Percutaneous osteosynthesis of thoraco lumbar fractures: is post CT-scann mandatory?

Abstract:

Introduction:

Percutaneous fixation of traumatic thoraco-lumbar spine fractures represents an innovative technique.

The objective of our work was to evaluate the pedicle screw placement of this technique using a post-operative CT-scan.

Methods:

We conducted a retrospective and descriptive study including 30 cases over a period of 2.5 years. We evaluated postoperative CT-scan parameters by studying the accuracy of pedicle screw placement using the Rao classification.

Results:

The mean age was 44 years, with a sex ratio of 1.3. The lesion was located at the thoraco-lumbar hinge in 73.34% and in 70% it was classified as A3 with a mean posterior wall recession of 36.33%. A total of 186 pedicle screws were inserted. According to the classification of Rao et al. 38.7% of the screws were misplaced, of which 11.29% were non-minor perforations (grade 2 and 3).

Conclusion: A preoperative CT scan with fine and clear slices is now essential. Postoperative CT to check the precise placement of the pedicle screws in asymptomatic patients has not shown any benefit. Therefore, a postoperative CT scan must be critically discussed and should be reserved for symptomatic patients

Key-words: Spine, Fracture fixation , CT scan, pedicle screw

Introduction:

Minimally invasive spine surgery has seen steady development in recent years.
Percutaneous insertion of pedicle screws has been developed as an alternative to the open technique, it is a reliable method, but technically demanding.
At present, there is a lack of data on the exact failure and success rates of this technique.
CT scanning as a routine postoperative check-up is recommended by various authors.
The aim of our work was to study the positioning of pedicle screws during percutaneous spinal osteosynthesis, using a postoperative CT scan of the spine.

Material and method:

We conducted a retrospective, descriptive study. Which focused on the period spanning 2 and a half years (January 2019 to June 2022).
We included in our study patients hospitalized in our department for a thoraco-lumbar spine fracture without neurological signs who had undergone percutaneous osteosynthesis.
We studied preoperative CT parameters: the AO Spine classification, posterior wall recoil, and postoperative CT parameters: the pedicle perforations were assessed using the classification system of Rao et al, Each pedicle was given a grade ranging from 0 to 3, The grading scale is as follows:

- Grade 0: no apparent pedicle violation
- Grade 1: < 2 mm pedicle perforation, with 1 screw thread outside the pedicle,
- Grade 2: pedicle perforation between 2 and 4 mm, with half the screw diameter outside the pedicle
- Grade 3: > 4 mm or complete pedicle perforation.

Results:

In this study, 30 patients underwent surgery for traumatic fractures of the dorsolumbar spine.

Mean follow-up was 34.21 months. The M/F sex ratio was 1.3.
We noted a clear predominance of domestic accidents, which were responsible for the trauma in 46.6% of cases, followed by work-related accidents in 23.3% of cases.
In 8 cases (26.6%) there was no hemoglobin loss, and in 17 cases (56.7%) hemoglobin loss was less than 1 g/dl. The average post-operative stay was 1.9 days.
Spinal trauma occurred at the thoracolumbar hinge in 22 cases (73.34%), and at the low lumbar spine in 8 cases (26.6%). No complications were noted in 76.7% of cases. Burst fractures predominated in our series: 21 fractures (70%) were classified as A3.
In 15 cases (50%) there was root canal involvement, with a mean posterior wall recession of 36.33%, ranging from 10% to 60%. In 6 cases (20%), posterior wall recession was greater than 50%.
A total of 186 pedicle screws were inserted, according to the classification of Rao et al: (figure 1).
- 51 screws (27.41%) had minor perforations classified as grade 1,
- 12 screws (6.45%) were classified as grade 2,
- 9 screws (4.83%) were classified as grade 3 (fig. 2, 3).
Following this classification, 72 screws (38.7%) were malpositioned, of which 21 screws (11.29%) were non-minor perforations (grade 2+3).
The vertebra most affected was L2 for grade 1, T12 for grade 2 and T11 and L2 for grade 3 (Table I). 3 of the screws classified as grade 3 (1.61%) were on the medial side. In 17 cases (18.27%), pedicle perforations were bilateral; in 13 cases (13.98%), the bilateral perforation was grade 1.
37 screws (19.89%) pierced the medial cortex and 35 (18.81%) the lateral cortex of the pedicle.
42 of the malpositioned screws (22.58%) were right-sided and 30 (16.12%) were left-sided.
We encountered only one case of anterior perforation of the vertebral body on the left side; this perforation was less than 2 mm and had no clinical repercussions (Fig. 4).

Discussion:
Computed tomography (CT) is considered the standard for assessing pedicle screw placement [1]. Several trials have used CT with two- and three-dimensional (2D and 3D) reconstructions to assess the accuracy of pedicle screw placement [2].
According to the literature, rates of pedicle screw misplacement vary from 2% to 20% (Table II). Pedicle diameter correlates significantly with the occurrence of screw malposition. In our study, we used 6 mm diameter screws for all patients. Aigner et al. showed that misplaced screws had a significantly smaller mean pedicle diameter than correctly placed screws (7.47 ± 3.17; range 2-17 mm) versus 7.97 ± 2.10; range 3-18 mm) [3].
The pedicle axis in the sagittal plane has a typical descending trajectory at thoracic level, whereas it is more horizontal in the lumbar vertebrae: this prevents correct front projection of the pedicle and upper plate of the thoracic vertebra on front fluoroscopy, and therefore requires a descending orientation of the X-ray beam [4].
The pedicle axis in the transverse plane, also defined as "pedicle convergence", depends on the level of the spine, with angles of around 30° at T1 and T2, which represent the most convergent pedicles in the thoracic spine. Pedicle convergence decreases progressively from T3 to T12. The least convergent pedicles are found at T12, with values of less than 10°. In the lumbar spine, pedicle convergence increases progressively from L1, with values around 10°, to L5, with values between 25° and 30°[5] .
Charles YP et al. have shown in their CT study that the positioning of the operating surgeon on the same side of the "pedicle" to be screwed is one of the parameters of successful percutaneous pedicle aiming: a better screw path is observed when the surgeon positions himself on the same side of the synthesis [2].
There are few studies in the literature concerning the rate of anterior effraction of the vertebral body. Belmont et al. reported a rate of 6% (17/279) of effraction of the anterior vertebral body in the thoracic spine[6] .
Accurate intraoperative imaging is a key factor in successful percutaneous pedicle screw placement [7]. Choi et al [8] compared fluoroscopic pedicle screw placement with CT-guided placement in six cadaveric specimens instrumented from T1 to S1. Using CT guidance, pedicle screws were accurately placed in 87.3% of instrumented pedicles. This figure dropped to 82.1% when guided by fluoroscopy. This precision is required intraoperatively (an advantage provided by the O-ARM imaging model) and can be well prepared preoperatively by an exhaustive scan study. However, percutaneous fixation has a steep learning curve, requiring the ability to master hand-eye coordination in order to maintain anatomically correct needle orientation [6].

Conclusion:

Collaboration between the orthopedic surgeon and the radiologist is the most sensitive time in the management of our patients: a preoperative CT scan with fine, sharp slices is now essential to assess: - The direction of the pedicles in the sagittal and transverse planes,
- The diameter of the pedicles of the fractured vertebra and of the fracture environment.
- The distance between the entry point and the anterior cortex of the vertebrae to be synthesized,
- Whether or not the pedicles of the fractured vertebra are intact.
- Communication between the upper vertebral plateau, the MVP and the MVA.
- The existence of anatomical vertebral variants.
In asymptomatic patients, a postoperative CT scan to check precise placement of the pedicle screws did not show any benefit. Therefore, postoperative CT must be critically discussed and should be reserved for symptomatic patients [9].

Table I: Screw grade by stage.

	T10	**T11**	**T12**	**L1**	**L2**	**L3**	**L4**	**L5**	**Totale**
Grade 1 :	4	9	6	5	**11**	2	-	-	37
Grade 2 :	1	1	**3**	2	2	-	-	1	10
Grade 3 :	-	**2**	1	1	**2**	1	-	-	7

Table II: Pedicle screw misplacement rates by series.

	Nombre de vis	Violation des pédicules	Perforation antérieur du corps vertébral
Chapman et al. 2015 **[1]**	885	4,7 %	3,6 %
Baird et al. **[9]**	120	3,3 %	0 %
Charles et al. 2020 **[2]**	173	**19,9 %**	0 %
Heintel et al. 2012 **[10]**	502	**2 %**	4,8 %
Raley et Mobbs 2012 **[11]**	424	4 %	0 %
Tinelli et al. 2014 **[12]**	682	2,2 %	0 %
Aigner et al. 2021 **[3]**	1068	7%	5,2 %

Notre série	**186**	**11,29 %**	**3,3 %**

References :

1. Chapman T, Blizzard D, Brown C. Erratum to: CT accuracy of percutaneous versus open pedicle screw techniques: a series of 1609 screws. European Spine Journal. 2015;25. doi:10.1007/s00586-015-4163-z.

2. Charles YP, Ntilikina Y, Collinet A, Schuller S, Garnon J, Godet J, et al. Accuracy and technical limits of percutaneous pedicle screw placement in the thoracolumbar spine. Surg Radiol Anat. 2021;43(6):843–853.

3. Aigner R, Bichlmaier C, Oberkircher L, Knauf T, König A, Lechler P, et al. Pedicle screw accuracy in thoracolumbar fractures- is routine postoperative CT scan necessary? BMC Musculoskelet Disord. 2021;22(1):986.

4. Wiesner L, Kothe R, Rüther W. Anatomic evaluation of two different techniques for the percutaneous insertion of pedicle screws in the lumbar spine. Spine (Phila Pa 1976). 1999;24(15):1599–1603.

5. Lien S-B, Liou N-H, Wu S-S. Analysis of anatomic morphometry of the pedicles and the safe zone for through-pedicle procedures in the thoracic and lumbar spine. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society. 2007;16:1215–22.

6. Chapman TM, Blizzard DJ, Brown CR. CT accuracy of percutaneous versus open pedicle screw techniques: a series of 1609 screws. Eur Spine J.6.

7. Patel RD, Graziano GP, Vanderhave KL, Patel AA, Gerling MC. Facet Violation With the Placement of Percutaneous Pedicle Screws: Spine. 2011;36(26):E1749–E1752.

8. Choi WW, Green BA, Levi AD. Computer-assisted fluoroscopic targeting system for pedicle screw insertion. Neurosurgery. 2000;47(4):872–878.

9. Baird EO, McAnany SJ, Overley S, Skovrlj B, Guzman JZ, Qureshi SA. Accuracy of Percutaneous Pedicle Screw Placement: Does Training Level Matter? Clinical Spine Surgery: A Spine Publication. 2017;30(6):E748–E753.

10. Heintel TM, Berglehner A, Meffert R. Accuracy of percutaneous pedicle screws for thoracic and lumbar spine fractures: a prospective trial. Eur Spine J. 2013;22(3):495–502.

11. Raley DA, Mobbs RJ. Retrospective computed tomography scan analysis of percutaneously inserted pedicle screws for posterior transpedicular stabilization of the thoracic and lumbar spine: accuracy and complication rates. Spine (Phila Pa 1976). 2012;37(12):1092–1100.

12. Tinelli M, Matschke S, Adams M, Grützner PA, Münzberg M, Suda AJ. Correct positioning of pedicle screws with a percutaneous minimal invasive system in spine trauma. Orthopaedics & Traumatology: Surgery & Research. 2014;100(4):389–393.

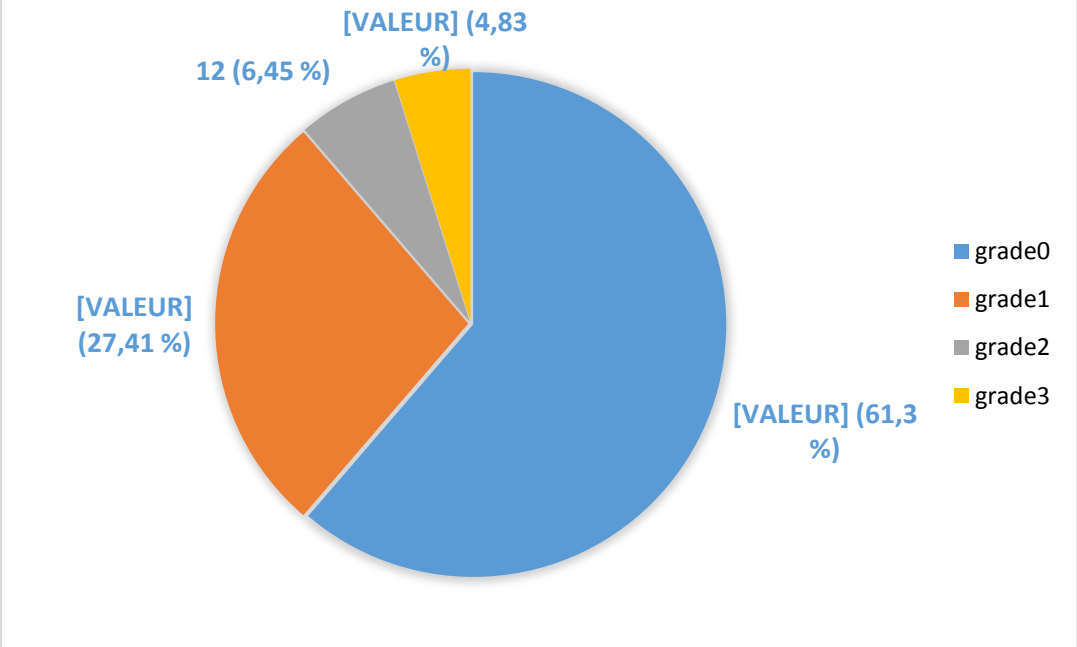

Figure 1: Accuracy of pedicle screw insertion

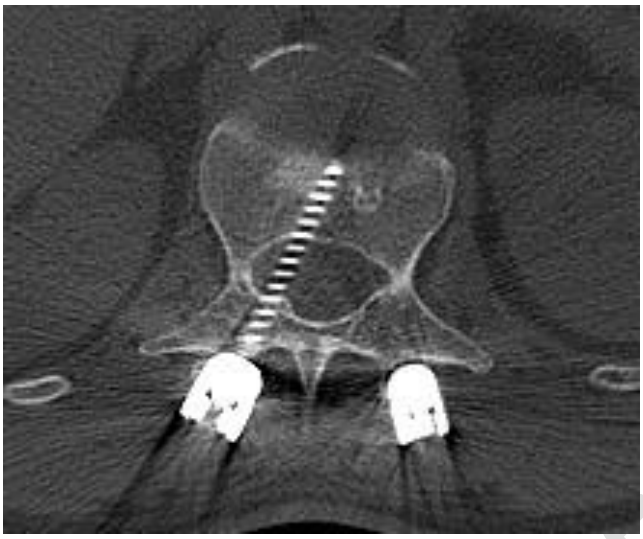

Figure 2: Grade 3 medial perforation without neurological signs of the L1 vertebra in a 43-year-old man.

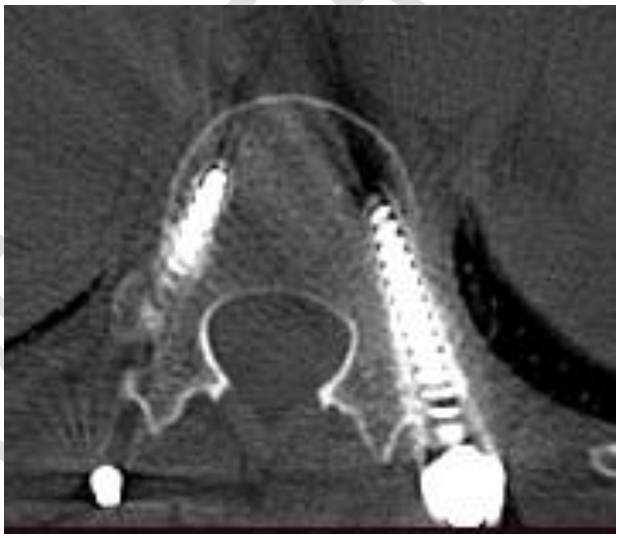

Figure 3: Grade 3 bilateral lateral perforation without neurological signs of the T12 vertebra in a 55-year-old woman.

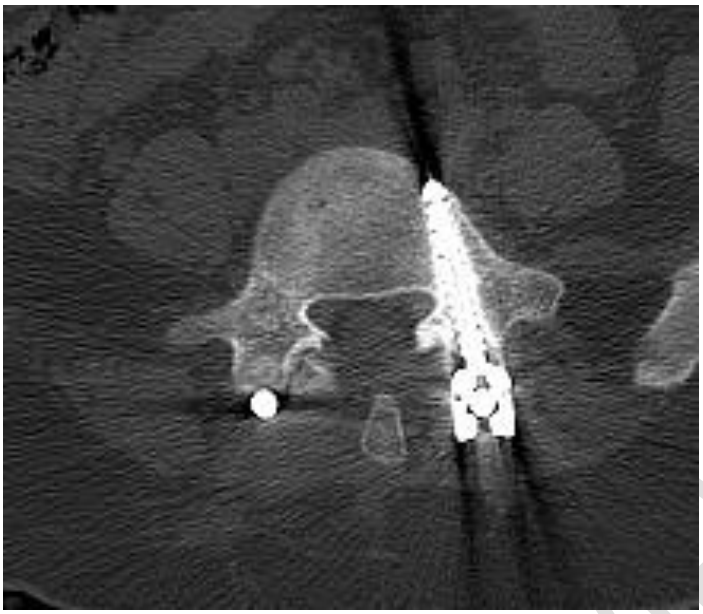

Figure 4: Left anterior perforation without neurological signs of the L5 vertebra in a 14-year-old girl.