Operative Techniques in
Orthopaedics

The Cortical Bone Trajectory for Lumbar Spine Fusion

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Cortical bone trajectory, also called cortical screw trajectory, is a novel, less invasive fusion alternative for disorders affecting the lumbar spine. Cortical screw constructs have several touted advantages over traditional pedicle screw constructs. First, the surgical exposure required for instrumentation placement is less than that required for traditional pedicle screw placement. This reduced exposure can help reduce blood loss and other approach-related morbidity. Second, the unique screw trajectory, along with a cortically threaded screw, allows for increased cortical bone purchase within the lamina and pedicle. This improved bone purchase can result in improved screw pullout strength, and possibly reduce the chance of screw loosening. Finally, cortically placed screw heads rest on top of the vertebral lamina, which is significantly more medial than traditional pedicle screws, making them more accessible and rod placement more straightforward. Cortical bone trajectory has been validated with several biomechanical cadaveric studies and shows promise with early clinical testing. The cortical screw trajectory may provide patients with lumbar spine pathology a less invasive fusion alternative. This article serves to describe the operative technique and provides a current review of the literature.
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KEYWORDS cortical bone trajectory, cortical screw trajectory, lumbar fusion, minimally invasive surgery, spine surgery

Introduction

Instrumented lumbar fusion is a commonly performed surgery that is indicated in cases of lumbar spinal instability resulting from trauma, spondylolisthesis, tumor, deformity, or iatrogenic instability. Since first described by Dr Boucher[1] in the late 1950s, the use of pedicle screw and rod constructs have become the modern, gold standard technique for instrumented lumbar fusions. Fixation through the pedicle allows significant control of the entire vertebral body,[2,3] and it reduces the rate of nonunion following fusion. Pedicle screws are traditionally inserted at the junction of the lateral facet and transverse process and are directed in a lateral-to-medial trajectory through the pedicle and vertebral body.[4,5] However, pedicle screw fixation is not without faults. The most commonly reported complication is misplacement of screws, which in certain circumstances may also result in dural or neurovascular injury.[6-14] A systematic review found that screw misplacement ranged from 6%-31% using the freehand technique, 15%-72% with the aid of fluoroscopy, and 0%-11% using computed tomography navigation.[15]

Achieving solid implant fixation can be complex clinical challenge for spine surgeons. Progressive construct instability as a result of screw loosening is another well known complication with pedicle screw instrumentation, especially in patients with poor bone quality.[4,16,17] The risk of a pedicle screw loosening is increased with screws that are primarily anchored in trabecular medullary bone and in patients with

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reduced bone mineral density.[16,18,19] Optimizing the amount of screw contact with cortical bone is one possible way to improve the overall screw strength.

Cortical bone trajectory (CBT), also called cortical screw trajectory, is a novel, less invasive instrumentation alternative that was initially described by Santoni et al in 2009.[16,20] As opposed to the traditional lateral transpedicular approach used with pedicle screws, the cortical screw entry point is medial to the edge of pars interarticularis and is directed in a caudal-to-cephalad in the sagittal plane and medial-to-lateral in the axial plane.[16,21] The primary advantage of this screw technique is the increased cortical bone contact of the lamina and pedicle, which improves the overall screw purchase and reduces the risk of screw loosening.[16,22] Despite using a smaller diameter screw, many studies have shown that the pullout strength and toggle strength is comparable to that of pedicle screws.[16,23-25] Oftentimes, surgeons can manually detect the increased screw purchase intraoperatively, as cortical screws require increased insertional torque during placement.[20,26] Although improved pullout strength and insertional torque do not necessarily correlate with favorable spinal fixation, radiographic studies comparing CBT and pedicle screws have also shown comparable results.[26]

In addition to the increased cortical bone purchase, CBT offers other favorable benefits to spinal surgeons. The CBT provides a more medial orientation of the screw heads compared to pedicle screws.[27] This allows easier placement of the rod construct, and excessive tissue retraction laterally is often not necessary. Furthermore, the lateral-to-medial trajectory of pedicle screws often requires significant muscle dissection resulting in postoperative muscle pain and increased risk of infection.[28,29] Conversely, the fusion preparation for CBT primarily focuses on the facet joints and spinal lamina. Exposure of the lumbar transverse processes is not required for most cases. This less invasive exposure can shorten the incision required for instrumentation placement and may reduce approach-related morbidity associated with paraspinal muscle dissection.[20,21,25,27,30]

Operative Technique

The operating room orientation and patient positioning is the same as with traditional instrumented lumbar fusions. The patient should be carefully positioned prone on a Jackson table, making sure to carefully pad all possible pressure points. The knees are slightly flexed and the legs are supported with pillows for comfort.

Following radiographic level localization, a midline longitudinal incision can be planned over the proposed levels of fusion. The lamina should be exposed in a standard surgical fashion, taking care to subperiosteally dissect the paraspinal muscles to minimize blood loss. Electrocautery can then be used to release the tissue attachments and reveal the underlying bony elements. The lumbar facet joints within the fusion construct should be fully exposed so they can be viewed in their entirety. As with traditional pedicle screw fusions, caution should employed when exposing the facet capsules superior and inferior to the planned fusion construct as to avoid capsular injury and possible delayed spinal instability. Typically, transverse processes do not need to be exposed. This reduces the need for larger incisions and lateral retraction, and the reduced muscle dissection also lowers approach-related morbidity.[5,21,25,27] However, if a total facetectomy is being performed, some ipsilateral transverse process exposure may be necessary for fusion preparation. The lateral edge of pars interarticularis should be exposed and well-visualized in all levels being fused, as this is the main surgical reference point for screw placement. In cases of severe spondylosis, partial removal of hypertrophic facet joints may be needed to effectively expose the pars.

The entry point is approximately 3 mm medial to the isthmus of pars interarticularis.[16,26] It is important to preserve a rim of bone at the pars to prevent lateral cortical breach during screw placement. Using a drill bit, the pilot hole can be performed, aiming 30°-45° caudal-to-cephalad in the sagittal plane and 20° medial-to-lateral in the axial plane (Fig. 1). The use of intraoperative stereotactic navigation can be valuable in

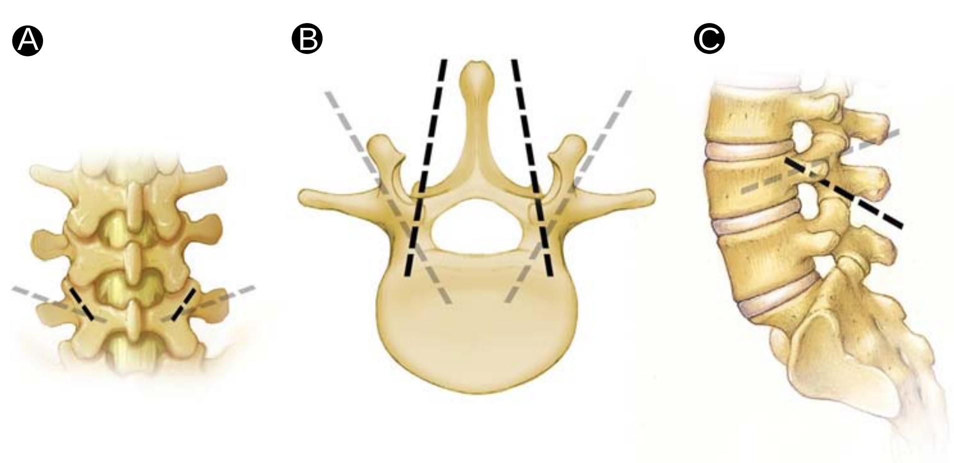

Figure 1 Anatomical comparison of cortical bone trajectory (black line) vs a traditional lateral transpedicular screw (gray line). (A) coronal view, (B) axial view, and (C) sagittal view. (Color version of figure is available online.)