

Thoracic pedicle screw

The use of thoracic pedicle screw instrumentation has become increasingly widespread in the treatment of scoliosis owing to the consistently superior results achieved in terms of fixation and deformity correction ^{1) 2)}.

The accuracy of pedicle screws is typically defined as the screws axis being fully contained within the cortices of the pedicle ^{3) 4)}.

Placement

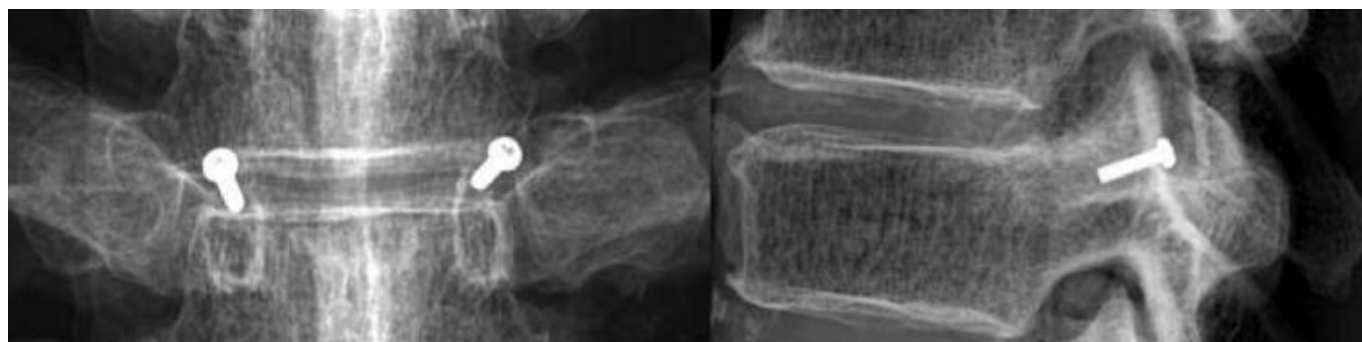
see [Thoracic pedicle screw placement](#).

Exposure

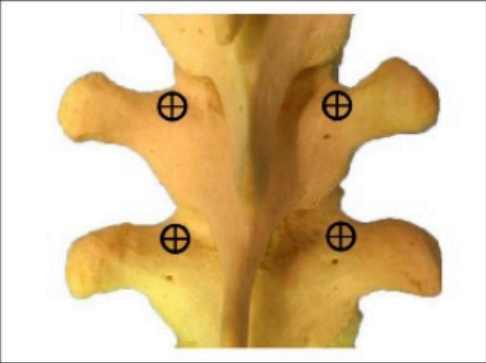
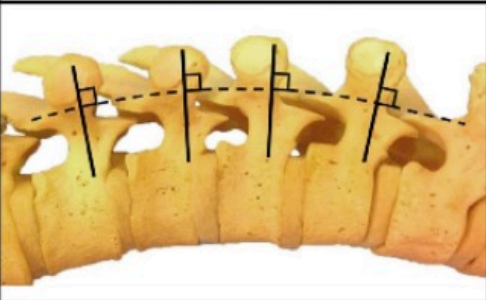
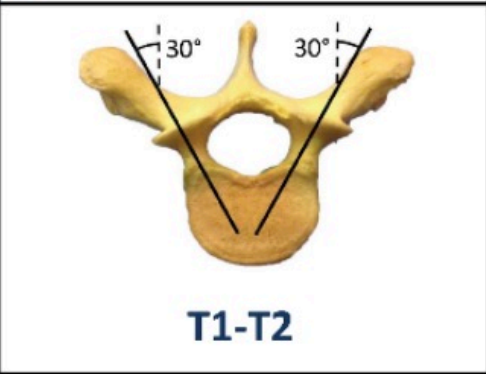
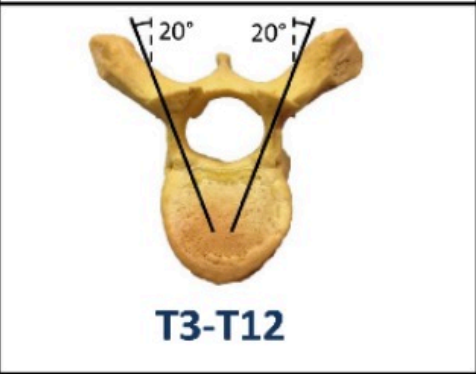
A midline [skin incision](#) is made one [spinous process](#) above the most cranial [thoracic vertebra](#) down to the spinous process of the most caudal vertebra. The [extensor](#) muscles are dissected laterally to the tips of the [transverse processes](#). The [inferior facet](#) is resected except in the most cranial vertebra, where the capsule is excised only. 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

Entry points

The base of the superior articular process at the junction of the lateral one-third and medial two-thirds can be used as an ideal pedicle entry point



⁵⁾.

T1-T12 ENTRY POINT		3 mm caudal to the junction of the transverse process – superior articular process
T1-T12 SAGITTAL TRAJECTORY		Orthogonal to the sagittal curvature of the dorsal spine
AXIAL TRAJECTORY	 T1-T2	 T3-T12

Complications

Pedicle screw instrumentation has become increasingly popular during the past 20 years and a vast selection of products is available on the market. With rising implantation rates, reports about specific complications also have increased. The main reason for these complications is the fact that the course of the pedicle and in turn the positioning of the pedicle screw cannot be adequately controlled visually. Based on the anatomy of the surrounding structures, complications caused by malpositioning can be divided into three main groups: mechanical, neurological and vascular. Beyond mechanical limitations of spinal motion, nerve injury can lead to neurological problems while injuries to vascular structures usually cause hemorrhage. These typical problems in general become apparent intraoperatively or in the immediate postoperative course ⁶⁾.

see Thoracic [screw misplacement](#).

The term acceptable has been hypothesized mainly in thoracic spine due to the frequent and clinically benign nature of pedicle wall compromise in smaller thoracic pedicles ⁷⁾.

Malpositioning

Malposition is the most commonly reported complication of thoracic pedicle screw placement, at a rate of 15.7% per screw inserted with postoperative computed tomography scans. The use of pedicle screws in the thoracic spine for the treatment of pediatric deformity has been reported to be safe despite the high rate of patients with malpositioned screws (11%). Major complications, such as neurologic or vascular injury, were almost never reported in this literature review of case series. Cases reports on the other hand have started to identify such complications ⁸⁾.

Although the clinical course in malpositioned pedicle screw instrumentation may stay unremarkable, in a proven injury to the thoracic aorta revision is mandatory to prevent further vascular damage. The appropriate strategy demands exact and provident planning using a preferably interdisciplinary approach ⁹⁾.

Reports of the accuracy of existing [neuromonitoring](#) methods for detecting or preventing medial malpositioning of thoracic pedicle screws have varied widely in their claimed effectiveness.

In a prospective, blinded and randomized study using a novel combination of input (4-pulse stimulus trains delivered within the pedicle track) and output (evoked electromyography from leg muscles) to detect pedicle track trajectories that once implanted with a screw would cause that screw to breach the pedicle's medial wall and encroach upon the spinal canal. For comparison, the authors also used screw stimulation as an input and evoked electromyogram from intercostal and abdominal muscles as output measures. Intraoperative electrophysiological findings were compared with postoperative CT scans by multiple reviewers blinded to patient identity or intraoperative findings.

Data were collected from 71 patients, in whom 802 screws were implanted between the T-1 and L-1 vertebral levels. A total of 32 screws ended up with screw threads encroaching on the [spinal canal](#) by at least 2 mm. Pulse-train stimulation within the pedicle track using a ball-tipped probe and electromyography from lower limb muscles correctly predicted all 32 (100%) of these medially malpositioned screws. The combination of pedicle track stimulation and electromyogram response from leg muscles proved to be far more effective in predicting these medially malpositioned screws than was direct screw stimulation and any of the target muscles (intercostal, abdominal, or lower limb muscles) we monitored. Based on receiver operating characteristic analysis, the combination of 10-mA (lower alarm) and 15-mA stimulation intensities proved most effective for detection of pedicle tracks that ultimately gave rise to medially malpositioned screws. Additional results pertaining to the impact of feedback of these test results on surgical decision making are provided in the companion report. Conclusions This novel neuromonitoring approach accurately predicts medially malpositioned thoracic screws. The approach could be readily implemented within any surgical program that is already using contemporary neuromonitoring methods that include transcranial stimulation for monitoring motor evoked potentials ¹⁰⁾.

Neuromonitoring strategy during placement of thoracic pedicle screws can significantly reduce the incidence of clinically relevant thoracic pedicle screw medial malpositioning ¹¹⁾.

Avoidance

Stereotactic image guidance

Despite the use of adjunctive techniques, accurate pedicle screw placement in thoracic spine remains to be challenging. New technology, such as stereotactic image guidance applied to screw placement has been associated with increased accuracy ¹²⁾.

However, this technique requires CT scanning with preoperative irradiation and expensive equipment. The free hand pedicle screw insertion technique exhibits similar accuracy in experienced hands as compared to the image-guided techniques ¹³⁾.

CT-based study demonstrated that T4-T9 concave segments have a smaller safe zone with respect to both cord-aorta injury in medial and lateral malpositions. In these segments, screws should be accurate and screw malposition is to be unacceptable ¹⁴⁾.

Biplane fluoroscopy guided robot system (BFRS)

The BFRS might be helpful in improving the accuracy of percutaneous pedicular screw insertion procedures. In the future, we will attempt to improve the accuracy and reliability of the BFRS and to determine new clinical applications for the BFRS ¹⁵⁾.

Triggered electromyography (t-EMG)

Independent of the screw position, average t-EMG thresholds were always higher at the convexity (CV) of the scoliotic curves in the apex and above the apex regions, presuming that the distance from the pedicle to the spinal cord plays an important role in electrical transmission. The t-EMG technique has low sensitivity to predict screw malpositioning and cannot discriminate between medial cortex breakages and complete invasion of the spinal canal ¹⁶⁾.

When compared with screws made of stainless steel (SS), most titanium alloy (Ti-alloy) pedicle screws behaved more like semiconductors, showing conduction properties that were highly frequency dependent. These properties likely contributed to the difficulties encountered in interpreting thoracic screw placements based on stimulus-evoked electromyography from direct screw stimulation ¹⁷⁾.

slide technique

This technique is very close to the “funnel technique”. The “funnel” and then the “slide” technique are mostly useful in complex spinal deformities as in neuromuscular patients. The “slide technique” is a safe, effective and cost-effective technique for pedicle screw placement in the thoracic spine especially in severe deformities. LEVEL OF EVIDENCE: IV ¹⁸⁾.

1)

Kim YJ, Lenke LG, Bridwell KH, Cho YS, Riew KD. Free hand pedicle screw placement in the thoracic spine: is it safe? *Spine*. 2004;29:333-342. doi: 10.1097/01.BRS.0000109983.12113.9B.

2)

Liljenqvist UR, Halm HF, Link TM. Pedicle screw instrumentation of the thoracic spine in idiopathic scoliosis. *Spine*. 1997;22:2239-2245. doi: 10.1097/00007632-199710010-00008.

3)

Belmont PJ, Jr, Klemme WR, Dhawan A, Polly DW. In vivo accuracy of thoracic pedicle screws. *Spine*. 2001;26:2340-2346. doi: 10.1097/00007632-200111010-00010.

4)

Kim YJ, Lenke LG, Cheh G, Riew KD. Evaluation of pedicle screw placement in the deformed spine using intraoperative plain radiographs: a comparison with computerized tomography. *Spine*. 2005;30:2084-2088. doi: 10.1097/01.brs.0000178818.92105.ec.

5)

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2551718/>

6)

Wegener B, Birkenmaier C, Fottner A, Jansson V, Dürr HR. Delayed perforation of the aorta by a thoracic pedicle screw. *Eur Spine J*. 2008 Sep;17 Suppl 2:S351-4. doi: 10.1007/s00586-008-0715-9. Epub 2008 Jul 10. PubMed PMID: 18622634; PubMed Central PMCID: PMC2525912.

7)

Belmont PJ, Jr, Klemme WR, Robinson M, Polly DW. Accuracy of thoracic pedicle screws in patients with and without coronal plane spinal deformities. *Spine*. 2002;27:1558-1566. doi: 10.1097/00007632-200207150-00015.

8)

Hicks JM, Singla A, Shen FH, Arlet V. Complications of pedicle screw fixation in scoliosis surgery: a systematic review. *Spine (Phila Pa 1976)*. 2010 May 15;35(11):E465-70. doi: 10.1097/BRS.0b013e3181d1021a. Review. PubMed PMID: 20473117.

9)

Tschoeke SK, Gahr P, Krug L, Kasper AS, Heyde CE, Ertel W. Late diagnosis of pedicle screw malplacement with perforation of the thoracic aorta after posterior stabilization in a patient with multiple myeloma: case report. *Spine (Phila Pa 1976)*. 2011 Jun;36(13):E886-90. doi: 10.1097/BRS.0b013e318202e4d1. PubMed PMID: 21343868.

10)

Calancie B, Donohue ML, Harris CB, Canute GW, Singla A, Wilcoxon KG, Moquin RR. Neuromonitoring with pulse-train stimulation for implantation of thoracic pedicle screws: a blinded and randomized clinical study. Part 1. Methods and alarm criteria. *J Neurosurg Spine*. 2014 Jun;20(6):675-91. doi: 10.3171/2014.2.SPINE13648. Epub 2014 Apr 1. PubMed PMID: 24684171.

11)

Calancie B, Donohue ML, Moquin RR. Neuromonitoring with pulse-train stimulation for implantation of thoracic pedicle screws: a blinded and randomized clinical study. Part 2. The role of feedback. *J Neurosurg Spine*. 2014 Jun;20(6):692-704. doi: 10.3171/2014.2.SPINE13649. Epub 2014 Apr 1. PubMed PMID: 24684176.

12)

Youkilis AS, Quint DJ, McGillicuddy JE, Papadopoulos SM. Stereotactic navigation for placement of pedicle screws in the thoracic spine. *Neurosurgery*. 2001;48:771-779. doi: 10.1097/00006123-200104000-00015.

13)

Modi H, Suh SW, Song HR, Yang JH. Accuracy of thoracic pedicle screw placement in scoliosis using the ideal pedicle entry point during the freehand technique. *Int Orthop*. 2009;33:469-475. doi: 10.1007/s00264-008-0535-x.

14)

Sarlak AY, Tosun B, Atmaca H, Sarisoy HT, Buluç L. Evaluation of thoracic pedicle screw placement in adolescent idiopathic scoliosis. *Eur Spine J*. 2009 Dec;18(12):1892-7. doi: 10.1007/s00586-009-1065-y. Epub 2009 Jun 14. PubMed PMID: 19526376; PubMed Central PMCID: PMC2899438.

15)

Kim S, Chung J, Yi BJ, Kim YS. An assistive image-guided surgical robot system using O-arm fluoroscopy for pedicle screw insertion: preliminary and cadaveric study. *Neurosurgery*. 2010 Dec;67(6):1757-67; discussion 1767. doi: 10.1227/NEU.0b013e3181fa7e42. PubMed PMID: 21107207.

16)

de Blas G, Barrios C, Regidor I, Montes E, Burgos J, Pizá-Vallespir G, Hevia E. Safe pedicle screw placement in thoracic scoliotic curves using t-EMG: stimulation threshold variability at concavity and convexity in apex segments. *Spine (Phila Pa 1976)*. 2012 Mar 15;37(6):E387-95. doi: 10.1097/BRS.0b013e31823b077b. PubMed PMID: 22024903.

17)

Donohue ML, Swaminathan V, Gilbert JL, Fox CW, Smale J, Moquin RR, Calancie B. Intraoperative neuromonitoring: can the results of direct stimulation of titanium-alloy pedicle screws in the thoracic spine be trusted? *J Clin Neurophysiol*. 2012 Dec;29(6):502-8. doi: 10.1097/WNP.0b013e3182767aac.

PubMed PMID: 23207589.

¹⁸⁾

Vialle R, Zeller R, Gaines RW. The “slide technique”: an improvement on the “funnel technique” for safe pedicle screw placement in the thoracic spine. Eur Spine J. 2014 May 14. [Epub ahead of print]
PubMed PMID: 24823849.

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