Enhancing Safety in Pedicle Screw Placement in Idiopathic Scoliosis

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Pedicle screw use in the surgical management of scoliosis has become well established. Originally approved only for use in the lumbar spine in adults, pedicle screws now are approved for the thoracic spine in adolescent scoliosis. However, unlike the adult lumbar spine, the thoracic pedicles in scoliosis are smaller because the patients are smaller and more variable because of the scoliosis deformity (Figure 1). A recent review on the accuracy of thoracic pedicle screw placement found that 95% of screws are within the pedicle and are acceptable (REFERENCE). However, considering that most patients will receive more than ten screws, that statistic suggests at least one out of two patients might have a less than ideal screw. Therefore, any measures that can improve the accuracy of pedicle screw placement are desirable for patient safety.

Many measures are at the pediatric spine surgeon’s disposal. The same review mentioned above confirmed that “navigation,” such as intraoperative computer-generated three-dimensional imaging with STEALTH and O ARM, improves the accuracy of screw placement (Figure 2). Navigation adds axial imaging to AP and lateral x-rays, which were the only intraoperative imaging available prior to the development of navigation. Axial images allows surgeons to visualize where their pedicle screws lie relative to vital anatomic structures near the spine (Figure 3). For instance, the spinal cord hugs pedicles in the concavity of the scoliotic curve (Figure 4). Spinal cord monitoring during scoliosis surgery is in use in most operating rooms, so pedicle screws that impinge on the spinal cord (Figure 5a) can be detected during surgery using electrical stimulation, and adjustments can be made accordingly. Another measure that can be made to improve pedicle screw safety is to minimize the number of concave screws and maximize the number of convex screws, because convex-sided pedicles are farther from the spinal cord. The aorta also abuts the spine on the concave side, meaning that pedicle screws there could impinge on it (Figure 5b). Screws abutting the aorta may remain asymptomatic, undetected by AP and lateral x-rays, until erosion causes life-threatening bleeding. Navigation enables the surgeon to better visualize his screw placement, and thus it lessens the risk of aberrant screw into the spinal cord or aorta, both which can lead to devastating complications. Confirmation of acceptable screw placement before the patient’s wound is closed so that any aberrant screws can be adjusted before the surgery is over is desirable and avoids a second trip to the operating room.

Pedicle screws provide for a strong construct for curve correction. Studies have shown that increasing the density, or number, of screws is associated with less correction of the sagittal (meaning looking at the spine from the side) curve, and results in a tendency for “flat back” phenomenon. The “flat back” phenomenon is a reduction in scoliosis when looking at the spine from the front (a good thing) but failure to re-establish a more natural sagittal curve (a bad thing). Patients often complain of rib prominence due to this phenomenon. A pedicle screw rotation maneuver can be done
on one side to allow for scoliosis correction while creating a natural sagittal curve. So, pedicle screws allow for scoliosis curve correction in multiple planes with one construct.

In summary, pedicle screws are powerful tools in the surgical management of scoliosis. But, they carry risks. Anything that can reduce these risks and improve outcome should be considered. These measures include computer-assisted navigation such as STEALTH and the O ARM, spinal cord monitoring and electrical stimulation of pedicle screws, reducing the number of screws in the concavity of the scoliosis curve, and using screws that allow three dimensional deformity correction including the rib prominence. Finally, pediatric spine surgeons can confirm acceptable screw placement before leaving the operating room or prior to hospital discharge by axial imaging in addition to standard AP + lateral x-rays. The value of having this information before the patient’s surgery is completed allows for immediate intervention. As pedicle screws become used increasingly in scoliosis surgery, spine surgeons can take measures to make them safe and effective.

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References
Figure 1: The pedicle screw is in a normal sized pedicle. The arrow points to a narrow pedicle. It is common to find pedicles of differing sizes in the vertebrae of a patient with scoliosis. The aorta is marked with a circle.

Figure 2: The o-arm (left) is slightly larger than a regular c-arm (right).

Figure 3: A screw that appears appropriately placed on x-ray might actually be impinging on the aorta (circle) or spinal cord (triangle).

Figure 4: A typical right thoracic scoliosis with the concave side on the left (asterisk) and the convex side on the right (arrow).
Figure 5a: The screw on the right-hand side of the image has breached the spinal canal, possibly impinging on the spinal cord. AP and lateral radiographs would demonstrate this screw to be in the bone. The axial view shows that the screw violates the canal and is in the vicinity of the spinal cord (triangle).

Figure 5b: The screw on the right-hand side of the image would appear normal on AP and lateral x-rays, but axial imaging shows it is the vicinity of the aorta (circle).