Provisional Ipsilateral Expandable Rod for Disc Space Distraction in Minimally Invasive Transforaminal Lumbar Interbody Fusion: Operative Technique

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Received, April 29, 2014.
Accepted, August 13, 2014.
Published Online, August 25, 2014.

BACKGROUND: Lumbar disc degeneration may be so advanced and asymmetrical that transforaminal access to the interbody space is limited. The extent of collapse may compromise the capacity to restore disc height and coronal balance in minimally invasive approaches. Although a variety of distractors are available for open approaches, currently there is no feasible distractor that is functional within a minimally invasive retractor.

OBJECTIVE: To describe the development of a provisional ipsilateral expandable rod for use in minimally invasive surgery for transforaminal lumbar interbody fusions to optimize access to the disc space, thereby facilitating placement of an interbody spacer.

METHODS: The authors report the clinical and radiographic data for 30 patients (3 open and 27 minimally invasive surgeries) with advanced degenerative disc disease in whom a provisional ipsilateral expandable rod was used to restore coronal balance and maintain disc height for interbody preparation and placement. Preoperative disc heights were measured, and the height of interbody spacer recorded. Mean restoration of disc heights was calculated.

RESULTS: The provisional ipsilateral expandable rod was successfully applied in both open exposures and within a minimally invasive retractor. The mean preoperative disc height was 4.9 mm (range, 1-9 mm), the mean height of the spacer inserted was 11.1 mm (range, 8-15 mm), and the mean increase in disc height was 6.2 mm (range, 5-11 mm).

CONCLUSION: A provisional ipsilateral expandable rod is feasible in either minimally invasive or open approaches. It has the capacity to maintain the disc height achieved by paddle distractors. This facilitates both the disc preparation and optimizes restoration of disc height and interbody spacer placement.

KEY WORDS: Degenerative spine disease, Minimally invasive, Lumbar spondylosis, Spondylolisthesis, Transforaminal lumbar interbody fusion

Operative Neurosurgery 10:555–564, 2014 DOI: 10.1227/NEU.0000000000000542

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A QR Code is a matrix barcode readable by QR scanners, mobile phones with cameras, and smartphones. **The QR Code above links to Supplemental Digital Content from this article.**

Restoration of coronal imbalance in the lumbar spine where asymmetrical degeneration has occurred is one of the more challenging tasks in minimally invasive transforaminal approaches. The degree of disc collapse may limit access to the disc space and thereby limit the restoration of disc height that may be achieved. There are a variety of techniques such as the use of a provisional rod on the contralateral side to capture the height achieved with a paddle distractor or interbody trial or bilateral access to the disc space to facilitate access. Osteotomy of the posterior superior lip of the inferior vertebrae may also allow for correction of local coronal plane anomalies and restoration of disc height. However, there are limitations to each of these techniques. Osteotomies have the potential to disrupt the cortical endplate and risk subsidence

ABBREVIATIONS: MIS, minimal invasive surgery; **TLIF,** transforaminal lumbar interbody fusion

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of the interbody graft. The disc height achieved with a paddle distractor or interbody trial in the ipsilateral disc space is not always well captured by a rod on the contralateral side. At times such a cantilever technique may actually exacerbate the coronal imbalance, making intradiscal access even more difficult. The result is placement of a smaller interbody graft, which may increase the risk of spacer migration and extrusion and decrease the restoration of disc height, foraminal height, and coronal balance. Use of a conventional rod on the side of the transforaminal approach to maintain the restored disc height in minimally invasive approaches is untenable as placement of such a rod obstructs access to the transforaminal corridor into the disc space.

An alternative is bilateral access to the disc space with a paddle distractor on one side and interbody access on the other. Although bilateral access to the disc space is routine for open posterior lumbar interbody fusion procedures, it adds a significant amount of time in minimally invasive surgery (MIS) transforaminal lumbar interbody fusion (TLIF) approaches, where decompression and an intradisc access are for the most part unilateral. The capacity to maintain the disc height achieved by paddle distraction on the ipsilateral side precludes the need for bilateral facetectomies and bilateral disc space access.

In the authors' experience, those cases in which a significant asymmetrical collapse of the disc space exists, maintaining the disc height achieved on the ipsilateral side by the paddle distractor or interbody trial is limited, even with contralateral provisional rod placement. Although bilateral access to the disc is a viable solution, the ideal solution for MIS TLIF approaches would be capture of the disc height that is achieved on the ipsilateral side by paddle distractors and interbody trials. This would allow for correction of the coronal imbalance, decompression of the symptomatic nerve root, as well as access to the disc space for an interbody fusion. However, the capacity to do this is limited in minimally invasive approaches. Current ipsilateral provisional distractors that project out of an expandable MIS retractor system are cumbersome in an already constrained area. Furthermore, these retractors limit visibility and the working channel into the disc space.

The authors sought a solution to the current limitations for restoring and maintaining intradisc height in minimally invasive approaches from an ipsilateral approach. Such a retractor would need to be (1) easily placed and removed through expandable minimally invasive retractors, (2) expandable to capture the height achieved with paddle distractors or interbody trials, and (3) not compromise the working channel into the disc space. In this paper, the authors introduce a provisional ipsilateral expandable rod for use in minimally invasive approaches and report their experience using this provisional rod in the first 30 cases (3 open and 27 minimally invasive).

PROVISIONAL IPSILATERAL EXPANDABLE ROD: DESIGN

The criteria for the design of an ipsilateral rod to be used in minimally invasive approaches would include facility of insertion and removal through an expandable minimally invasive retractor system, the capacity to capture the distraction achieved during interbody preparation without the need for additional instruments to do so and maintain a low profile away from the disc space so as not to interfere with decompression and disc preparation or interbody insertion. To comply with these criteria, a 2-component system was designed consisting of a sleeve arm with a distractor latch and spring and a rack arm that would capture the height as the interbody was distracted. Coming off at right angles from these arms are pedicle screw fixation points (Figure 1). When applying the expandable retractor at the time of surgery, the pedicle screws heads are turned 90° from the position that would be used for the permanent rod for placement of the device. This places the lateral aspect of the expandable rod outside the corridor needed for preparation of the disc space and interbody spacer placement (Figure 2). When inserted in a polyaxial pedicle screw tulip head, a fixed position may be achieved with placement of a set screw. The expandable rod was designed to collapse down to 21 mm from pedicle fixation point to fixation point and may expand up to 42 mm.

METHODS

The purpose of this study was to demonstrate the feasibility of applying an ipsilateral expandable provisional to the MIS TLIF and assessing the capacity to restore disc height. On completion of prototype development, the authors collected the preoperative, intraoperative, and postoperative radiographic data on 30 consecutive patients who underwent single-level and 2-level TLIFs with the assistance of a provisional ipsilateral expandable rod. The first 3 cases were performed via a midline open approach to establish the feasibility of the device. The 27 subsequent cases were performed with minimally invasive expandable retractors. Preoperative heights were measured from the center of the disc space from either anteroposterior or lateral radiographs or coronal and sagittal reconstructions. Data on the interbody spacer height were collected. In those cases

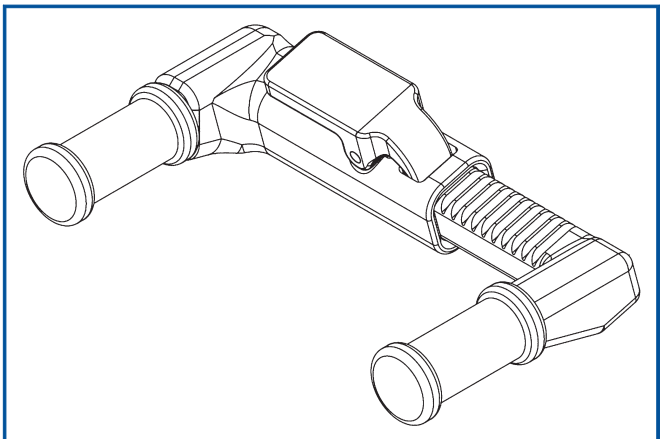

FIGURE 1. *Concept drawing of the provisional ipsilateral expandable rod for minimally invasive surgery for transforaminal lumbar interbody fusions. Used with permission from Luis M. Tumialán, MD.*

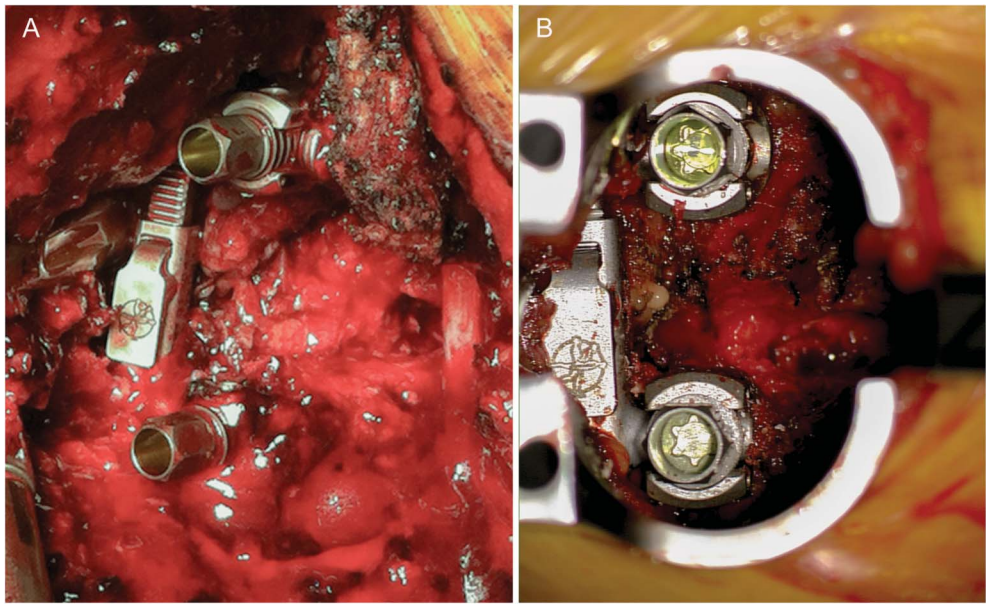

FIGURE 2. **A**, *conceptual surgical view through a minimally invasive surgery retractor of the ipsilateral provisional rod. The tulip heads of the polyaxial screws are turned 90°. By doing this, the lateral aspect of the retractor is outside the transforaminal lumbar interbody fusion (TLIF) corridor.* **B**, *intraoperative photograph of the provisional ipsilateral expandable retractor being used in an open TLIF. Used with permission from Barrow Neurological Institute.*

with asymmetrical collapse, the side with the greater degree of collapse was measured.

Patients were evaluated with postoperative anteroposterior and lateral radiographs on the first postoperative day and at 1, 3, and 6 months. Radiographs were evaluated for any evidence of interbody spacer migration or subsidence.

Surgical Technique

In both minimally invasive and open cases, 4 low-profile pedicle screws (Solera; Medtronic, Memphis, Tennessee) were secured before beginning the decompression and disc preparation. In the minimally invasive cases, the instrumentation was performed through an expandable MIS retractor system (Quadrant; Medtronic Sofamor Danek, Memphis, Tennessee), Next, the provisional expandable rod is secured into position on the side of the transforaminal approach before commencement of the decompression. The tulip heads of the pedicle screws are turned 90°, and a rod inserter is used to apply the expandable rod onto the pedicle screw heads (Figure 3). Set screws are secured into position but not broken off. This eliminates the polyaxial movement of the pedicle screw tulip head and fixates the provisional rod into position (see **Video, Supplemental Digital Content**, which shows the operative technique for using an ipsilateral provisional expandable rod [used with permission from Barrow Neurological Institute], http://youtu.be/MKHkOSCmwLQ).

A complete facetectomy and removal of the pars are then performed followed by a decompression of the thecal sac and traversing and exiting nerve roots. On completion of the decompression of the neural elements, the disc space is incised and the disc removed. Preparation of the endplates is then performed with a series of curettes. With disc material removed, paddle distractors are now used to distract the disc space. As each paddle distractor is rotated within the disc space, the ipsilateral provisional expandable rod captures the height achieved by rotating the distractor. At the same time, a conventional rod is placed in the contralateral pedicle screws to capture the height achieved on that side with tightening of the set screws. With the disc height restored and maintained, it becomes increasingly easier to access, visualize, and prepare the disc space. This allows for more complete removal of the disc and preparation of the endplate.

As the interbody trials are inserted in the disc space, additional disc height is achieved and captured. The profile of the interbody trials expands the posterior aspect of the disc height, which is not achieved by a paddle distractor. This additional height is captured by the provisional rod without concern for collapse of the disc space on removal of the interbody trial. An interbody spacer of the same size as that of the final interbody trial used may be inserted in the disc space again without concern that collapse of the disc space will complicate the insertion. On satisfactory placement of the interbody spacer, the expandable rod is collapsed by compression of the distractor latch, and the set screws are removed along with the expandable provisional rod. A permanent rod is then inserted and secured. Increased restoration of the disc height allows for the capacity to place the interbody under additional compression. This not only minimizes the risk of migration of the interbody while creating an ideal environment for fusion, it allows for restoration of segmental lordosis.

RESULTS

Thirty consecutive patients underwent either open or MIS TLIFs with use of the ipsilateral provisional distractor. Indications for surgery included mobile grade I spondylolisthesis (17 patients),

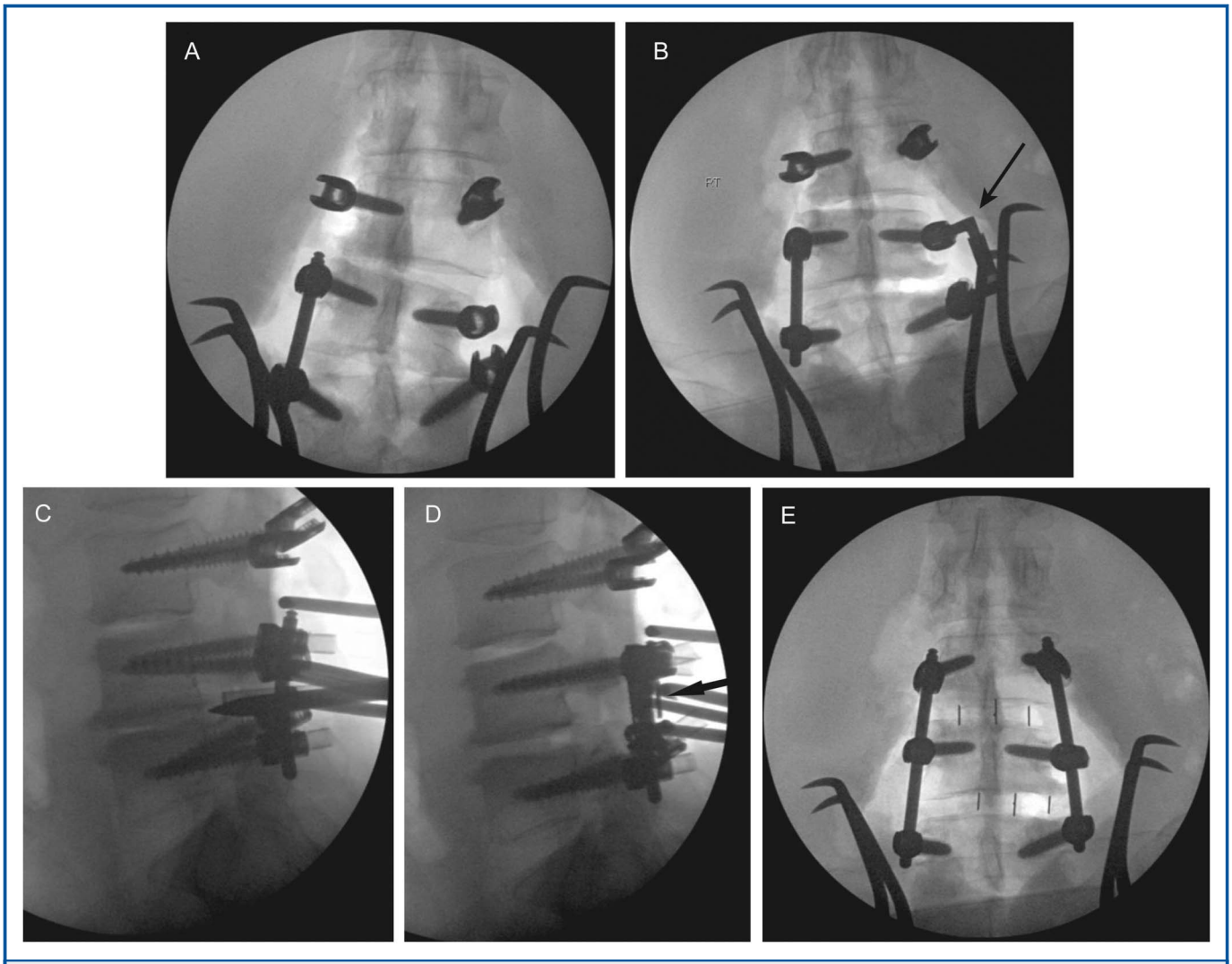

FIGURE 3. **A**, *anteroposterior (AP) fluoroscopic image of exacerbation of coronal imbalance with use of a contralateral rod.* **B**, *AP fluoroscopic image of restoration of the coronal imbalance with the provisional ipsilateral expandable rod.* **C**, *lateral fluoroscopic image demonstrating the inability to adequately access disc space with a contralateral rod.* **D**, *lateral fluoroscopic image with provisional ipsilateral rod in position as denoted by the arrow. Access to the disc space is facilitated by restoration of height.* **E**, *final AP fluoroscopic image with interbodies in position. Used with permission from Barrow Neurological Institute.*

degenerative disc disease with radiculopathy (11 patients), recurrent disc herniation (1 patient), and degenerative disc disease with recurrent facet cyst formation (1 patient). Levels operated on included L2-3 (1 patient), L3-4 (5 patients), L4-5 (23 patients), and L5-S1 (2 patients). The mean preoperative disc height measuring the center of the disc space on anteroposterior and lateral radiographs or coronal and sagittal constructions of a multiplanar computed tomography scan was 4.90 mm (range, 1-9 mm), the mean height of the interbody spacer inserted was 11.1 mm (range, 8-15 mm), and the mean increase in disc height postoperatively was 6.2 mm (range, 4-10 mm (Table).

Plain radiographs were reviewed at 1 month, 3 months, 6 months, and 1 year (when applicable) and compared with the immediate weight-bearing postoperative radiograph. All 30 patients in this series had a minimum of 6 months of follow-up. Mean follow-up for the series was 9.4 months (range, 6-14 months). There was no evidence of migration of the interbody devices in any of the patients in this series identified on plain radiographs. There were 2 cases of subsidence in which the interbody subsided into the caudal endplate a distance of 2 mm by the third postoperative month. This subsidence was stable in both of these patients at 6 months. There were no revision surgeries required. Twenty-seven of the 30 patients have demonstrated radiographic fusion with bone formation within the interbody device and the absence of motion of the spinous processes on flexion-extension study. The remaining 3 patients have completed

TABLE. Indications for Surgery, Levels, and Preoperative and Postoperative Heights

Pt	Indication	Approach	Level(s)	Preoperative Disc Height, mm	Interbody Spacer Height, mm	Difference, mm
1	Degenerative disc disease, pseudarthrosis, adjacent segment degeneration	Open	L2-3, L3-4	6	11	5
2	Degenerative disc disease, coronal imbalance, radiculopathy	Open	L3-4, L4-5	1	11	10
3	Degenerative disc disease	Open	L3-4, L4-5	4	11	7
4	Spondylolisthesis	MIS	L4-5	5	9	4
5	Spondylolisthesis	MIS	L4-5	8	13	5
6	Degenerative disc disease, recurrent facet cyst, radiculopathy	MIS	L4-5	6	11	5
7	Degenerative disc disease, radiculopathy, coronal imbalance	MIS	L4-5	2	9	7
8	Spondylolisthesis	MIS	L5-S1	5	11	6
9	Degenerative disc disease	MIS	L3-4	4	9	5
10	Spondylolisthesis	MIS	L4-5	5	11	6
11	Degenerative disc disease	MIS	L4-5	5	10	5
12	Degenerative disc disease, radiculopathy, coronal imbalance	MIS	L3-4	3	9	6
13	Spondylolisthesis	MIS	L4-5	5	11	6
14	Spondylolisthesis	MIS	L4-5	6	12	6
15	Degenerative disc disease, radiculopathy, coronal imbalance	MIS	L4-5	6	13	7
16	Spondylolisthesis	MIS	L4-5	9	11	2
17	Spondylolisthesis	MIS	L4-5	6	11	5
18	Degenerative disc disease, radiculopathy, coronal imbalance	MIS	L4-5	1	8	7
19	Spondylolisthesis	MIS	L5-S1	3	9	6
20	Third recurrence of disc herniation	MIS	L3-4	9	13	4
21	Spondylolisthesis	MIS	L4-5	4	11	7
22	Spondylolisthesis	MIS	L4-5	6	12	6
23	Spondylolisthesis	MIS	L4-5	4	11	7
24	Spondylolisthesis	MIS	L4-5	4	12	8
25	Degenerative disc disease, recurrent facet cyst, radiculopathy	MIS	L4-5	5	13	8
26	Spondylolisthesis	MIS	L4-5	3	14	11
27	Spondylolisthesis	MIS	L4-5	5	12	7
28	Spondylolisthesis	MIS	L4-5	9	15	6
29	Recurrent facet cyst	MIS	L4-5	5	11	6
30	Spondylolisthesis	MIS	L4-5	3	9	6
	Average			4.90	11.10	6.20

[a]Pt, patient; MIS, minimally invasive surgery.

6 months of follow-up, remain asymptomatic, and will have radiographs obtained at 12 months.

CASE ILLUSTRATIONS

Open

Case 1

A 59-year-old woman with progressively worsening bilateral radicular symptoms was found to have both a right-sided L3 radiculopathy and a left-sided L4 and L5 radiculopathy by clinical examination and electromyography. Plain radiographs demonstrated advanced degeneration of the disc spaces at both L3-4 and L4-5. The patient underwent an open 2-level decompression and instrumented fusion with placement of transforaminal interbodies at L3-4 and L4-5. During the discectomy at L4-5 approached from the symptomatic side (left), capture of the interbody height was suboptimal with the contralateral rod. Despite introduction of 9- and 10-mm spacers into the L4-5 disc space with capture by the contralateral rod, the disc space remained collapsed (Figures 3A and 3C). The provisional ipsilateral expandable rod was placed in the left-sided pedicle screws. Paddle distractors were reintroduced

into the disc space, and the disc height was captured by the ipsilateral expandable provisional rod (Figures 3B and 3D). Maintenance of disc height facilitated preparation of the disc space and placement of an interbody spacer. The provisional expandable ipsilateral rod was then applied to the L3-4 disc space with similar benefit (Figure 3E).

Case 2

A 72-year-old man with previous instrumented interbody fusion at L3-4 and L4-5 presented with increasing amounts of axial back pain and bilateral radicular leg pain. Magnetic resonance imaging demonstrated adjacent segment degeneration at L2-3 with both facet arthropathy and central stenosis. Computed tomography and radiography demonstrated a pseudarthrosis at L3-4. After an extensive trial of nonoperative measures without improvement, the patient underwent a reexploration of the previous fusion, along with revision of the L3-4 level and extension to L2-3. After preparing the interbody space, paddle distractors were used to restore the height of the L2-3 disc space. Despite using up to an 11-mm paddle distractor with a provisional rod on the contralateral side, there was difficulty placing a 10-mm interbody trial because of the collapse of the posterior aspect of the disc space and the degree of scalloping of the endplates (Figure 4A). The pedicle screw heads were rotated 90°, and the provisional ipsilateral expandable rod was secured into position. A 10-mm followed by an 11-mm paddle distractor was then used, and the height was captured and maintained by the expandable provisional rod (Figure 4B). Without the provisional rod, a 10-mm interbody trial was unable to be introduced into the disc space. With the height captured by the provisional rod, an 11-mm spacer was able to be secured into position (Figures 4C and 4D).

Minimally Invasive

Case 3

A 59-year-old man with a mobile grade I spondylolisthesis, facet arthropathy, and resultant lumbar stenosis underwent an L4-5 MIS TLIF. After placement of all 4 pedicle screws with expandable minimally invasive retractors (Quadrant; Medtronic), the provisional ipsilateral expandable rod was secured into position with set screws (Figure 5A). On completion of the facetectomy, laminectomy, and discectomy, the disc space was prepared. After removal of the cartilaginous endplates, the disc space was distracted using paddle distractors with the expandable rod already in position. This prevented the scalloped endplates from limiting access to the disc space (Figure 5B). The disc height was expanded from 9 mm preoperatively to 13 mm intraoperatively. An interbody spacer was rotated into position without impediment from the expandable rod (Figure 5C). With the amount of exposure provided by the expandable rod, a second interbody was able to be rotated into position (Figure 5D).

Case 4

A 62-year-old woman with advanced degenerative disc disease, a recurrent facet cyst, and recurrent radiculopathy underwent an L4-5 MIS TLIF (Figure 6). After placement of all 4 pedicle screws, the provisional ipsilateral retractor was secured into position. A complete facetectomy and laminectomy were performed to decompress the symptomatic nerve root. The disc space was accessed and prepared. The preoperative disc height of 7 mm at the posterior aspect of the vertebral bodies was restored to 10 mm with the expandable provisional rod in position (Figures 6B-6D). The lateral projection of the expandable rod did not compromise access to the transforaminal corridor, as demonstrated in Figure 6E.

DISCUSSION

There are several techniques that allow for restoration of coronal balance and disc height at a significantly degenerated segment in the lumbar spine. Restoration through anterior interbody and transpsoas interbody approaches are perhaps the most proficient manner to accomplish these goals.[1-3] Unilateral access to the disc space through a transforaminal approach, by comparison, may be more limiting in achieving this.[1] In the setting of a coronal imbalance and a nerve root compression syndrome, if a transforaminal approach were to be used, direct decompression and visualization of the symptomatic nerve is conceptually appealing to both the surgeon and the patient. This mandates an approach to the disc space on the more collapsed side. If this is performed via a unilateral approach, there may be a limitation to the restoration of disc height and the size of the interbody spacer placed in the absence of ipsilateral provisional distraction or maintenance of the restored disc height.

In the circumstance of severe coronal imbalance, a transpsoas or anterior approach may be conceptually preferable to restore foraminal height and optimize interbody height. Although the experience in the literature has demonstrated the efficacy of indirect decompression with restoration of the disc height, it is difficult to entirely dismiss the possibility of the need for additional surgery that will directly decompress the affected nerve root when anterior or transpsoas techniques are applied.[2,3] Therefore, advancements are needed in MIS TLIF techniques and instrumentation to match the capacity of the transpsoas and anterior approaches to restore coronal balance from a unilateral transforaminal approach.

In posterior approaches, several techniques allow for provisional distraction of the disc space. Placement of a contralateral rod, ipsilateral rod, and bilateral access to the disc space may address this shortcoming; however, there is an inherent limitation to apply these techniques in minimally invasive unilateral approaches. Under ideal circumstances, a unilateral transforaminal approach would be from the symptomatic side, which is typically the more collapsed part of the disc. As mentioned previously, a contralateral rod does not always capture the height achieved from an ipsilateral paddle distractor and at times may actually worsen the coronal imbalance because of the distance from the cantilever arm, as demonstrated by Figure 3A. This increases the difficulty of accessing and placing an interbody spacer instead of facilitating it. In these scenarios, bilateral access to the disc space may to some

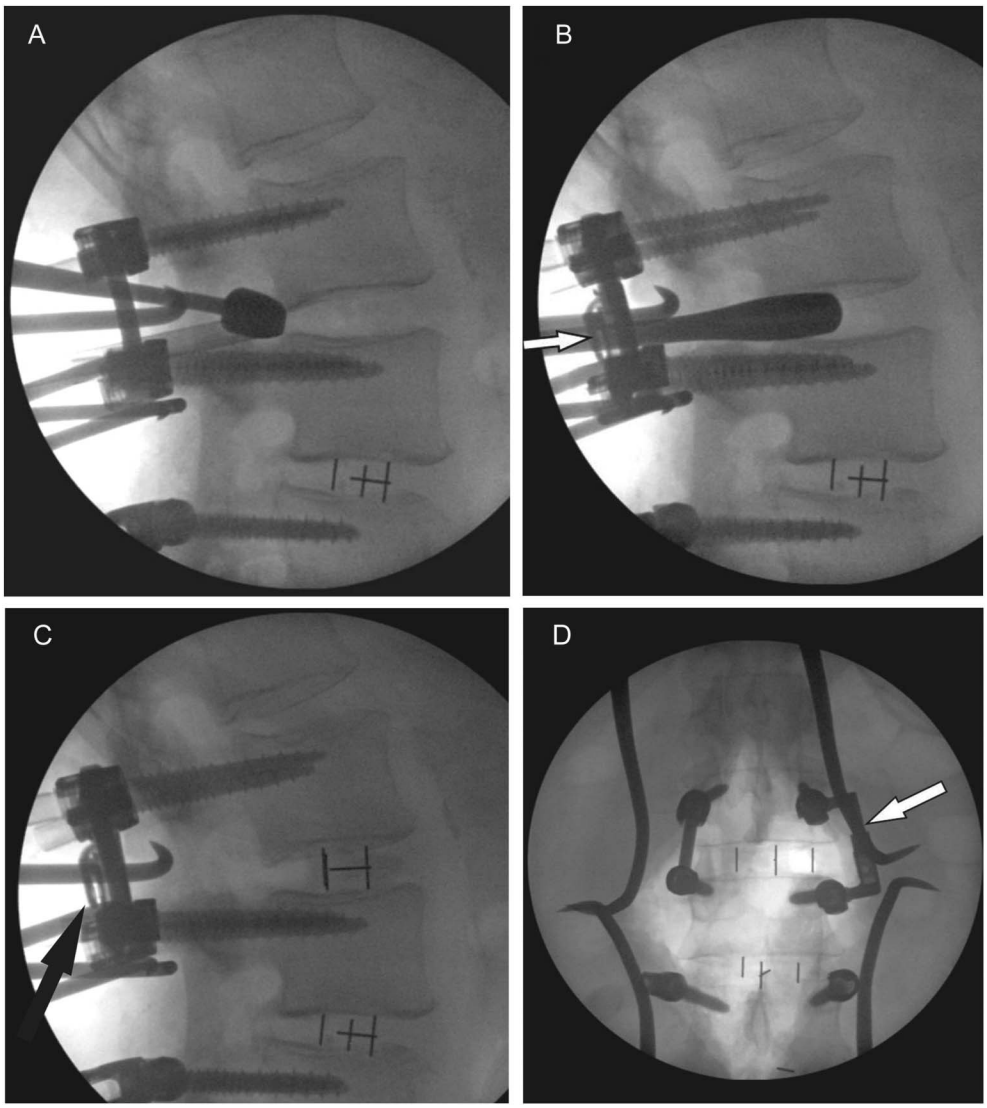

FIGURE 4. *Lateral fluoroscopic images demonstrating the application of the ipsilateral provisional expandable rod.* **A**, *a 10-mm interbody trial attempting to be introduced into the disc space after having distracted the disc space with an 11-mm paddle distractor and a contralateral rod. The scalloped endplate results in restoration of height in the center of the disc space, but a limited restoration at the posterior aspect of disc space, limiting the insertion of a 10-mm interbody trial.* **B**, *with the provisional ipsilateral expandable rod in position (arrow), the distraction achieved by the paddle distractor may be captured.* **C**, *lateral fluoroscopic image of interbody height captured by the provisional expandable ipsilateral rod.* **D**, *an 11-mm interbody trial may now be secured into the disc space and an 11-mm spacer may be placed in the disc space. Used with permission from Barrow Neurological Institute.*

extent resolve this limitation, but has been demonstrated to add time to the surgery.[4]

The issue of cage migration and extrusion in TLIFs is one of the areas where a provisional ipsilateral expandable rod has the potential to make an impact. Kimura et al[5] reviewed risk factors for cage extrusion in lumbar interbody fusion in 1070 patients. These authors identified 9 patients in their series in whom an interbody device migrated after surgery. The risk factors that were identified for cage extrusion were interbodies placed at L5-S1, instability, multilevel surgery, and scalloped endplates. Scalloped endplates represent a unique anatomic circumstance for lumbar interbody fusions, where the height in the center of the disc is significantly greater than the height at the posterior aspect of the disc space. Such configurations may limit the insertion of the

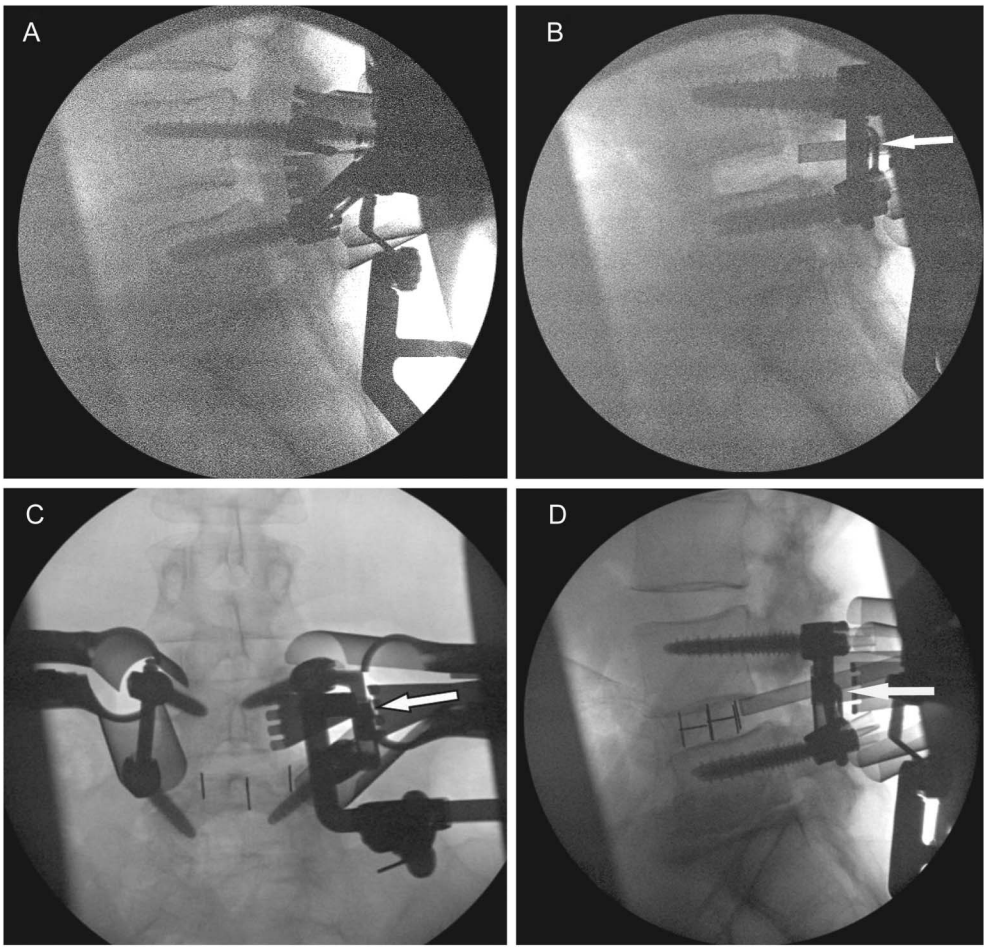

FIGURE 5. **A**, *lateral fluoroscopic image with 4 pedicles in position before distraction of the disc space.* **B**, *provisional ipsilateral expandable rod in position as denoted by the arrow. Note the posterior aspect of the disc space is distracted, facilitating interbody access.* **C**, *anteroposterior fluoroscopic image demonstrating interbody device placement with provision rod in position as denoted by the arrow.* **D**, *exposure of the disc space was adequate enough to allow for a second interbody spacer to be placed. Used with permission from Barrow Neurological Institute.*

optimally sized interbody spacer and thereby increase the risk of cage migration.[6-8] The use of expandable interbody devices and chiseling the scallop out of the posterior aspect of the disc space are the various alternatives to currently resolve this, but have their own limitations.[9] Expandable interbody devices introduce a point of failure where the expanded device may collapse down to a smaller height. This results in loss of the interbody device–cortical endplate interface pressure and may lead to migration. Kim et al[9] report the management of one such collapse where, after removal of the expandable device, a static interbody spacer was secured. An osteotomy of the posterior superior lip of the inferior vertebrae has the potential to further open the disc space access to address this shortcoming. The authors believe that the ipsilateral expandable provisional rod introduces yet another alternative.

It is the previously mentioned anatomic scenarios in minimally invasive transforaminal approaches that the authors intended to address with the ipsilateral provisional expandable rod. The goal of this ipsilateral provisional distraction is to optimize the height and width of the interbody spacer that is placed. Optimally sized interbody spacers have been demonstrated to minimize the risk of cage migration and subsidence.[8,10] The application of this technique is analogous to the use of Kaspar posts in the cervical spine, where distraction on the posts allows for a larger interbody to be placed. After placement of the cervical interbody, the distraction is released and the interbody endplate interface pressure is optimized for arthrodesis. With this provisional rod, a similar concept is applied. The provisional distractor can maintain heights equal to or greater than those of the interbody that will be placed. After securing the interbody into position, the

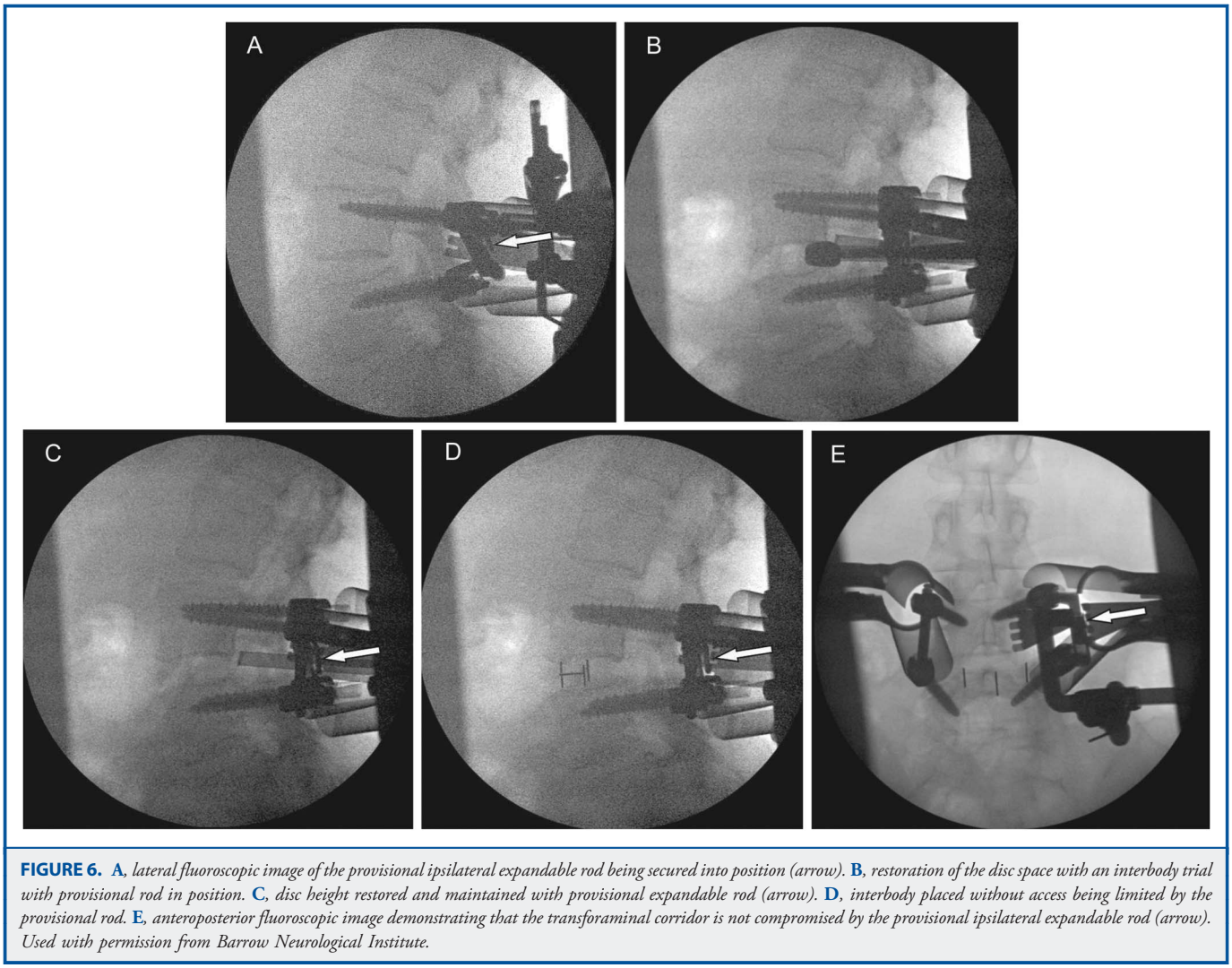

FIGURE 6. **A**, *lateral fluoroscopic image of the provisional ipsilateral expandable rod being secured into position (arrow).* **B**, *restoration of the disc space with an interbody trial with provisional rod in position.* **C**, *disc height restored and maintained with provisional expandable rod (arrow).* **D**, *interbody placed without access being limited by the provisional rod.* **E**, *anteroposterior fluoroscopic image demonstrating that the transforaminal corridor is not compromised by the provisional ipsilateral expandable rod (arrow). Used with permission from Barrow Neurological Institute.*

distraction is removed with the release latch and the interbody–cortical endplate interface pressure is optimized. In theory, optimizing this interface pressure should decrease the risk of migration or extrusion of the interbody. As demonstrated in this series of 30 consecutive patients with a minimum of 6 months of follow-up, there was no evidence of migration of the interbody device.

These case illustrations demonstrate the capacity of this rod to maintain the height achieved by paddle distractors and interbody trials in advanced degenerative disc disease with coronal imbalance and to maintain the height of the posterior aspect of the disc space equal to the height of center of the disc in scalloped disc spaces. The provisional ipsilateral expandable rod increases the access to the disc space, facilitates preparation of the endplates, and optimizes the placement and height and width of the interbody device in minimally invasive approaches without compromising the transforaminal corridor into the disc space. In certain instances, the exposure offered by the provisional rod actually facilitates placement of additional interbody spacers (Figure 5D). Although the authors prefer a 4-pedicle screw, 2-rod construct, the application of this provisional rod may be of value to those surgeons who prefer unilateral fixation in MIS TLIFs.[11-15] The capacity to restore and maintain height on the same side of the transforaminal approach precludes the need for a contralateral provisional rod and may further facilitate the unilateral approach.

CONCLUSION

A provisional ipsilateral expandable rod is a feasible option in open and minimally invasive transforaminal approaches. It has the capacity to maintain the disc height achieved by paddle distractors and interbody trials. This provisional rod increases access to the disc preparation, optimizes restoration of disc height, and facilitates interbody spacer placement. The use of this device

makes it possible to achieve greater corrections in disc height and coronal imbalance via a unilateral MIS TLIF approach.

Disclosure

Dr Tumialán is a consultant for Medtronic. The device described in this manuscript has been issued a patent by the United States Patent Office entitled: MIS TLIF systems and related methods: US Patent number: US8764757; application number: US 13/756,505. The device disclosed in this paper is the sole intellectual property of Dr Tumialán. The device was conceived, designed, and developed without funding or compensation from Medtronic. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENT

The authors describe use of a novel device used to maintain disc space distraction achieved through the use of paddles and interbody trials while performing a transforaminal lumbar interbody fusion. They share cases in their series of 30 patients who were treated largely with the MIS technique. Such a device may be useful in select instances. We have found that performing a thorough discectomy using both straight and angled instruments, in addition to an osteotomy of the posterior superior lip of the inferior vertebrae, is sufficient to achieve excellent correction of local coronal plane anomalies and restore disc height. In fact, the numbers reported here are not obviously different from those achieved using the cantilever TLIF technique.[1] Finally, although this device may facilitate insertion of a larger graft with less impaction, such a device should not be a substitute for a properly performed discectomy and subsequent disc release.

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