



CASE REPORT

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Navigation Guided L2-S1 Oblique Lumbar Interbody Fusion using a Novel L5-S1 fully Navigated Cage

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ABSTRACT

Background: The use of navigation guidance during vertebral interbody work can be utilized to enhance surgeon visualization of the anatomy and subsequently improve cage placement accuracy.

Case Description: In this case, we present a 62-year-old male with a degenerative coronal and sagittal imbalance and lumbar stenosis causing low back pain, radicular pain, and neurogenic claudication. Surgical treatment with a fully navigated L2-3, L3-4, L4-5, and L5-S1 oblique lumbar interbody fusion (OLIF) was performed followed by posterior fusion from L2 to the pelvis.

Conclusions: To our knowledge, this was the first long-construct OLIF conducted with navigation to the S1 segment, and the second case involving a fully navigated L5-S1 OLIF cage ever performed. Patient consent was obtained for the surgical procedure and for publishing the material included in this case study.

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Highlight Box

Key Findings

- A navigated OLIF cage at the L5-S1 segment is effective in positioning an interbody device at this level in a lateral decubitus position without the use of fluoroscopy.

What is known and what is new?

- The anterior to the psoas lumbar fusion approach has significant advantages over other approaches in correcting spinal deformity and achieving fusion. Navigation techniques can aid with the approach, and navigated integrated interbody cages can be used for optimal placement without the need for fluoroscopy.
- We report a case of a long fusion involving the first navigated OLIF cage at L5-S1 as well as navigated OLIF cages at L2-L5.

What is the Implication, and what should change now?

- Navigation integrated interbody cages can be easily placed and are effective in treating complex spinal deformities. The recent development of a fully navigated L5-S1 interbody cage designed to be placed through a retroperitoneal approach in a lateral decubitus position is one option to minimize radiation exposure and optimize cage placement.

Background

An anterior to the psoas oblique approach to the lumbar spine

was first described by Mayer in 1977 as an alternative to the anterior approach [1]. This minimally invasive approach allows spinal access through a small corridor between the peritoneum and psoas muscle. Similar to a direct lateral approach, the anteropsoas approach does not require posterior surgery and therefore sparing the patient from an extensive spinal or paraspinal muscular dissection. However, in contrast to the lateral approach, the method does not traverse or dissect the psoas muscle [2]. The technique is associated with decreased risk of psoas muscle and lumbar plexus injury and quicker postoperative mobilization compared to other techniques [3-5]. The oblique approach may be utilized for all degenerative indications and is particularly efficacious in the correction of sagittal and coronal deformities [2]. Major risks of the approach include iliac vessel injury, transient neurological damage, and sympathetic chain injury [4].

The oblique lumbar interbody (OLIF) L2-5 procedure is not sufficient to access the L5-S1 segment for anatomical reasons with complicated vascular structures. The unique anatomy of the L5-S1 segment presents different challenges and considerations when approaching the level. Due to this, the L5-S1 segment requires a modified approach. A modified anterior lumbar interbody approach in the lateral position can be used with the assistance of a vascular surgeon to perform the procedure. However, interbody disc work and cage placement is performed at an oblique angle, making it slightly more difficult to assess the vertebral midline and place the cage symmetrically. A fully

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navigated OLIF cage (Anterlign, Medtronic) has been developed for this purpose. We report a novel technique for an L2-S1 OLIF with navigation guidance in the lateral decubitus position.

Illustrative Case

A 62-year-old male presented with persistent chronic back pain and severe radiating right leg pain. Having failed conservative medical management of physical therapy and epidural steroid injections, he sought further surgical care. Informed consent was obtained from the patient. His examination revealed a stooped posture, shuffling gait, and normal neurologic exam. X-rays revealed advanced degenerative changes with a spinopelvic mismatch and a coronal deformity (Figure 1). Magnetic resonance imaging demonstrated degenerative changes with disc height collapse and bulging in L2-L3, L3-L4, L4-L5, and L5-S1, with resultant right-sided neuroforaminal narrowing at the spinopelvic junction and left sided foraminal narrowing at the concavity of the curve (Figure 2). Having failed conservative management, the patient elected for a spinal reconstructive surgery. The decision was made to correct the pathology utilizing OLIFs at L2-S1 with posterior augmentation from T10 to the pelvis. We utilized L2-S1 navigation-guided OLIF cages [Anterlign, Medtronic] in a single lateral decubitus position staged with a posterior fusion of T10-pelvis with S2-Alar-Iliac (S2AI) pelvic fixation and L2-S1 laminectomies (Figure 3). Due to the length of the construct and cantilever forces on the L5-S1 segment, sacropelvic fixation was chosen to reduce the risk of pseudarthrosis after multilevel fusion.

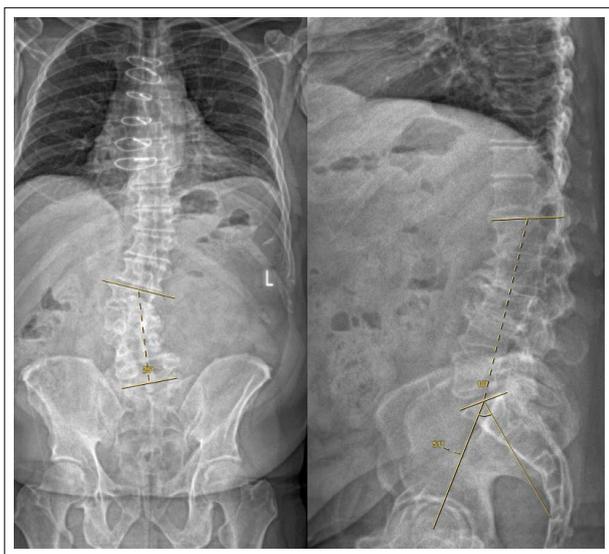


Figure 1: Anteroposterior and lateral radiographs show lumbar spondylosis, a coronal right sided lumbar scoliosis of 25 degrees, lumbar lordosis of only 18 degrees, and spinopelvic mismatch (pelvic incidence – lumbar lordosis) of 33 degrees. The segmental kyphosis between L2 and L4 is also of significance.

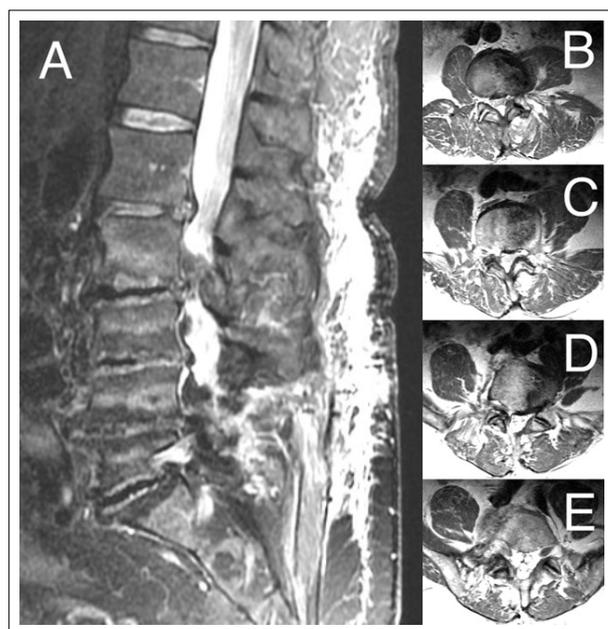


Figure 2: (A) Sagittal T2-weighted magnetic resonance imaging showing collapse of disc spaces and degenerative changes causing lateral recess and foraminal stenosis from L2-S1 with axial sections of L2-L3 (B), L3-L4 (C), L4-L5 (D), and L5-S1 (E).

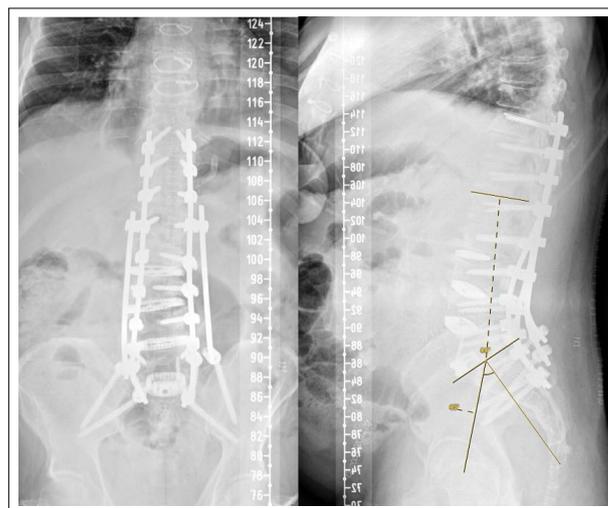


Figure 3: Post operative antero-posterior and lateral x-rays showing improvement in the segmental lumbar scoliosis, increased lordosis, and improvements in disc and foraminal height.

The patient was positioned in the right lateral decubitus position with the left side facing upwards. The Stealth Navigation platform was then rigidly attached to the posterior superior iliac spine. Two fluoroscopic images were taken to align the patients in situ positional anatomy with the segmented perioperative CT anatomy. Once CT registration had occurred, particular care was utilized to the patient's positioning to reduce the introduction of error to the registration. This included mobilization of the navigation platform, heavy-handed maneuvers, leaning on the patient, and minimizing neuromonitoring evoked potential signals.

Due to the incongruent angle of approach for L5-S1 and the upper levels, two separate incisions were performed to facilitate adequate access to the cranial and caudal fusion levels. Incisions were made with the assistance of navigation guidance making note of the anterior aspect of the psoas muscle and the location of the center of the disc space. For the L5-S1 level, the corridor between the great vessels could be visualized on the navigation pane. A vascular surgeon was used to assist in the L5-S1 approach. The fascia was incised and the abdominal musculature was split bluntly. A left lateral retroperitoneal approach was used for both the upper levels and the L5-S1 level. The L5-S1 disc space was exposed first via an oblique corridor, followed by the L2-L5 corridor. For the L2-L5 levels, skin was first incised followed by splitting the abdominal musculature. The navigation tools are sometimes helpful to identify the angle of approach through the musculature to reach the anterior aspect of the psoas muscle. After the external oblique, internal oblique, and transversalis muscles are split, the retroperitoneal fat is reached which is then dissected bluntly until the psoas can be visualized. Upon visualization, the psoas may be teased off of the disc space. With direct visualization of the disc space, annulotomies were performed at each level followed by trialing of oblique lateral interbody fusion cages in ascending sizes. Once the correct cage size was determined for each level, the cages were packed with bone allograft and bone morphogenetic protein to aid with arthrodesis. The cages were inserted in a lateral directed manner for L2-L5.

For L5-S1, a similar dissection is carried out through the abdominal layers but instead of approaching the spine laterally anterior to the psoas muscle, a more anterior approach is utilized usually between the common iliac vessels and often with the aid of a vascular surgeon. After disc preparation the cage may be inserted in an anterior manner at L5-S1 all with an offset navigated inserter, allowing for real time visualization of cage position.

Cage positioning at each level was verified with intraoperative fluoroscopy. The patient was then turned prone and standard posterior T10-S2Alar instrumentation was performed with iliac fixation.

No intraoperative complications occurred and only 75mL of intraoperative blood loss was estimated during the entire L2-S1 procedure. The total operative duration for this 5-level OLIF was 376 minutes. Postoperative imaging demonstrated implants to be in an appropriate position (Figure 2). He was discharged on the seventh postoperative day with no complications during his inpatient stay.

Discussion

Observations

We present a novel technique of utilizing a navigated L5-S1 oblique lumbar interbody fusion (OLIF). The L5-S1 OLIF is fundamentally similar to a laterally positioned retroperitoneal ALIF, which has already been proven effective for various spinal disorders. The L5-S1 OLIF may achieve bony stability, improve alignment, and indirectly decompress the L5-S1 neural elements [6]. In a retrospective study by Woods et al., the authors demonstrated a 97.9% arthrodesis rate, which may be secondary to the excellent visualization and access to the disc space [7]. To our knowledge, with this case, we report the first navigation-guided long-construct

extending to the L5-S1 segment. We demonstrate this technical case to build upon the role of intraoperative navigation to enhance cage placement accuracy, maximize patient outcomes, and reduce intraoperative blood loss.

Due to the somewhat disorienting oblique angle, navigation guidance may be utilized to adjust and reorient surgeons [8]. Recently, navigation has been reported in OLIF as an alternative to fluoroscopy, though there remain few studies assessing the accuracy of navigated OLIF with large cohorts and at the L5-S1 level [9,10]. Xi et al. [10] reported the use of navigation in OLIF from L1 to L5, demonstrating nearly 95% cage placement accuracy on radiographic analysis. Among the included 214 patients in the trial, only one patient required revision surgery for suboptimal cage placement. Further, no patients experienced vascular or long-term neurological deficits following surgery.

Navigation during minimally invasive spine surgery has been shown to reduce intraoperative radiation exposure to the staff and improve cage placement accuracy compared to fluoroscopy [11]. Matityahu et al. reported ideal placement in 130 percutaneous sacroiliac screw fixation surgeries without inaccuracy, while over 20% of fluoroscopically affixed screws were misplaced. In a meta-analysis, Tian and Xu reported that CT-based navigation systems had 90.8% pedicle screw placement accuracy compared to 85.5% with fluoroscopy [12]. In lateral cage placement specifically, misplacement rates have been reported as high as 3.8% [13]. Cage misplacement may result in neurologic symptoms and persistent pain, observed in Malham et al [14], reporting that 2.5% of patients experienced iatrogenic leg pain secondary to cage misplacement in 122 lateral lumbar interbody fusion patients. While navigation has been shown to significantly improve cage placement accuracy in OLIF, the OArm second spin for pedicle screw fixation may expose patients to higher doses of radiation [15]. However, Konieczny et al. reported a near 60% reduction in radiation exposure to the patient with navigation technology with improved accuracy during the procedure.

Perioperative data from a large retrospective assessment of navigated OLIFs demonstrated an average of 129 minutes per operative level, and a mean estimated blood loss of 55.5mL per level [10]. Our current case shows marked improvements in both parameters illustrating the efficacy of navigation-guided L2-S1 fusion.

Lessons

Outcomes of the procedure demonstrate the feasibility of the method for early postoperative discharge, low intraoperative blood loss, and short operative duration. The use of navigation technology OLIF may improve the accuracy of interbody cage placement and be an appropriate method for long-construct fusions.

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