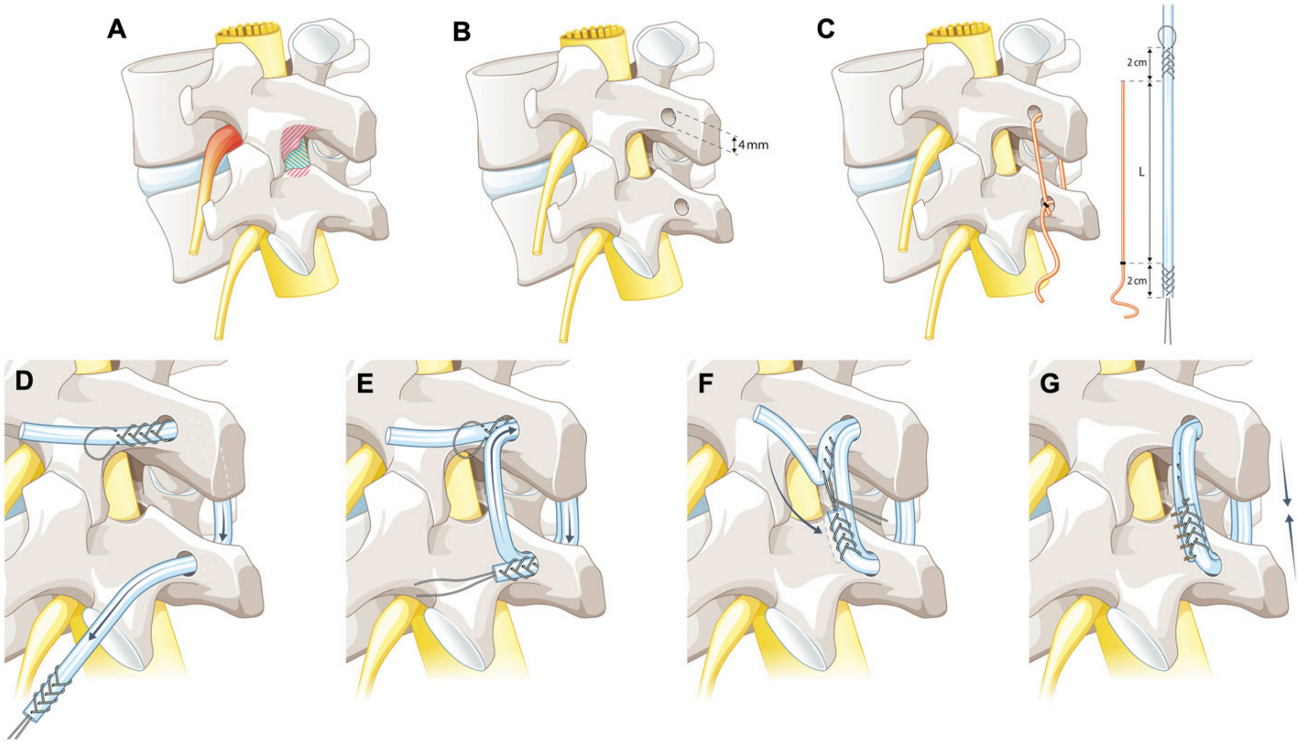

Fig. 4

Illustration of vertebropexy. **Fig. 4-A** L4/5 segment before decompression. **Fig. 4-B** L4/5 segment after decompression and holes drilled in both spinous processes. **Fig. 4-C** The required length of tendon allograft was measured by passing a suture through the holes in the spinous process and forming a loop. This distance was measured and corresponded to the unreinforced central portion of the graft. **Fig. 4-D** Reinforcement of the tendon with Fiberwire No. 2. **Fig. 4-E** Passing the graft through the holes using a double-loop technique. **Fig. 4-F** Fiberwire sutures were tied using the cow hitch technique. **Fig. 4-G** Final result after looping the graft and tying the sutures.

Discussion

We report the first clinical experience with lumbar vertebropexy, a new surgical method based on the principle of ligamentous stabilization. Promising early clinical and radiologic results were obtained, based on a series of previous biomechanical investigations[10,15].

Degenerative spondylolisthesis associated with spinal stenosis often leads to surgery, with good outcomes compared with

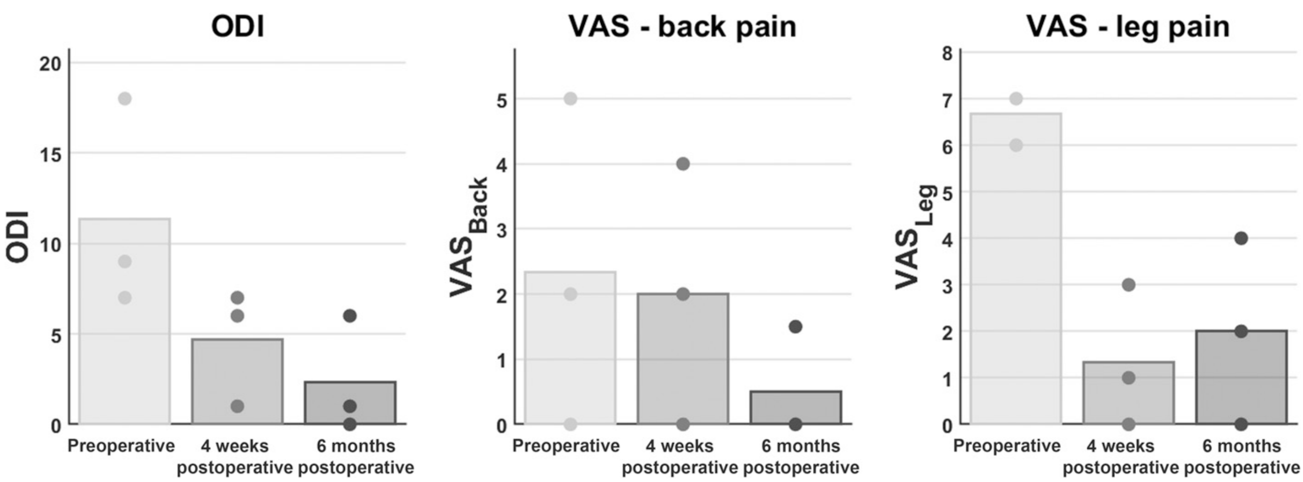

Fig. 5

Clinical outcome parameters: preoperative baseline, 4-week, and 6-month postoperative values. The depicted bars indicate the average patient outcome parameters at each considered time point.

nonsurgical treatment options[20]. Surgical treatment options include decompression alone and decompression with fusion. Furthermore, dynamic stabilization systems (e.g., Dynesys, Total Posterior Spine System) might be another option. However, these have been associated with high screw loosening rates[8,21] and have therefore been abandoned. Clinical parameters such as young patient age, reduced disc height, and increased ODI, as well as radiological parameters such as degree of spondylolisthesis and disc type, have since been identified to guide the decision-making process[22]. However, the problems associated with fusion, such as prolonged postoperative recovery, more surgical complications, higher costs[23], and long-term sequelae such as implant failure, pseudoarthrosis, and adjacent segment degeneration, have not been resolved.

We have developed lumbar vertebropexy based on a previously published case of a fusion-free solution for dropped head syndrome (occipitopexy[24]) and several previously reported biomechanical studies[10,15]. The goal of vertebropexy was to overcome the disadvantages of spinal fusion and provide a solution for situations where some additional stability is needed. Biomechanical testing showed that semirigid ligamentous fixation not only restored native segment stability after decompression but also transferred the segment to a more stable state without immobilizing the segment[17]. The greatest effect was seen in flexion-extension, with a significant reduction of 70% compared with microsurgical decompression[10], making vertebropexy ideal from a biomechanical point of view for the treatment of low-grade spondylolisthesis.

Although promising so far, with only 3 cases described, no superiority of interspinous vertebropexy over decompression alone or even dorsal fusion can be claimed at this time. Furthermore, only very short-term results are presented, and further follow-up is needed before definitive conclusions can be drawn. However, the satisfactory short-term clinical and radiographic results are very promising, especially in situations where the decision to add fusion to decompression is borderline.

Even if long-term results are needed, we believe that reporting early clinical results is important because this technique should be further investigated in a stepwise scientific manner, optimally by different research groups.

Conclusion

In this case series of 3 patients, lumbar vertebropexy for ligamentous stabilization was performed as an adjunctive procedure after decompression to achieve greater segmental stability. The satisfactory clinical and radiologic results at 6 months suggest that this procedure may be a valuable alternative to rigid fusion in the treatment of low-grade degenerative spondylolisthesis. Further studies will be initiated to elucidate long-term results. ■

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