

TRANSPEDICULAR FIXATION OF THE THORACO-LUMBAR SACRAL SPINE: ANALYSIS OF 124 SCREWS

FIXAÇÃO TRANSPEDICULAR DA COLUNA TORACO-LOMBO-SAGRADA:
ANÁLISE DE 124 PARAFUSOS

FIJACIÓN TRANSPEDICULAR DE LA COLUMNA TORACOLUMBOSACRA:
ANÁLISIS DE 124 TORNILLOS

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ABSTRACT

Objective: To evaluate the correct placement of transpedicular screws in the thoracic, lumbar and sacral spine using the free hand technique. **Methods:** Clinical and imaging (CT scan) evaluation of 25 patients (13 female and 12 male) undergoing spinal instrumentation for a total of 124 transpedicular screws applied using the free hand technique. The screws were inserted from T11 to S1, most of which were placed at levels L4, L5 and S1. **Results:** 94% of transpedicular screws were placed correctly in the pedicle. It was found that 6% (seven screws) were misplaced and among those, only two violated the inferomedial wall, one less than 2 mm and the other between 2 and 4 mm. None of the patients had complications associated with incorrect positioning of the screws. **Conclusion:** The free hand technique is safe to be used in the instrumentation of the thoracic, lumbar and sacral spine.

Keywords: Lumbar vertebrae; Bone screws; Spinal fusion.

RESUMO

Objectivo: Avaliar a técnica free hand de colocação de parafusos transpediculares na coluna torácica, lombar e sagrada. **Métodos:** Avaliação clínica e imagiológica (tomografia computadorizada) de 25 pacientes (13 mulheres e 12 homens) submetidos a instrumentação vertebral num total de 124 parafusos transpediculares aplicados, utilizando a técnica free hand. Os parafusos foram inseridos de T11 a S1, e a maioria destes foram colocados nos níveis L4, L5 e S1. **Resultados:** 94% dos parafusos transpediculares estavam correctamente colocados no pedículo. Verificou-se que 6% (7 parafusos) estavam mal colocados e destes apenas dois violavam a cortical inferomedial, um destes apresentava uma perfuração inferior a 2 mm e o outro entre 2 e 4 mm. Nenhum dos pacientes seguidos apresentou complicações associadas ao incorrecto posicionamento dos parafusos. **Conclusão:** A técnica free hand é segura na instrumentação da coluna torácica e lombo-sagrada.

Descritores: Vértebras lombares; Parafusos ósseos; Fusão vertebral.

RESUMEN

Objetivo: Evaluar la colocación de tornillos transpediculares utilizados en las vértebras de la columna torácica, lumbar y sacra, introducidos mediante la técnica free hand. **Métodos:** Evaluación clínica y radiológica (Tomografía Computadorizada) de 25 pacientes (13 mujeres y 12 hombres) sometidos a la instrumentación espinal para un total de 124 tornillos transpediculares aplicados mediante la técnica free hand. Los tornillos se insertaron desde T11 a S1, la mayoría de los cuales fueron colocados en los niveles L4, L5 y S1. **Resultados:** 94% de los tornillos transpediculares se colocaron correctamente en el pedículo. Se encontró que 6% (siete tornillos) se colocaron mal; de estos, solamente dos habían sobrepasado la cortical inferomedial, uno presentaba una perforación inferior a 2 mm y el otro entre 2 y 4 mm. Ninguno de los pacientes acompañados tuvo complicaciones asociadas con la colocación incorrecta de los tornillos. **Conclusión:** La técnica free hand es segura en la instrumentación de la columna torácica y lumbosacra.

Descriptores: Vértebras lumbares; Tornillos óseos; Fusión vertebral.

INTRODUCTION

First reported by Boucher in 1959 and popularized by Roy-Cammille^{1,2} in the 1960s, transpedicular vertebral fixation has become the most widely used fixation technique for the spine, in degenerative pathology, trauma, as well as tumors.

With the increased popularity of this technique, its safety and efficacy have been extensively discussed.

The pedicle is the most stable structure for fixing the spine; however, transpedicular instrumentation is a demanding procedure whose complications include unstable fixation, and neurological, vascular, and visceral injuries. The techniques and materials which permit the optimization and confirmation of the intraosseous location of the screws have been improved to ensure the greater safety of this procedure.

The transpedicular instrumentation has been evaluated in several articles through studies with radiography (XR), computed tomography (CT), or magnetic resonance (NMR). The rates of misplaced screws vary according to several factors: the experience of the surgeon, the patient biotype, the level instrumented, and the method used for determining the position of the screw.³⁻⁵

The XR has been considered to be insufficient for assessing the location of these screws by several authors, given that it is associated with a high number of false positives and false negatives.⁵ CT is accepted as a reliable method for this assessment.

The aim of this study is the clinical and imaging evaluation of transpedicular instrumentation using the free-hand technique.

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MATERIALS AND METHODS

During the year 2010, 42 patients underwent open posterior transpedicular fixation. Of these, 25 returned for clinical and radiographic follow-up.

Thirteen patients were female (53%) and 12 (47%) were male. The average age at surgery was 57 years (41-70). The mean body mass index was 28.4. The etiologic diagnosis was traumatic in six patients and degenerative in 19 patients. The number of screws placed at each level was: T11-8, S12-2, L1-10, L2-14, L3-16, L4-24, L5-28, S1-22. (Figure 1)

We used the free-hand technique in all patients. This technique is based on specific anatomical references for the placement of the screws. A probe is carefully inserted through the pedicle, progressing through the vertebral body. The walls and floor of the pedicle are probed with the hook palpator. The screw is introduced through this route, and after it is placed, control is performed with the image intensifier (anteroposterior and lateral views).

All screws were placed by the same team of two experienced surgeons and the diameter of the screws ranged between 5.5 and 6.5 mm. The median follow-up period was 8 months.

The subjects included in the study underwent clinical evaluation by neurological examination and characterization of pain by the visual analog scale (VAS). The imaging study consisted of CT. The CT (2 mm slices with frontal, sagittal, and axial reconstructions) allowed us to accurately assess the location of the screws.

The orientation of the screws was classified as superior, inferior, lateral, medial, superolateral, inferolateral, inferomedial, and superomedial. If the medial wall was observed to be perforated, it was specified whether this was < 2 mm, 2-4 mm, 4-6 mm and > 6 mm.

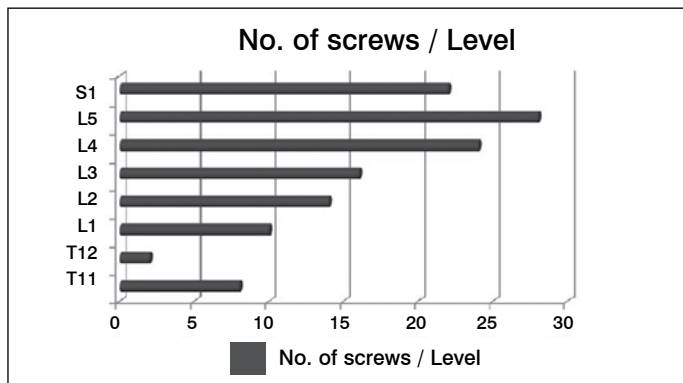


Figure 1. Number of transpedicular screws placed at each level of the rachis.

RESULTS

Of the 124 transpedicular screws that were placed, 117 (94%) were well placed and seven (6%) were misplaced. Of the latter, five had superolateral orientation and two had inferomedial orientation, one of less than 2 mm and the other between 2-4 mm. (Figures 2, 3, and 4)

Patients with misplaced screws show no neurological, vascular, or visceral complications or signs of implant instability.

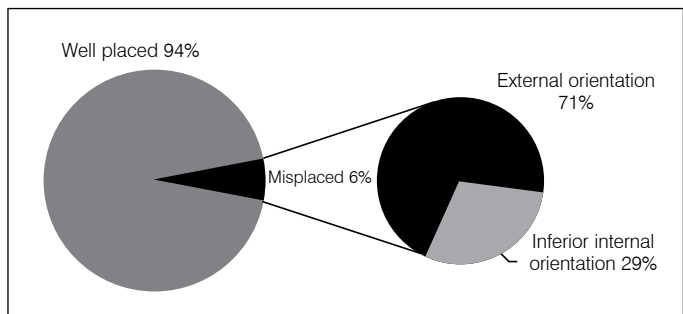


Figure 2. Imaging assessment of transpedicular screws.

Most patients characterized their pain as mild or moderate in the follow-up period. (Figure 5)

One major postoperative complication was observed, an epidural hematoma at level L4-L5 resulting from thrombolysis in the immediate postoperative period (by acute myocardial infarction). The motor and sensory recovery was not complete.

Three screws placed in S1 showed a halo of resorption in the control CT, but with no pull-out of the screws, cortical bulging, or associated radiculopathy. (Figure 6)

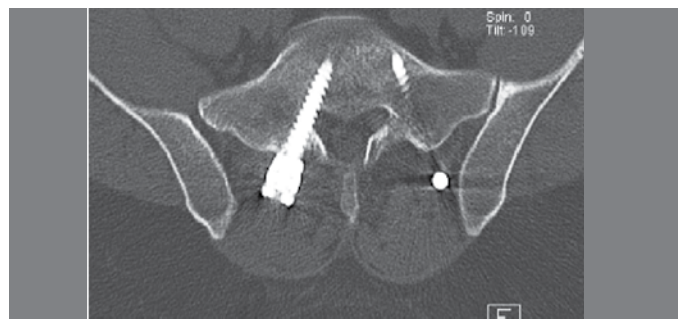


Figure 3. Transpedicular screw violating the medial cortex.

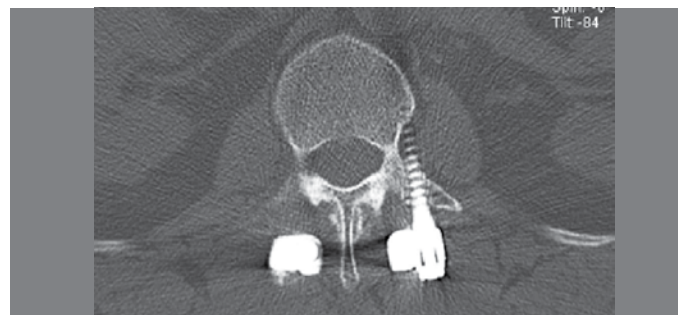


Figure 4. Misplaced transpedicular screw (lateral orientation).

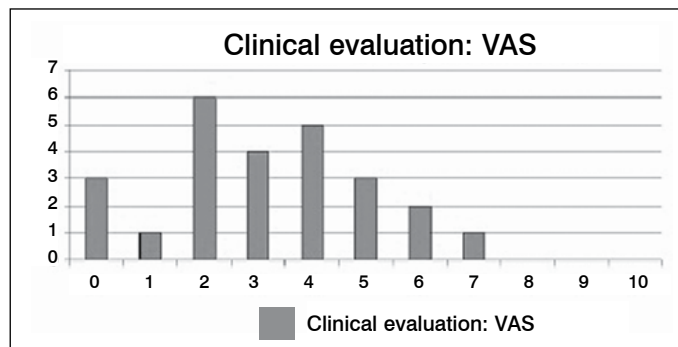


Figure 5. Clinical evaluation: VAS.



Figure 6. Halo of resorption in S1 screw.

DISCUSSION

Spinal instrumentation with transpedicular screws is a demanding technique, given the small margin for error and the proximity of the nerve roots. Several methods seek to decrease the risk of nerve damage: pedicle guide wires oriented through the image intensifier, laminectomy for the direct visualization of the medial wall, intraoperative electromyographic study, intraosseous endoscopy and navigation systems based on CT.

Several studies have been published on navigation systems using CT preoperatively and intraoperatively and the findings are conflicting. Some suggest that better results are obtained when CT-guided instrumentation is combined with neuronavigation, both in terms of accuracy of placement of the screws and in terms of cost.^{6,7}

The morphometric analysis of cadaveric pedicles has been studied by several authors. Cinotii et al.⁸ concluded that the narrowest pedicles are T6 (4.3 mm), T7 (4.7 mm), T8 (4.8 mm) and T5 (4.9 mm). The authors suggest that the preoperative planning of chest instrumentation should include CT study, since between T4 and T8 the diameter of some pedicles may not be sufficient for the secure placement of screws. Beyond that, analysis with CT makes it possible to notice the orientation of the pedicle in the horizontal plane, a feature that varies greatly between individuals.

Schulze et al.³ also advocate preoperative pedicle analysis and recommend the use of 5 mm screws in a pedicle with a diameter less than 8 mm, 6 mm screws in pedicles measuring between 8 to 9.5 mm, and 7 mm screws for larger pedicles.

Regarding the surgical technique, a study by Ringel et al.⁹ compared screws placed using the conventional free-hand technique with screws guided by a surgical robot and concluded that the latter is not better than the free-hand technique in the placement of screws, and involves a greater dose of radiation to the patient (preoperative study with CT), a high cost, and contrary to what one would expect, an increased surgical time.

In a meta-analysis that sought to evaluate several published studies concerning the placement of transpedicular screws, the rate of well-placed screws was observed to be very high (93.8-86.7%). The studies analyzed included populations *in vivo* and cadavers, as well as screws placed with and without navigation support systems. In the navigation-assisted subgroup, 95.2% of the screws were well placed and in the population not assisted by navigation, 90.3%.¹⁰

Kim and Lenke¹¹ found a rate of 8% of misplaced thoracic screws, 30% of which were medial and 70% of which were lateral.

Of these screws, none caused neurological, vascular, or visceral injury, which is consistent with other published studies. A publication by Schulze et al.³ concluded that neurological symptoms rarely correlates with a misplaced screw, even if the penetration of the medial wall exceeds 6 mm.

Interestingly, in our sample there were no misplaced screws in the thoracic vertebrae. (Figure 7) This finding may be related to

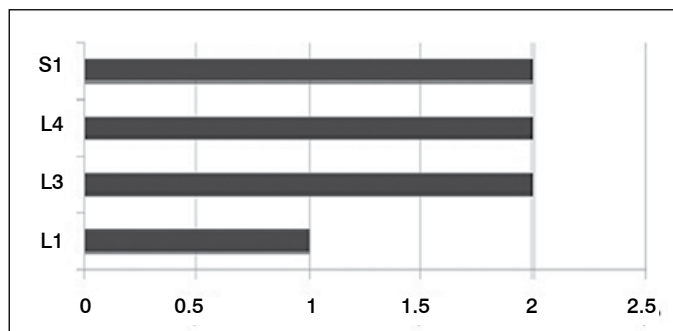


Figure 7. Levels at which misplaced screws have been documented.

the greater number of screws placed in the lumbar spine, given that thoracic screws have smaller diameters, or with a more careful placement due to the pedicle being narrower.

Another factor that is clearly related to the correct placement of the screws is the experience of the surgeon. Regarding the learning curve for spinal instrumentation, a study that compared the rates of misplacing screws by an experienced surgeon and a fellow spine surgeon concluded that these two were superimposable after 80 screws were placed by the fellow surgeon.¹²

Many surgeons consider postoperative evaluation with plain radiographs in the AP and lateral views to be appropriate. Several studies have demonstrated that conventional radiology reports many false positives and false negatives. Currently, CT is considered to be the gold standard for the evaluation of pedicle violations, and this should be the method of choice in scientific studies that intend to evaluate the location of transpedicular screws.^{13,14}

Its routine use involves high costs and high doses of radiation to the patient, so we recommend its use only in patients with neurological changes after instrumentation.

It has also been observed that CT demonstrates excellent correlation with the macroscopic cadaveric findings when transpedicular instrumentation is evaluated.¹⁵

CONCLUSION

The correct positioning of the screws was achieved in 94% of cases by a team of two experienced surgeons.

The free-hand technique seems to be safe and accurate; however, we conclude that it is extremely important that the surgeon be familiar with pedicle anatomy and that the screw path is repeatedly confirmed in order to ensure correct placement.

All authors declare no potential conflict of interest concerning this article.

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