Technical Note

A minimally invasive technique for percutaneous lumbar facet augmentation: Technical description of a novel device

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Abstract

Background: We describe a new posterior dynamic stabilizing system that can be used to augment the mechanics of the degenerating lumbar segment. The mechanism of this system differs from other previously described surgical techniques that have been designed to augment lumbar biomechanics. The implant and technique we describe is an extension-limiting one, and it is designed to support and cushion the facet complex. Furthermore, it is inserted through an entirely percutaneous technique. The purpose of this technical note is to demonstrate a novel posterior surgical approach for the treatment of lumbar degenerative.

Methods: This report describes a novel, percutaneously placed, posterior dynamic stabilization system as an alternative option to treat lumbar degenerative disk disease with and without lumbar spinal stenosis. The system does not require a midline soft-tissue dissection, nor subperiosteal dissection, and is a truly minimally invasive means for posterior augmentation of the functional facet complex. This system can be implanted as a stand-alone procedure or in conjunction with decompression procedures.

Results: One-year clinical results in nine individual patients, all treated for degenerative disease of the lower lumbar spine, are presented.

Conclusions: This novel technique allows for percutaneous posterior dynamic stabilization of the lumbar facet complex. The use of this procedure may allow a less invasive alternative to traditional approaches to the lumbar spine as well as an alternative to other newly developed posterior dynamic stabilization systems.

Key Words: Interspinous, minimally invasive, posterior dynamic stabilization

INTRODUCTION

In this report, we describe the development and use of a novel, percutaneous posterior dynamic stabilization (PDS) system. We additionally present our initial 1-year clinical results with the use of this system. This device, PercuDyn (Interventional Spine, Inc., Irvine, CA), is delivered percutaneously through a paramedian Wiltse type approach where it is then applied bilaterally through the superior articular facets of the inferior body. This device is currently available for clinical use in both the United States and in foreign markets. Biomechanically,
the device serves to augment the posterior elements and stiffen the functional segments. Here it acts as a mechanical stop beneath the inferior articulating facet of the segment. It works to limit extension and therefore prevent further compression of the central canal, spinal foramina, and the lateral recess space. Biomechanically, the device serves to augment the posterior elements and stiffen the functional segments as well. In this report, we provide a technical description of this percutaneous surgical technique, a brief notation of the device biomechanics, as well as the system’s clinical application with our initial 1-year clinical results.

**OPERATIVE TECHNIQUE**

Following induction of general anesthesia or light anesthesia with sedation, the patient is positioned prone in a lordogenic position on a Jackson table or some other compatible radiolucent operative table. We have found that a Jackson table, with its relatively unencumbered area below the table platform, is ideal particularly when targeting the S1 pedicle since the gantry of the C-arm may require it to be positioned at a significant coronal angle with respect to the table. The bilateral paramedian incision sites are localized with anterior-posterior fluoroscopy with the image at the level to the top of pedicle where the device will be implanted. Two approximately 15-mm incisions are opened through skin and fascia, and an access needle is introduced and under fluoroscopy it is placed over the pedicle, ensuring that its tip is exactly positioned at the bottom of the facet [Figures 1a and 1b]. The position of the access needle is verified under fluoroscopy. After that the position is verified, the proximal end of the needle is moved 10° medially and 10° caudally in order to be introduced through the superior articulating process into the pedicle [Figure 1c]. At this point, the location of the access needle’s position is verified with lateral and anterior-posterior fluoroscopy. The access needle is advanced through the pedicle until the tip of the access needle is aligned with pedicle margin. The central trochar of access needle is extracted and a K-wire is introduced and fixed in the bone at the same depth as the access needle [Figure 1d]. The access needle is withdrawn carefully so as not to separate the K-wire from the pedicle as it will serve for the basis for following steps. The teleport dilator is then introduced. In a step-fashion, the tissue is dilated to a larger diameter while maintaining contact with the pedicle [Figure 2a]. After the interior teleport components of the dilator are removed, a 3.0-mm drill is introduced coaxially over the K-wire [Figure 2b]. The drill is then retracted and the K-wire is kept in place. The next step is to make a threaded pathway with a 4.5-mm tap (again without surpassing the K-wire depth) [Figure 2c]. A countersink is then used to shave the inferior portion of the facet and the pedicle. This is done with a 10-mm countersink that will serve as the primary focal point of rotation for the stabilizer [Figure 2d]. A 4.5-mm titanium anchor is then introduced and then anchored in the pedicle [Figures 3a-c]. The anchor is designed with an unlocking mechanism that it is automatically freed from the driver instrument when the ideal depth is achieved. The dilator and the guidewire are now removed. The polycarbonate–urethane stabilizer (PCU) [Figure 4a] is then inserted, thus wedging it beneath the facet complex and thereby supporting this portion of the facet from above [Figures 4b and 4c]. Anterior-posterior and lateral fluoroscopic confirmation of the PCU placement is then affirmed. Full compression of the PCU is then achieved by tapping the stabilizer in place with the slap-hammer provided. At this time, the procedure is then repeated on the contralateral side [Figure 4d]. The incisions are then closed and infiltrated with anesthetic. The final placement of the stabilizer, demonstrating the relationship of the device to the surrounding anatomy as well as the forces acting upon the implant, is shown in Figure 5.

**RESULTS**

Nine consecutive patients, aged 26–75 years of age (mean 49.3 years), including eight males and one female, were treated with the described device. All patients presented with symptomatic disease of the lower lumbar segments (one patient at L3/L4, two patients at L4/L5, and six patients at L5/S1). Operative patients had all failed previous attempts at conservative care. Patients were followed prospectively, with preoperative visual analog scale (VAS) and Oswestry disability index (ODI) scores as well as 1-year follow-up pain and disability scores. No patient was lost to clinical follow-up. Clinical 1-year outcome data are reported in Table 1 for the nine patients treated with this technique.

**DISCUSSION**

In this report, we describe a novel instrumentation system that can be surgically inserted in a truly minimally invasive fashion bilaterally through two paramedian muscle-splitting 15-mm incisions. Unlike other interspinous stabilization systems, which require a 4–5-cm midline incision and muscle dissection to expose the laminae and facet joints to ensure proper placement of implant, these stabilizers can be percutaneously alone or combined with other decompression procedures. In addition, most of the interspinous process stabilization systems are not suitable for use at the L5/S1 level because of the commonly encountered small, or vestigial, S1 spinous process. This is not a limitation with the currently described system. Recent biomechanical results at our institution have further substantiated the
Figure 1: Graphics demonstrating the sequential operative procedure for the placement of access needle and K-wire. (a) Trajectory of access needle: anterior-posterior view. (b) Trajectory of access needle: lateral view. (c) The access needle is advanced through the pedicle. (d) The central obturator of the access needle was withdrew and replaced with a K-wire.

Figure 2: Soft tissue dilatation, drill, tapping, and countersink shaving of the bone. (a) Soft tissue dilatation is achieved by introducing a teleport dilator. (b) Drilling of the bone through a K-wire. (c) Tapping of the bone through a K-wire. (d) Countersink shaving of the inferior portion of the facet and the pedicle.

Figure 3: Cannulation and placement of the anchor into the pedicle. (a) Picture of the anchor. (b) Anchor placement: anterior-posterior view. (c) Anchor placement: lateral view.

Figure 4: Insertion of a PCU stabilizer. (a) Picture of a PCU stabilizer. (b) PCU stabilizer is installed onto the anchor: anterior-posterior view. (c) PCU stabilizer is installed onto the anchor: lateral view. (d) Final AP view after the bilateral PercuDyn placement.

Figure 5: Diagrams showing final anatomy of the device following placement. As shown in (a) the stabilizers are placed inferior to the inferior articulating facets from the level above (*) and superior to the superior articulating facet from the level below (**). In parts (b) and (c), arrows demonstrate the forces that impact the stabilizer in biomechanical testing. The stabilizer serves to off-load the facet joints and decrease dorsal disk pressure. This increases foraminal area, especially in extension.
Table 1: Prospective 1-year clinical results in the first nine patients treated consecutively by the senior author

| Patient number | Age (years) | Sex | Indication | Preoperative VAS back/leg | Preoperative ODI | Postoperative VAS back/leg | Postoperative ODI | 1-year ODI |
|----------------|-------------|-----|------------|---------------------------|-----------------|-----------------------------|------------------|-----------|
| 1              | 65          | Female | Adjacent level stenosis L3/L4 | 88/53          | 50              | 14/10                       | 28               | 32        |
| 2              | 66          | Male   | Recurrent lateral and foraminal stenosis L5/S1 | 70/70          | 60              | 50/50                       | 18               | 38        |
| 3              | 56          | Male   | Neurogenic claudication, bilateral stenosis L5/S1 | 30/75          | 49              | 30/75                       | 26               | 30        |
| 4              | 75          | Male   | Neurogenic claudication, bilateral stenosis L4/L5 | 35/35          | 29              | 30/30                       | 26               | 28        |
| 5              | 45          | Male   | Degenerative disc disease, right L4/L5 foraminal and recess stenosis | 50/60          | 42              | 20/20                       | 26               | 30        |
| 6              | 26          | Male   | Degenerative disc disease, left L5/S1 foraminal stenosis | 80/90          | 41              | 15/0                        | 21               | 19        |
| 7              | 39          | Male   | L4/L5 degenerative disc disease, right L4/L5 lateral recess stenosis | 87/91          | 35              | 30/0                        | 21               | 21        |
| 8              | 41          | Male   | L5/S1 degenerative disc disease, recess stenosis bilateral L5/S1 | 67/88          | 39              | 10/0                        | 21               | 21        |
| 9              | 31          | Male   | L5/S1 degenerative disc disease, L5 foraminal stenosis | 82/57          | 36              | 0/5                         | 26               | 12        |

attributes of the device. When comparing PercuDyn with X-stop and the Isobar, all three devices demonstrated unique attributes with cadaveric testing. Importantly, PercuDyn was the most effective at preventing extension with a follow load.

It should be noted that the concept of semirigid stabilization has led the development of multiple systems to employ ‘dynamic stabilization’ of the lumbar segments. Many of these devices are meant to hold the degenerative segment in a semiflexed position. This flexion indirectly increases foraminal height and also improves the dimensions of the canal. One important limitation of the current device is that it does not hold the degenerative segment in flexion. Rather, the stabilizers are placed between the inferior articulating facets of the upper vertebral body and the superior articulating facets of the inferior vertebral body. This is done to ‘off-load’ the facet joints, thus acting as a ‘bumper’ that dissipates energy. This is particularly helpful in preserving foraminal height in extension.

While the exact indications for this device may change with further study, we believe that the ideal candidate is a patient who has had minimal response to conservative therapy and early signs of symptomatic lumbar degenerative disc disease. More exactly, this patient would have a borderline canal diameter and would be symptomatic primarily at the extremes of motion (particularly extension). In these patients, a larger surgery, such as transfemoral lumbar interbody fusion, may be avoided. However, patients with severe stenosis of the central canal or the neural foramen are not candidates for this surgery as only direct decompression will alleviate their symptoms. Of two patients with minimal change in VAS and ODI in our series, one had moderate to severe central stenosis. More traditional techniques of direct decompression via laminectomy or laminotomy are likely more appropriate for these individuals. Furthermore, patients with segmental instability, including those with pars defects or spondylolisthesis, are not candidates for this technique. These patients need more formal instrumented fusions to address their anatomical instability.

In addition, it should be noted that the current device can be easily used at L5/S1 as well as other lumbar segments. In fact, at L5/S1, the device may be easier to apply given the orientation of the facet joint at this level is almost perpendicular to the trajectory of device application. At the L4/L5 level and higher, the facet joints are oriented in a more parallel fashion, necessitating a more difficult trajectory angle. In addition, it should be noted that many interspinous stabilization devices cannot be used at L5/S1, given an often small or poorly developed S1 spinous process. Unlike these devices, the current system can be applied at the L5/S1 level.

Although there are many methods available in the treatment of degenerative disease of the lumbar spine, the development of new techniques adds only to the options available to the modern spine surgeon. In this report, we describe a novel, minimally invasive technique that may be appropriate as an alternative to traditional approaches lumbar stabilization as well as other emerging techniques in posterior dynamic stabilization. This technique is fully minimally invasive and the system’s attributes have been demonstrated by both our initial
biomechanical and clinical experience. Further long-term outcome studies will be needed to further understand the attributes of this surgical technique and the role of this technique in the modern management of symptomatic degenerative disease of the lumbar spine.

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