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Minimally Invasive Management of Complications from Previous Midline Spinal Surgery

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Abstract

Study background: The application of MIS techniques to address complications of previous midline surgery has not been fully explored.

Methods: Three patients with previous midline lumbar surgery underwent revision surgery with minimally invasive approaches for management of either: infection, recurrent radiculopathy or symptomatic heterotopic bone formation.

Results: Patient 1 was found to have a persistent discitis 10 months after a lumbar fusion that was complicated by a pseudoarthrosis and infection requiring a second surgery for additional stabilization and third surgery for an incision and drainage. To avoid reopening the incision for a fourth time, a minimally invasive retractor was used to access the disc space and remove the interbody spacer. Patient 2 experienced a recurrent radiculopathy three months after an L5-S1 transforaminal lumbar interbody fusion. CT scan demonstrated heterotopic bone formation into the S1 neural foramen. A minimally invasive retractor was used through a paramedian incision to explant the pedicle screw rod construct on the symptomatic side, remove the heterotopic bone formation and decompress the neural foramen. Patient 3 experienced onset of an S1 radiculopathy 11 years after an L4 to S1 fusion. A fixed tubular minimally invasive retractor was used to access the S1 neural foramen and decompress the symptomatic root.

Conclusions: Minimally invasive spinal surgical techniques have the capacity to adequately address focal complications that have occurred with midline surgery. These techniques preclude the need to reopen a previous incision, which is especially valuable in those patients with delayed healing capacity, extensive previous surgery or previous infection.

Keywords: Complications; Heterotopic Bone Formation; Infection; Minimally Invasive Spine Surgery

Introduction

Over the past decade, the application of minimally invasive spinal surgical techniques has expanded rapidly. Surgeons have become increasingly comfortable with limited operative corridors and competent with the expanded armamentarium of minimally invasive instruments and retractors. Consequently, indications for minimally invasive techniques have broadened to include neoplasms and deformity, conditions which were relegated to the realm of traditional midline open surgery only a decade ago. Indeed, several case series and case-control series have appeared in the literature evaluating use of the minimally invasive techniques for intramedullary and vertebral column tumors, thoracic disc herniations and corpectomies, scoliosis [1-8]. Minimally invasive surgical techniques are increasingly conceptualized by surgeons as less of a complete shift in operative paradigm, and more as the analog of conventional open surgery: direct operative visualization with essentially the same operative fundamentals.

Despite this increasing use of minimally invasive techniques for indications and anatomical locations previously considered outside the realm of the minimally invasive precinct, revision surgery, particularly revision surgery after open surgery, has not been extensively explored with minimally invasive techniques. In general, however, minimally invasive surgery has generally been shown to demonstrate decreased infection rate, decreased blood loss, decreased use of narcotics and decreased duration of hospitalization [9-13]. These aforementioned advantages address the primary challenges of any revision surgery, which include longer operative times, greater blood loss and higher infection rates. Consideration of minimally invasive techniques, therefore, becomes a rational choice for revision. However, the clinical data that has been published in this area has been limited to minimally invasive fusions after open laminectomies and recurrent disk herniations without explantation of instrumentation or decompression of previously fused segment. To our knowledge, this report represents the first description of posterior minimally invasive techniques used for explantation of hardware from a previous midline posterior instrumented case.

We present three cases that highlight the advantages of MIS approaches for the treatment of patients who became symptomatic from complications related to prior midline open surgery. These cases emphasize the considerations and techniques associated with minimally invasive corridors, which afford the opportunity to minimize surgical morbidity for treating highly specific and focused anatomical pathology. While valid concerns for parallel skin incisions, altered anatomy and absent bony landmarks may cause apprehension for the application of these techniques, the cases presented herein, illustrate the feasibility and the efficacy of minimally invasive techniques in the setting of previous midline surgery.

Case 1

History

A 68-year-old diabetic woman initially presented with a mobile grade I spondylolisthesis at L4-5, and underwent an L4-5 posterior lumbar interbody fusion with a PEEK interbody, complicated by a

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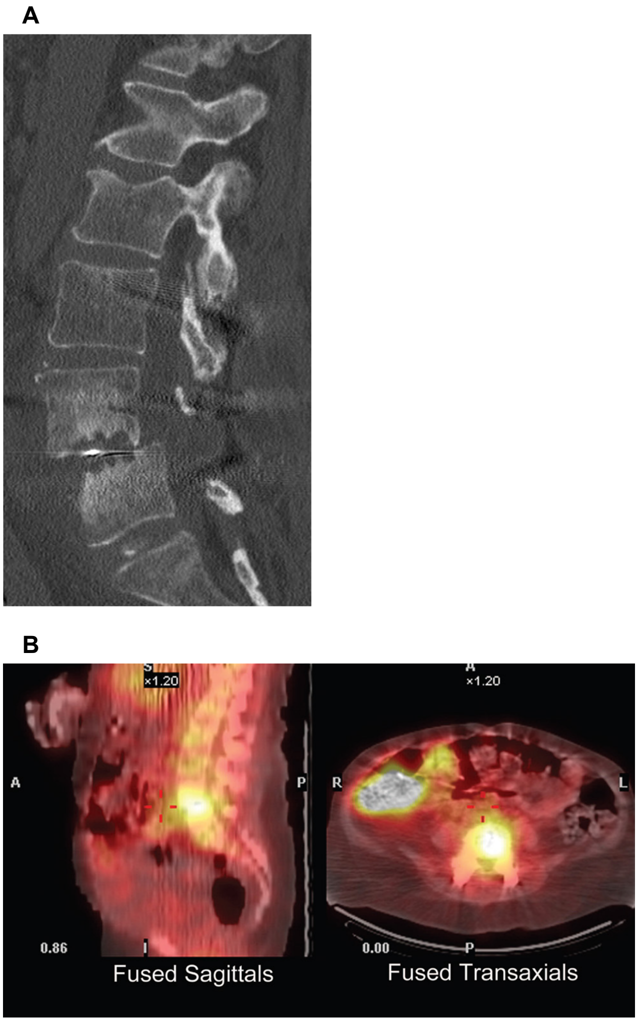

Figure 1: (A) Sagittal reconstruction of a lumbar CT performed 4 months after an incision and drainage for a MRSA infection. The interbody device is seen within the disc space of L4-5. Erosion of the endplate has progressed significantly in the interval time from her most recent surgery. (B) Nuclear medicine study which demonstrated increased uptake at the L4-5 level, but none in the vicinity of the pedicle screw instrumentation. Used with permission from Barrow Neurological Institute.

symptomatic pseudoarthrosis at 6 months. The patient underwent a revision surgery with extension of the instrumentation to the L3 level. This was operation was complicated by an MRSA infection, cultured from both the blood and the wound. The management of this infection required an incision and drainage as well as long term antibiotics. All of the devascularized grafting material was removed at the time of the third surgery. Neither the hardware nor the interbody device was explanted at the time of this incision and drainage. Initially, the inflammatory markers normalized and the patient did clinically well with resolution of her pain and healing of her wound. The patient completed three months of intravenous vancomycin. Four months after the incision and drainage, the patient returned with increasing back pain.

Neurological examination, laboratory and radiographic data

A CT scan obtained at that time demonstrated erosion of the endplates at L4 and L5 with migration of the interbody device (Figure 1 A). Inflammatory markers (C-reactive protein and erythrocyte sedimentation rate) had significantly increased from their previously normalized values. A nuclear medicine study demonstrated significantly increased uptake isolated to the L4-5 disc space (Figure 1B). A CT guided biopsy from the disc space confirmed MRSA.

Surgical intervention

Review of the radiographic data demonstrated the nidus of the infection lay in the disc space. In the absence of resolution of the infection with long term intravenous antibiotics, removal of the interbody device was indicated. Options for the removal included reopening the previous incision, explantation of the instrumentation and interbody device or removal of only the interbody device. The absence of increased radionucleotide uptake in the vicinity of the pedicle screws, suggested that only removal of the interbody device was needed. Given the previous issues with wound healing, the authors opted against reopening the previous incision and instead proceeded with explantation of the interbody device through a minimally invasive approach.

With the patient prone on a radiolucent table, a 22-mm incision was planned over the L4-5 disc space on the right side. Sequential dilatation of the fascia and muscle was then performed followed by placement of a minimally invasive expandable retractor (Figure 2).

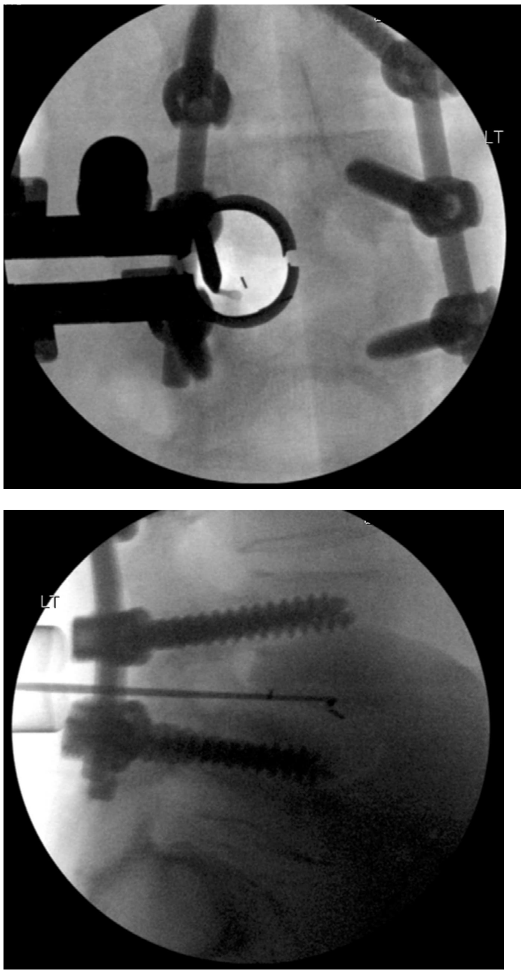

Figure 2: Owl's eye view (A) and lateral fluoroscopic images (B) of the expandable retractor placed medial to the pedicle screw rod construct. A bayoneted forward angle curette was used to extract the device once the L5 nerve was identified, mobilized and retracted medially. Used with permission from Barrow Neurological Institute.

Anteroposterior, owl's eye, and lateral views were used to place the interbody spacer along the trajectory of the retractor. The lateral aspect of the previous bone work was identified and a complete facetectomy was performed. The traversing nerve root of L5 was identified and retracted medially. Kerrison rongeurs were then used to enlarge an opening in the previously accessed disc space and the interbody spacer extracted with a forward angled bayonetted curette. The disc space was debrided, copiously irrigated and then packed with resorbable vancomycin embedded beads.

Postoperative course

Cultures taken from the spacer and the intradiscal space grew out MRSA. The patient was placed on 6 weeks of intravenous vancomycin. Twenty-five months after this procedure, the patient has no evidence of recurrent or persistent infection (Figure 3).

Case 2

History

A 46-year-old active duty service member presented with recurrent radiculopathy 3 months after having undergone a midline L5-S1 transforaminal lumbar interbody fusion with human recombinant bone morphogenetic protein. The patient initially did well from this operation and at one month had complete resolution of his radicular symptoms and improving back pain. During the third month, the patient experienced recurrence of his S1 radiculopathy.

Neurological examination and radiographic data

An MRI performed at 12 weeks demonstrated increased signal intensity emanating from the disc space at L5- S1 clearly in contact

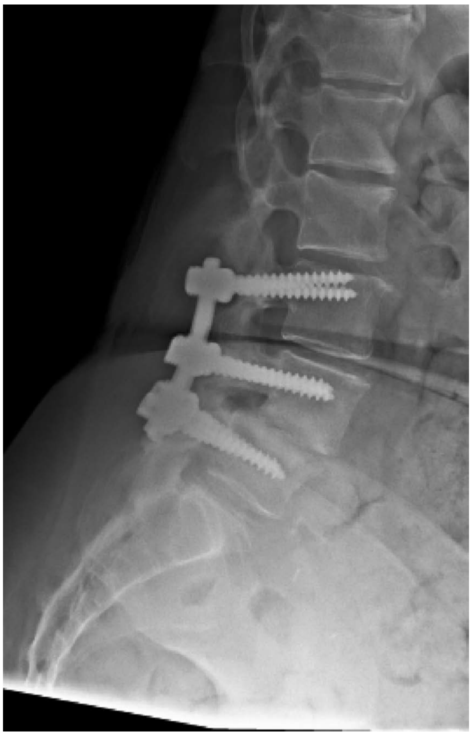

Figure 3: Lateral x-ray of patient 1 eight months after surgery. The patient had resolution of her preoperative back pain with normalzation of her inflammatory markers off all antibiotics. Used with permission from Barrow Neurological Institute.

Figure 4: Axial MR T2-weighted image of a patient who presented 11 weeks after an L5-S1 TLIF with a new onset progressively worsening left S1 radiculopathy. There is increased signal intensity behind the interbody device effacing the thecal sac and abutting the neural foramen. Used with permission from Barrow Neurological Institute.

with the traversing S1 root (Figure 4). The patient was initially treated nonoperatively with a selective nerve root block. On exam, the patient had mild plantarflexion weakness and pain along the S1 distribution. The Achilles reflex on the left was absent. Persistent symptoms prompted further evaluation and a CT scan performed at 6 months demonstrated heterotopic bone formation along the trajectory of the placement of the interbody device (Figure 5).

Surgical intervention

Because of persistent symptoms limiting the ability of the patient to return to unrestricted full duty, decompression of the nerve root was considered. Given the fact that the patient had unilateral symptoms and a robust radiographic fusion by CT scan, a minimally invasive approach from the left side was chosen for explantation of the pedicle screw rod construct and decompression of the nerve root. An incision was planned with fluoroscopy overtop of the L5-S1 pedicle screw rod construct. A 28-mm incision was then made, the fascia divided and sequential dilation of the muscle performed encompassing the pedicle screw rod construct (Figure 6). Once docked onto the instrumentation, the rod and two pedicle screws were removed.

Upon removing the S1 pedicle screw, the remaining pedicle screw hole became a frame of reference for the decompression of the S1 root. The heterotopic bone was then identified and drilled just medial and superior to the S1 pedicle screw hole until the interbody device was uncovered from within the bone. At this point, drilling proceeded medially with a diamond bit until the bone in the foramen could be removed with a curette. At this point, the S1 nerve root became readily identifiable. With the certainty of the position of the S1 nerve root, a wide foraminotomy was able to be performed (Figure 7).

Postoperative course

The patient was discharged on postoperative day one with resolution of his radiculopathy. He would return to unrestricted full duty on the second postoperative month and remains on active duty 36 months after the procedure.

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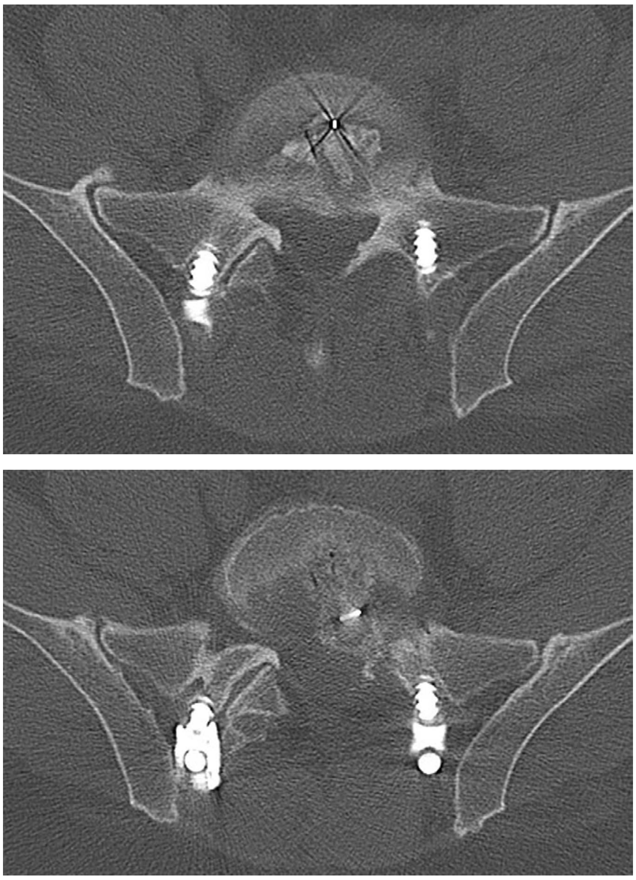

Figure 5: Axial CT obtained 6 months after surgery demonstrating a robust interbody fusion (A) but also bone formation into the canal and neural foramen (B). Used with permission from Barrow Neurological Institute.

Case 3

History

A 46-year-old man who had undergone an L4 to S1 posterolateral fusion presented with a delayed right S1 radiculopathy 11 years after his initial surgery. The patient had a full recovery from this operation and remained symptom free for years. The patient presented to our clinic with the insidious onset of right radicular pain of three month duration.

Neurological examination and clinical course

On examination, the patient demonstrated 4/5 strength on plantarflexion on the right. The remaining motor examination was normal. There was no sensory abnormality. The Achilles reflexes were 1+ on the right and 2+ on the left. Electromyography was consistent with an S1 radiculopathy. The patient underwent a CT guided selective nerve root block of the right S1 nerve root with complete relief of his symptoms.

Radiographic data

MRI was limited because of artifact. A CT of the lumbosacral spine demonstrated a robust posterolateral fusion. In the vicinity of the S1 neural foramen, the posterolateral fusion encroached on the canal and the traversing nerve root (Figure 8).

Surgical intervention

In the absence of sustained relief from multiple selective nerve root block, a decompression of the S1 nerve root was considered after 6 months of persistent symptoms. Given the extent of previous surgery and the desire to avoid reopening the previous incision for a unilateral radiculopathy, a minimally invasive technique offered a focal surgical alternative to opening the entire previous two level instrumented fusion. A 16-mm incision was planned over top of the right S1 pedicle screw. After sequential dilatation of the muscle layer, a 16-mm tubular retractor was guided with AP and lateral fluoroscopic imaging just medial to the right S1 pedicle screw. The pedicle screw was then identified and the posterolateral fusion mass drilled until the lateral aspect of the canal could be identified (Figure 9). Once the lateral aspect of the thecal sac was identified, bone removal extended laterally and inferiorly. The S1 nerve root was then identified and a generous foraminotomy performed.

Postoperative course

The patient had complete resolution of his preoperative symptoms

Figure 6: Lateral fluoroscopic image demonstrating placement of retractor overtop of the L5-S1 pedicle screw rod construct (A). After explantation of the rod and screws, the heterotopic bone formation was removed and the S1 nerve root decompressed. Used with permission from Barrow Neurological Institute.

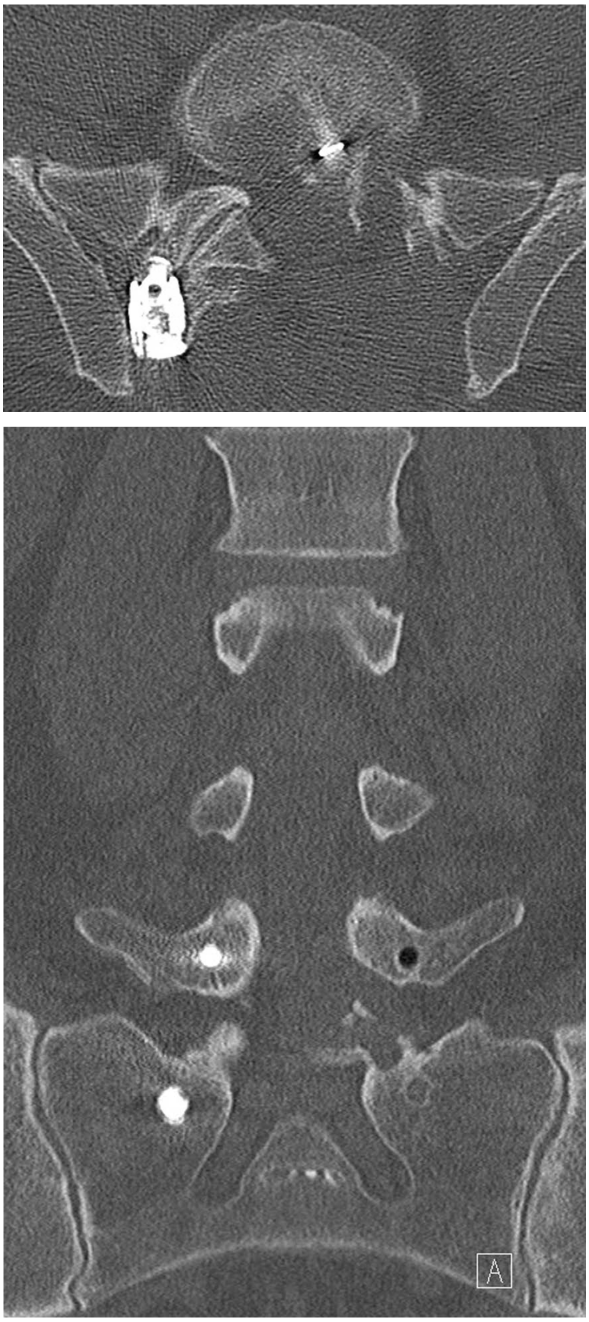

Figure 7: Postoperative axial and coronal reconstruction CT of the lumbosacral spine demonstrating the explantation of the pedicle screws and decompression of the S1 nerve root. Used with permission from Barrow Neurological Institute.

and returned to his previous level of activity within the first postoperative month. He remains asymptomatic 18 months after surgery.

Discussion

When considering surgical strategies for revisions of previous surgery, the intuitive approach would be to target the region of the anatomy which is the root cause of the patient's symptoms. Minimally invasive techniques allow for such a targeted approach. The very nature of revising a previous midline surgery, on the other hand, typically mandates opening in its entirety the previous incision and visualizing at least to some extent the previous surgical exposure. In those circumstances where a focal lesion is present, such as the cases reported herein, minimally invasive techniques offer an alternative to this. The caveat to this is the limited exposure, which comes with any minimally invasive approach. To mitigate the effect of a limited exposure, the authors emphasize thorough preoperative planning, fluoroscopic guidance for positioning the retractor and the position and trajectory of the retractor itself.

The presence of pre-existing instrumentation is both helpful and challenging. On fluoroscopy, pedicle screws are landmarks that can help define the anatomy of the pedicle for the surgeon. However, screw heads and connecting rods limit access to the neural foramina and can be a significant impediment to obtaining adequate decompression. The decision should be made preoperatively whether to remove the instrumentation or to leave it intact. Secondary reimplantation after successful decompression is a possibility. We determine whether to remove the hardware based on high-resolution CT of the area of interest. If a contralateral fusion or interbody fusion is robust, a short-segment fusion is present, and the likelihood of instability after decompression

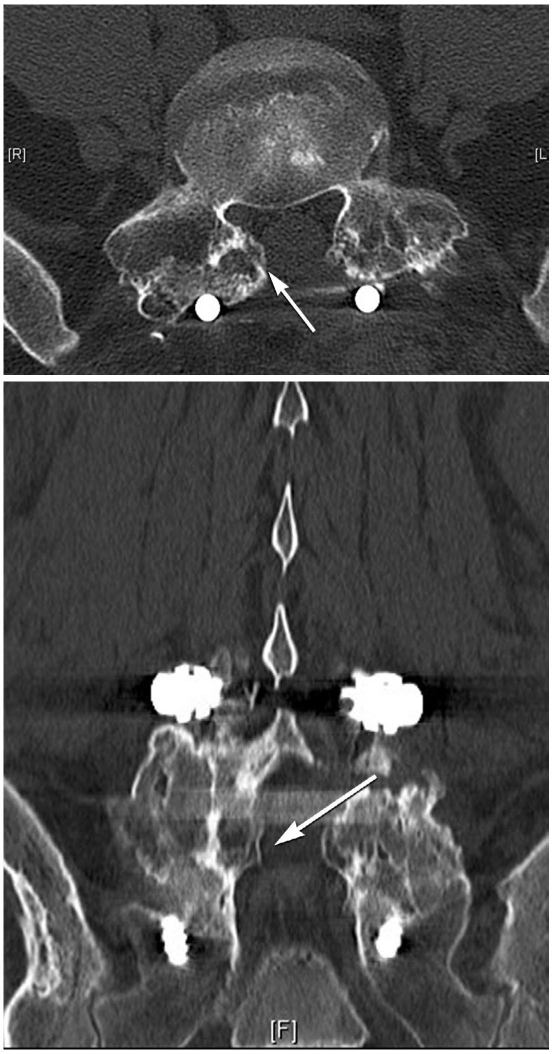

Figure 8: Axial and coronal CT demonstrating an extensive posterolateral fusion mass encroaching on the thecal sac and the right S1 nerve root. Used with permission from Barrow Neurological Institute.

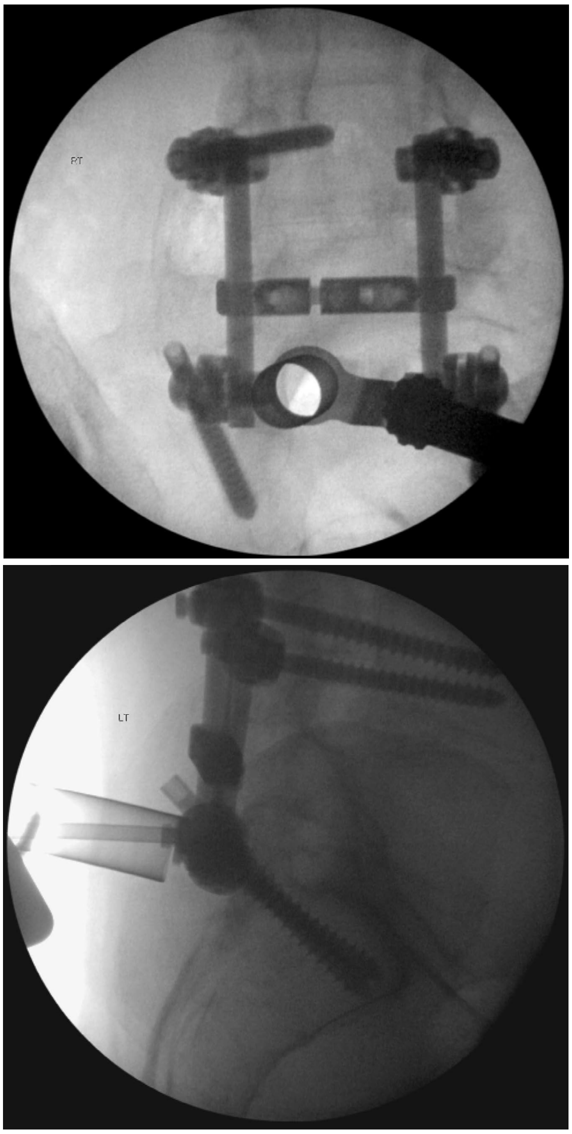

Figure 9: Owl's eye view and lateral fluoroscopic image demonstrating the position of the tubular retractor at the level of and just medial to the S1 pedicle screw. Used with permission from Barrow Neurological Institute.

is limited, we prefer to remove the hardware to widen the surgical corridor. Removal of instrumentation for simple decompression of adjacent level disease is not frequently necessary.

In the context of previous surgery, the standard landmarks such as the facet or the pars may have been removed. These are useful landmarks for minimally invasive approaches and their absence in revision surgeries may be disorienting to the surgeon in a limited operative field. Under these circumstances, the use of fluoroscopy (anteroposterior, lateral, and owl's eye view) is of tremendous value to appropriately position the minimally invasive access port, especially in the medial-lateral trajectory. The authors routinely obtain all three of these views for all minimally invasive revision cases to ensure optimal placement of the retractor for these revision surgeries. Once docked, the instrumentation takes the place of aforementioned landmarks.

In the case of explantation (Case 2), the pedicle screw hole determines the position of the traversing nerve root. The traversing nerve root is typically within 3-4 mm medial to the medial most aspect of the pedicle screw hole. And so, even when a complete fasciectomy was performed (as in Case 2), the remaining pedicle screw hole may be used as a reliable landmark to guide the decompression. Using a trajectory parallel to disc space of the symptomatic root to set the trajectory of the retractor further optimizes the exposure for a decompression. This is illustrated in Case 2, where a unilateral explantation and nerve root decompression was performed to address heterotopic bone formation.

In those cases where the instrumentation remains in place (Cases 1 and 3), the surgical corridor is even more narrow and the position of the retractor even more crucial. When access to the disc space is required (Case1), docking the retractor firmly against the rod and parallel to the caudal endplate creates the optimal trajectory for intradiscal work. Prior to this, however, a thorough understanding of the bony anatomy is crucial and a high resolution preoperative CT becomes essential to plan the surgical corridor. In Case 1, identifying the integrity of the lateral aspect of the facet was invaluable when attempting to determine a safe corridor into the disc space. Once docked on the lateral facet, medial to the pedicle screw rod construct, the remaining bone was removed, the nerve root safely identified and the disc space accessed. For decompression of a symptomatic nerve root with the instrumentation in position (Case 3), again the pedicle screw corresponds to the symptomatic root and becomes the reference point for the decompression.

Revision of a previous midline surgery with a minimally invasive approach elevates the degree of complexity. A review of one surgeon's experience with minimally invasive revision interbody fusions after previous midline laminectomies or discectomies found significantly higher rates of durotomy in revision surgeries versus primary fusions [14]. In the 17 patients reviewed by Selznick and colleagues, all had previously midline surgery and subsequently underwent a minimally invasive TLIF [14]. These authors demonstrated the feasibility of minimally invasive approaches after previous midline surgery. Unlike the patients in our series, however, none had previous instrumentation that required explanation. The patients reported herein demonstrate the feasibility of revising previous midline instrumented fusions with a minimally invasive approach. Based on our experience managing patients with previous instrumented midline surgery, we agree with Selznick and colleagues and further emphasize that revision MIS approaches of previous instrumented midline surgery should only be attempted by surgeons who routinely practice MIS.

Revision surgery under any circumstance is more technically challenging and associated with an elevated risk for complications such as CSF leak and infection [14-17]. In addition to the surgeon's experience, we emphasize the importance of preoperative planning with high resolution imaging, identifying a safe surgical corridor and the use of intraoperative fluoroscopy (anteroposterior, lateral, and owl's eye view). Collectively these elements are invaluable adjuncts to a surgeon's experience to mitigate further complications and optimize outcomes for such revision surgeries.

When successfully performed, minimally invasive revision surgery has the inherent advantage of a smaller incision, less blood loss and lower risk of infection [9,12,13,18]. In the cases presented herein, the main advantage was avoiding reopening an extensive previous incision. Instead, all three patients in this report had incisions that ranged from 16-28 mm. The importance of avoiding a previously infected incision in a diabetic patient for the fourth time (Case 1) with these techniques cannot be emphasized enough.

Conclusions

Thorough preoperative planning, appreciation of the remaining bony anatomy and precise docking of a fixed diameter or expandable minimally invasive retractor collectively optimize the visualization of the anatomy necessary for a successful revision operation. While not all situations may be amenable to a minimally invasive approach, those complications that arise from a focal problem within one aspect of an otherwise extensive operation do lend themselves to a minimally invasive solution. From the experience with these three cases, the authors conclude that minimally invasive techniques for revision of complications from open surgery is a viable option and may reduce the risk and morbidity of open revision for the same problem.

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