Thoracic Pedicle Screws
Pedicular Approach
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Goals of Surgical Treatment
To stabilize the thoracic spine; to correct a kyphotic deformity.

Diagnosis
Instability of the thoracic spine can be caused by fracture, tumor, or spondylodiscitis. Kyphotic deformity can be caused by delayed fracture, Scheuermann’s disease, or other reasons for a hyperkyphotic thoracic spine. The diagnosis is made by physical findings and a standing antero-posterior (AP) and lateral x-ray of the whole spine completed by a lateral view of the thoracic spine in supine position with traction (Fig. 17–1).

Indications for Surgery
Thoracic spine instability, painful hyperkyphosis, significant thoracic cosmetic deformity due to hyperkyphosis, thoracic pedicular approach for bone biopsy of the vertebral body.

Contraindications
1. Children or small adults in whom the pedicle size does not allow screw placement with a diameter of 5 or 6 mm.
2. Severe osteoporosis.

Advantages
1. No implant contact to neural structures of the spinal canal.
2. High stability; pedicle screw can be loaded by three-dimensional correction forces.

Disadvantages
1. Medial screw misplacement can lead to severe neurologic deficits.
2. Thoracic pedicle diameter (mostly the transverse diameter) can be too small for 6-mm screws even in normal adults.

Procedure
The patient is placed in a prone position on a frame or pillows with no pressure on the abdomen. The arms are positioned cranially with anteverision of the shoulders. Lateral C-arm control is helpful, but image quality can be poor in the upper thoracic area due to ribs and shoulder. The surgeon should be able to do the thoracic pedicular approach even without C-arm control. If the following rules are respected, the risk of medial misplacement of the screws is very low. Attention must be given to the correct entry point of the thoracic pedicle. If the pedicle seems to be too small on an AP x-ray (pedicle size is limited by transverse diameter), a computed tomography (CT) scan should be done in the levels that are to be instrumented. We do not recommend pedicle screws with an outer diameter less than 6 mm in adults or adolescents because of the risk of breakage. In the pediatric population, we recommend 5-mm screws.

The medial wall of the thoracic pedicle is thicker than the lateral, and the length of the pedicle is shorter compared with the lumbar pedicle. Even if the transverse pedicle diameter is not much bigger than the screw diameter, the stability of the inserted screw is sufficient, because a greater part of the screw is inserted in the thoracic vertebral body compared with the lumbar situation. In the following technique the screw can cut the thinner lateral wall but not breach the more important medial wall of a pedicle, which is not much bigger than the screw. With an oblique screw orientation a lateral pedicle fracture can be avoided. If the anatomic conditions do not allow the implantation of a 6-mm-diameter screw, we recommend the use of hooks, claws, or wires to fix the internal fixateur to the spine.

Exposure
A midline incision is made one spinous process above the most cranial vertebra down to the spinous process of the most caudal vertebra. The extensor muscles are dissected laterally to the tips of the transverse processes. The inferior facet is resected except in the most cranial vertebral body, where the capsule is excised only (Fig. 17–2). The lateral border of the superior facet is identified with a probe. A parallel line of the lateral border of the superior facet corresponds to the y-axis of the entry point to the pedicle. The transverse process is divided in three horizontal parts. A parallel line between the middle and the cranial third of the transverse process corresponds to the x-axis. The intersection of both axes does not correspond to the center of the pedicle but to the lateral border of the oval pedicle and it is more lateral than the entry point for the Roy-Camille technique (Fig. 17–3A-C). We open the cortex over this point with a Perthes awl, which is directed in the horizontal plane 20 to 25 degrees from lateral to medial and 5 to 10 degrees in the sagittal plane from cranial to caudal. If a lateral C-arm control is available, we find the ideal direction in the sagittal plane on the C-arm view. We prepare the screw hole with a 3.2-mm drill, which is used speedless or at very low speed pushing the drill machine up and down carefully. A penetration of the anterior cortex has to be strictly avoided. Another option is to prepare the screw hole with a probe. The length of the screw is measured with a depth gauge. With a 3-mm ball-tip probe, the quality of the interior pedicle wall is evaluated for penetration. At this stage the screw position may be confirmed by placing a Kirschner wire into the pedicle canal and checking the orientation with AP and lateral x-rays. If the desired screw length falls between two available screws, we implant the shorter one. In hard sclerotic bone, we prepare threads with a tap diameter 6 mm to the appropriate depths.

In some individuals the transverse processes have a special shape like a bow so that the tips of the transverse processes are orientated toward the posterior. In such a case the entry point would be too distorted and positioned posteriorly, and the way for the screw would be longer, requiring greater precision regarding the entry point and direction of the screw axis (Fig 17–3D). The risk of misplacement increases with the need for increased precision. To make it easier, a distal part of the transverse process is resected away, allowing the entry point to be closer to the level of the surface of the superior facet.

The 12th thoracic vertebra often has variations of the facet joints and the transverse processes. Often the transverse processes are short and the facet joint is typically thoracic-oriented coronary. In a situation with a more lumbar type of facet joint sagittally oriented, we follow the rules of screw placement in lumbar pedicles. If the 12th thoracic vertebra shows both variations—on one side a thoracic and on the other side a lumbar type of facet joint—lateral C-arm control or a preoperative CT scan must be used for correct placement.

We do not use different entry points and axes between the upper, middle, and lower thoracic spine even if the coronal shape of the pedicle changes from round to oval because the recommended technique minimizes potential misplacement for the entire thoracic spine (T1-T12). Only low-profile screw-rod systems should be used in the thoracic spine to avoid soft tissue problems such as pain or wound healing disturbance. We prefer a hinged type of pedicle screw with a hinge between the screw head and the shaft of the screw above the site where peak stresses and failures typically occur in rigid rod screw constructs (Fig. 17–4). This reduces stress shielding and facilitates the screw-rod connection.

Before an attempt is made to reposition the thoracic spine, posterior, anterior, or combined releases have to be completed, if necessary. A bony defect in the anterior column needs to be reconstructed.

A posterolateral spondylodesis is performed (Fig. 17–5), in cases with anterior reconstruction of the anterior column or anterior release together with an anterior spondylodesis.

Pitfalls
1. The 12th thoracic vertebra often is a transitional vertebra with anatomic variations. Careful x-ray examination is necessary and a CT scan can be indicated when anomalies are recognized like facet joint alteration, stump ribs, unilateral rib, etc.
2. The correct horizontal axis of the position of the pedicle screw (20 to 25 degrees) is important to avoid causing a fracture of the lateral wall of the pedicle. In a rotated vertebra the establishment of the correct axis is more difficult. At the apex of a structural scoliosis, rotation and torsion of the vertebra can increase the difficulties further because the pedicle by itself can be altered.

Complications
1. The uppermost and lowermost screws can break out when the correction of a rigid kyphotic deformity is attempted. Posterior release (V-shaped interlaminotomy with complete resection of the lower facets) and/or anterior release (discectomy) should be done before the correction is attempted.
Figure 17-1
Preoperative standing anteroposterior (AP) (A) and lateral (B) x-rays showing Scheuermann's disease. (C) Preoperative radiograph of the hypomochlion view showing Scheuermann's disease.
Figure 17–2
Intraoperative situs after detachment of the extensor muscles.

Figure 17–3
(A–D) Four drawings showing entry point and axis for screw placement.
Figure 17–4
Photograph of a hinged-type pedicle screw, the Segmental Spinal Correction System (SSCS). (Courtesy of Ulrich Company, Ulm, Germany, with permission.)

Figure 17–5
Posterolateral spondylodesis.

Figure 17–6
Postoperative standing AP (A) and lateral (B) x-rays of the spine showing correction and stabilization of a Scheuermann’s hyperkyphosis.
2. Soft tissue problems in slim adults: Only implants with low profile should be used in the thoracic spine.
3. Inadequate instrumentation in unstable spines: A cross-connector should be used.
4. To avoid flattening of the thoracic spine, the rods are bent following the normal kyphotic profile.
5. If a penetration of the medial wall of the pedicle is noticed, a laminectomy should be done to visualize the dura. If the dura is torn, the leakage has to be sutured and corticosteroids should be given (For-tecortin initially 50 mg, on the first postoperative day 8 mg every 4 hours, on the second postoperative day 4 mg every 8 hours).
6. A lateral fracture of the pedicle normally leads to loss of screw stability. An unstable screw should be removed and the adjacent segment should be instrumented. If this is not possible, the screw should be replaced by a pedicle hook, or pedicle hook with a transverse process hook to construct a claw. Sublaminar wiring of the rod to the spine could be done alternatively to hook implantation.

Postoperative Care
1. AP and lateral x-ray before the patient leaves the operating room.
2. Mobilization during the next 3 days, depending on the patient’s general condition, without external support.
3. Physical activities are restricted for the first 3 months; no limitation after 1 year postoperation (Fig. 17–6).

Suggested Readings