The Transverse Process Trajectory Technique As An Alternative Method for Thoracic Pedicle Screw Implantation: A Radiographic and Biomechanical Analysis

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Introduction: Thoracic pedicle screw placement using the Free-Hand (FH) Technique has become widely utilized and has improved fixation strength in spinal deformities. Studies have shown a FH technique to be safe and have relatively low re-operation rates for misplaced screws. Despite this, pedicle breeches can be common particularly in sclerotic pedicles or in spinal deformity. Since the transverse process has a continuous cortical path to the pedicle, it has been annectocally used as a guide for pedicle screw trajectory. The screw entry channel is created at the lateral aspect of the junction of the superior facet and the cephalad region of the transverse process in which a trough is created from its tip. We define this technique as the Transverse Process Trajectory Technique (TPTT). The purpose of this study is to compare the accuracy and the reproducibility of TPTT in the hands of three surgeons with varying degrees of surgical experience. The performance of TPTT was compared with the conventionally used Free-Hand technique (FH). In addition, a biomechanical analysis was performed to assess the de-rotational strength between the two groups.

Methods: Six fresh frozen human cadaveric torsos were procured for this study. The specimens were screened with radiographs to identify any pre-existing deformities, fractures, or tumors. Three surgeons with varying experience participated in the study [Experienced (E) with 20 years of practice, Surgeon(S) with <10 years of practice and a senior resident trainee (T)]. Each surgeon instrumented the thoracic levels (T1-T12) for two cadaveric torsos utilizing both the TPTT and the FH techniques which were alternated at each sequential level with the order of techniques reversed on the contralateral side and then reversed for the second cadaver for each surgeon. The implantation sequence and the pedicle screws sizes (major diameter and length) used were kept consistent across the specimens. The time taken from pilot-hole creation to final placement was recorded for each screw. After the instrumentation was complete for all the specimens, the specimens were evaluated using CT scans for incidence of pedicle breaches as per the Gertzbein scale. The direction of the pedicle breaches was also recorded. After the radiographic analysis, the instrumented vertebral column was harvested and each thoracic vertebral body was separated and denuded of any soft tissue. The anterior half of each vertebral body was potted in polyester resin. Half of the instrumented vertebrae were used for axial pullout testing while the other half were used for derotation strength testing. A total of 72 instrumented vertebrae were tested. Paired t-test and ANOVA with Tukey correction were used compare the techniques within and between surgeons.

Results: In total, 48 pedicle screws were inserted by each surgeon**.** The incidence of critical breaches was comparable for all surgeons regardless of their level of training: E(TPTT 4.2% vs FH 4.2%, p=1.00), S(TPTT 16.7% vs FH 4.2%, p=0.35) and T(TPTT 8.3% vs FH 0%, p=0.489). More medial breaches were observed with TPTT while more lateral breaches were observed with FH.
In addition, there was no difference in screw placement time for the E and S groups, although TPTT placement time was longer for the T group. The average time taken for screw implantation for each surgeon were as follows: E (TPTT 79 seconds vs FH 81 seconds), S (TPTT 86 seconds vs FH 84 seconds) & T (TPTT 130 seconds vs FH 113 seconds).
The pullout strengths were comparable between FH and TPTT (TPTT 961N vs FH 988N, p=0.316).
Comparable derotation strength was observed for TPTT when compared with FH(TPTT 1.06Nm/deg vs FH 0.93 Nm/deg, p = 0.072).

Discussion: In this study we describe the TPTT as a new pedicle screw implantation technique that may be useful for spinal deformity and abnormal pedicle screw morphology. In a clinical, radiographic, and biomechanical analysis with three surgeons of varying skill level, the TPTT was found to have similar placement time, screw accuracy, and biomechanical performance as the traditionally used FH technique. Although not significant, overall there were more critical breeches in the TPTT group among less experienced surgeons, which may represent a learning curve that requires further study.

Significance: The Transverse Process Trajectory Technique (TPTT) is an alternative screw insertion technique for thoracic pedicle implantation with comparable accuracy, time for implantation, and biomechanical strength. It mayand reproducibility to the traditional screw insertion techniques that may facilitate accurate screw placement in the deformity setting.

References: 1) Brown et al., Scoliosis, 2010. **2)** Mattei. et al., Neurology India, 2009. **3)** Parent. et al., Spine, 2008. **4)** White et al., Spine, 2006

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Images and Tables:

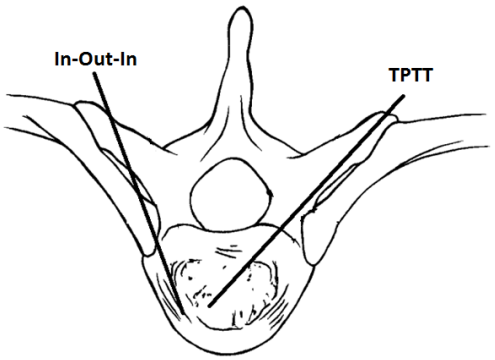

Image 1: Comparison between TPTT and In-Out-In Technique