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Handsfree techniques on thoracic pedicle screws insertion in congenital scoliosis patients with a history of previous surgery

Abstract

Thoracic pedicle screw has become the treatment of choice for spine whose technique has superior biomechanics. It is commonly used treatment of scoliosis, spinal deformity (such as kyphosis), trauma, tumors, infecion, and other pathologies. The technique requires precision, otherwise, consequences could occur (death or paralysis) because of malposition in spinal cord or visceral injury.

Keywords: Handsfree technique, congenital scoliosis, trauma

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Case report

Thoracic pedicle screws deliver various advantages compared to other approaches of spinal fixation. 1.Stronger pull-out strength, 2. Better control in the sagittal, coronal, and rotational planes as a result of increased stability to axial, bending and rotational forces by three-column fixation, 3. Lesser arthrodesed vertebral motion segments 4. Negates the need of postoperative bracing and securing fixation after laminectomy or incompetent posterior elements. In spite of having potential benefits, many surgeons avoid using thoracic pedicle screws because much concern for neurologic, vascular and visceral complications has been observed.[1–5]

Nowadays, surgeons often prefer the freehand technique when it comes to pedicle screw placement in the thoracic segment of the spine. Present techniques, however, mostly depend on surgeon's selection and tendencies, as these techniquesare not reproducible and is different per case. Moreover, the majority of these techniques involves many point of entries and directions depending on the level and region of thoracic spine. Due to the fact that there are many various sizes of thoracic pedicles, as well as various adjacent structures, positioning freehand screw requires a high level of precision and expertise.

Discussion

The complicated anatomy of the thoracic vetebrae poses various challenges to the fixation technique of thoracic pedicle screw. This leads to the high incidence of malposition and the potential injury to adjacent structures. By using the freehand technique to fixate the pedicle screws, the patient's exposure to radiation could be minimized. This is the reasoning behind why this technique is currently becoming the preferred choice for thoracic anatomical problems, including musculoskeletal trauma, degenerative disease of the spine, different types of scoliosis, and tumours. Nowadays, however, with the abundance and high availability of assisted technologies and navigation, spine surgeons should still master the basic structure of spine instrument, as to familiarize them selves with the freehand technique and diminish the patient's exposure to prolonged radiation and its adverse effects.[6–14]

A review by parker et al.[15] reported high accuracy from thoracic pedicle screw placement with up to 98.3% accuracy. The other 1.7% comprises ofbreaches found in 9% of the different cohort of patients in the study. Among these patients, only 0.8% demanded revision surgery. This furthermore adds to the merits of the safety of the freehand technique. It is paramount that the different results from different studies to be discussed in this paper, regardless to the inclusion of "safe zone" as a parameter for accurate screw placement; For example, Modi, et al.[16] Found the final accuracy rate to be 90.7%, after a lot of breaches were included as the safe zone. Without the inclusion of safe zone, the accuracy rate tumbled to only 62.5%. Surprisingly, these seemingly important findings are not proven to be statistically significant.

The highest outcome was reported by Modi et al.[16] which stated a percentage of 21.6%. This result might be caused by the fact that these screws were applied in patients with severe scoliosis, where the anatomical landmarks is highly complicated, causing difficulties to outline them. This study did not report any neurovascular complications, despite the high percentage of breach. Another study by Parker et al.[15] found 2.5% lateral breach, while Fennel et al.[6] and Kim et al.[5] found 4.1% and 6.2% respectively. These data furthermore adds to the strength of the argument of the safety and feasibility of freehand thoracic screw placement in the thoracic region of the spine.

Additionally, breach rate of the thoracic and the lumbar freehand screw was also analyzed by Parker et al.[15] of which the findings shows that the in thoracic spine provided higher rate than lumbar (2.5% vs

0.9%). This findings are predicted, as the pedicles in the lumbar spine are anatomically wider than the ones found in the thoracic spine. Parker et al.[15] also proposed that this finding may be caused by the fact that the surgeon aims to prevent spinal cord damage by avoiding the medial wall, as well as the anatomically thicker medial wall of the pedicle.

Kim et al also discussed about using a "safe zone" for medial and lateral breaches in the vertebral bodies; breaches of <2mm is classified as a "definite safe zone", while breaches of 2 to 4mm is classified as a "probable safe zone", and ultimately, a breach of 4 to 8 mm as a "questionable safe zone". This definition is further discussed by Belmont et al.,[17] who broadened the definition of "safe zone" for lateral breach up to 6mm. However, all studies listed uniformly accords that a breach of 3 to 4mm is considered safe and that if the patient presented no significant symptoms, there is no need to conduct screw repositioning. The author implores to not use the expanded safe zone definition, as most of the included studies limits the safe zone from 2mm to 4mm. A study by Kim et al.[5] made the 4-8mm limit as "questionably safe" instead of "safe" or "probably safe". Thus, the 4mm limit is the most frequently used(and reported)upper limit for a breach. Safe zone provides the surgeon with an elbow room to comfortably perform the freehand technique, as well as some room for improvisation and improvement, The study conducted by Kim delivers the most powerful evidence regarding to the merits of safety for this technique; they don't have reported neurological or vascular complication with the longest follow up period of up to 10 years. Furthermore, even after performing a comparison of result from eight different surgeons, Parker et al found a generally low incidence of complication in over 3,000 screws placed.

Step by step freehand technique

1. After the incision, subcutaneous tissue and muscles of the thoracic dissection are created,which exposes the spine. The surgeon should then be able to visualize the superior articulating processes and transverse processes of the vertebrae, after which the inferior articulating process can be removed. The removal process is sometimes required for osteotomy but is not necessarily for standalone pedicle screw placement.
2. By utilizing highspeed electrical or pneumatic drill to decorticate the bone on the site of the entry point. A uniform entry point can be used in all levels in the thoracic spine. This is located 3 mm caudal to the junction of the lateral margin of the superior articulating process and the transverse process
3. From the entry point, cannulation the pedicle is performed and the gearshift probe is pushed to the intended level according to preoperative CT analysis. When the screw is inserted, the gearshift probe helps determine the length required and the appropriate diameter of the screw. A straight gearshift is used with medial trajectory which is 30 degrees for T1 and T2, and 20 degrees for T3 through T12. The pedicle is cannulated in an orthogonal trajectory pertaining to the dorsal part of the spine.
4. Continuing with removal the gearshift probe and followed by inserting a ball-tipped instrument to assess any penetration (breach) of the bony wall in five directions in relation to the screw location: medial, lateral, superior, inferior, and anterior.
5. Undertap the pedicle tract using a tap which is 0.5-1mm smaller than the intended pedicle screw size. After which, a ball-tipped instrument is used to correct any possible breaches within the vertebral body. The pedicle screw will then be inserted.This is done done using manual or powered drivers, though the latter is preferred by the author as it provides ergonomic ease and is more precise.
6. The sagittal trajectory of the pedicle screw insertion should be kept positionally orthogonal to the curvature of the dorsal spine at each level

The uniform entry point we discovered is repeated at every thoracic level, as far as the trajectory of the cranial-caudal orthogonal cannulation is used. This contrasts with earlier studies, in which variable entry points were suggested to be laterally and caudally inclined; As one of them advances to the upper thoracic region, and medial and cephalad, the other one advances distally.

Conclusion

Pedicle screw placement has numerous advantages as well as complications which often involves the neurologic, visceral and vascular structures adjacent to the spine. The use of freehand technique and a proper placement of pedicle screw provides an accurate, reliable, and safe method for pedicle screw insertion in order to treat a variety of spinal disorders and deformities.

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Conflict of interest

There is no conflict of interest.

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