Degenerative facet joint changes in lumbar percutaneous pedicle screw fixation without fusion

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ABSTRACT

Background: Aim of the study was to evaluate degenerative lumbar facet-joints changes after percutaneous pedicle screw fixation (PPSF) in the treatment of lumbar fractures.

Materials and methods: Thirty patients underwent short PPSF without fusion. CT-scan was performed in the pre- and post-operative time at four, eight and 12 months. The six zygapophyseal joints adjacent the fracture's level were evaluated.

Results: At four months patients showed no differences between pre- and post-operative joint radiographic aspect. At eight and 12 months, CT-scan demonstrated a progressive degeneration only in the middle joints respectively in 21.42% and in 76.92% of the cases. All 10 disrupted facet joints showed progressive degenerative changes at eight and 12 months.

Conclusion: Lumbar percutaneous fixation without fusion induces little degenerations essentially collocated in the middle joints close to fracture level at eight and 12 months. In the proximal and distal joints adjacent the screws degenerative changes can be seen only when associated to pedicle-screw encroachment.

Level of evidence: Level IV retrospective study.

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1. Introduction

Percutaneous pedicle screw fixation without fusion represents an alternative procedure for management of thoracic and lumbar amyelic type A fracture according to Magerl classification [1].

Conservative treatment with brace and bed rest was considered a valid treatment for thoracic and lumbar type A fractures, throughout the main disadvantage is represented by residual kyphotic deformity [2]. Surgical fixation allows significant reduction of regional deformity. Percutaneous pedicle screw fixation (PPSF) restores a good sagittal alignment similar to those reported for open surgery [3].

Some authors analysed the advantages and limits of PPSF reporting satisfactory results for the treatment of thoraco-lumbar fractures [4,5].

Removal of internal fixation is advocated after fracture healing to preserve the lumbar spinal segment mobility. Early instrumentation removal prevents zygapophyseal joint (ZJ) osteoarthritis as a possible consequence of prolonged fixation [6,7].

In several studies, the ZJ hypomobility plays a major role in inducing time-related degenerative changes leading to osteoarthritic radiographic assessment [6,8]. Histological changes observed in hypomobile joints are progressive and strictly related to fixation time as reported in experimental studies [9,10].

Few studies analyzed progression of degenerative changes interesting transfixed joints [11], while it’s well known that pedicle screw misplacement could lead to cartilage damage and subsequent ZJ ankylosis [12,13]. The absence of anatomical landmarks makes the pedicle screw entry point identification in percutaneous way strictly dependent to fluoroscopic images. Screw trajectory too medial or deeper toolip insertion can lead to impingement between implant and joint space with consequent zygapophyseal ankylosis [13].

At our knowledge, there are no studies that evaluate the transfixd ZJ degeneration after short PPSF for vertebral fracture using CT images. Aim of the study was to evaluate the ZJ degenerative changes at four, eight, 12 months after percutaneous fixation for the treatment of type A lumbar fracture.

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2. Materials and method

Since November 2011 to November 2012, 120 pedicle screws were implanted percutaneously in 30 consecutive patients affected by lumbar fractures, at our institution. Mean age of patients was 55.1 years (range 20–79), 17 males and 13 females. Inclusion criteria were: type A3 lumbar fractures according to Magerl Classification [1], no neurologic involvement, sagittal index >15° according to Farcy criteria [14]. Exclusion criteria were: previous surgery at lumbar spine, lumbar fracture previously treated with brace. In all patients short PPSF (four screws) without fusion was performed. Implanted levels ranged from T12 to S1.

Under general anaesthesia patients were positioned prone on a radiolucent operating table. Conventional C-arm fluoroscopy was used for the entire procedure. The entry point of the guide wire is located in the lateral end slightly cranial margin of the pedicle on the AP projection. Four sequential dilators are inserted to dilate the musculature and fascia, the three inner dilators are subsequently removed, leaving the outer largest dilator along with the guide wire in place. At this point the constructed extender sleeve attached to the cannulated polyaxial screw is inserted as a single construct using the fitted cannulated screwdriver. Screw diameter ranged from 5.5 mm to 6.5 mm with a length variable from 35 to 55 mm. (Pathfinder Zimmer-Abbot Spine Austin Texas) Then can be inserted a titanium rod 5.5 mm in diameter, pre-shaped to check the correction of vertebral height and sagittal alignment. Final step was engaged the rods in the polialxaxial cannulated screws and than stabilize with nuts.

Pre-operative and post-operative thin-cut CT-scans (2.5 mm contiguous images, reconstructed at 2 mm intervals in order to obtain sagittal and coronal reformats) of the pertinent spinal levels was obtained for all 30 patients in order to assess fracture healing to removal the instrumentation. Postoperative CT-scan analysis was performed at four months in 10 patients (group A), eight months in seven patients (group B) and 12 months in 13 patients (group C). CT-scan images were also used to evaluate screw facet joint impingement and facet joint degeneration. Each joint space was divided in two parts in the axial plane: peripheral articular surfaces were called A; central zone was called B. The CT-scan of the involved level was assessed by two independent observers. Facet joints degenerative alterations were classified according to criteria similar to those published by Pathria [15] (Table 1). In each patient six ZJ were evaluated and divided into: superior, middle and inferior (Fig. 1). The superior ZJ is represented by the superior facet of the proximal transfixed vertebra and the inferior facet of the proximal contiguous vertebra. The middle one is represented by the inferior facet of the proximal transfixed vertebra and the superior facet of the fractured vertebra. The inferior one is represented by the superior facet of the distal transfixed vertebra and the inferior facet of the fractured vertebra. The Pathria grade at the preoperative time and at the last follow-up was recorded in all patients. Impingement of the facet joints with screw was evaluated according to Moshirfar classification [12] (Table 2). The data of all consecutive patients treated were included in this study and analyzed in a retrospective fashion.

3. Statistics

Descriptive statistics were calculated. The results obtained were analysed using the Student t test and verified with Fisher’s exact test. Significance was accepted at \( P < 0.05 \). The inter-rater reliability and the level of agreement were analyzed using the weighted \( k \) statistic. There are some limitations that need to be acknowledged and addressed regarding the present study. The number of cases is too limited for broad generalizations. Further empirical evaluations and greater patients’ series are needed to validate the present results.

4. Results

Eleven patients presented an A3.1, 4 an A3.2, 15 an A.3.3 acute fracture. Fractures’ levels were: L1 in 19, L2 in four, L3 in five, L4 and L5 in one case respectively. All the hardware were removed within 12 months after surgery.

A total of 60 ZJ in 10 patients (group A) were studied at four months. CT-scan demonstrated no differences between preoperative and postoperative time and no facet joint violation (\( P=0.10 \)) (Fig. 2).

Mean preoperative Pathria grade at superiors and middle facet joints was 0.6 versus a mean post-operative grade of 0.6 (\( P=0.10 \)). Mean pre-operative Pathria grade at inferior facet joints was 0.7 versus a mean post-operative grade of 0.7 (\( P=0.10 \)). A total of 42 ZJ in seven patients (group B) were studied at eight months. CT-scan

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**Table 1**

Table showing Pathria classification for degenerative alterations of the zigoapophyseal joints.

<table>
<thead>
<tr>
<th>Pathria grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal facet joint space (2 ± 4 mm width)</td>
</tr>
<tr>
<td>1</td>
<td>Narrowing of the facet joint space (&lt;2 mm) and/or small osteophytes and/or mild hypertrophy of the articular process</td>
</tr>
<tr>
<td>2</td>
<td>Narrowing of the facet joint space and/or moderate osteophytes and/or moderate hypertrophy of the articular process and/or mild subarticular bone erosions</td>
</tr>
<tr>
<td>3</td>
<td>Narrowing of the facet joint space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and subchondral cysts</td>
</tr>
</tbody>
</table>

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**Table 2**

Table showing Moshirfar classification for screw encroachment.

<table>
<thead>
<tr>
<th>Moshirfar Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Pedicle screw clearly within the facet joint</td>
</tr>
<tr>
<td>Type 2</td>
<td>Pedicle screw head clearly within the facet joint</td>
</tr>
<tr>
<td>Type 3</td>
<td>Pedicle screw and/or screw head within 1 mm from/or abutting the facet joint without clear joint involvement</td>
</tr>
</tbody>
</table>

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Fig. 1. Sagittal CT-scan view of the superior, middle and inferior joints considered for each patient in the study.
Joint the same degenerative aspects observed at eight months but they were present in 76.92% of the cases (Fig. 6). Seven proximal and distal facet joints were violated by instrumentation and showed regressive changes.

Mean pre-operative Pathria grade was in the superior, middle and inferior facet joints of 0.92 versus a mean post-operative grade of 1.07, 1.8, 1.03 respectively. The facet at the fracture level showed an early and more severe worsening compared to the facet joint at the instrumented levels ($P = 0.001$). No superficial modification of articular surface were observed in the proximal and distal joints without screw violation.

In our series the incidence of the violations was 12% of all screws and 23.3% of all patients. Violation occurred in three cases at T12 and L2 and occurred in two cases at L1 and L5.

All 10 violated facet joints showed progressive degenerative changes at eight and 12 months. According to Moshirfar classification [12] a type 1 facet joint violation occurred in two cases, a type 2 in four cases and a type 3 in four cases.

Damage of the middle apophyseal joints was predominantly peripheral. A zone degeneration was observed in the 78.2% of the immobilized joints, while the simultaneous degeneration of B and A zone is observed only in 8.6% of cases.

5. Discussion

Percutaneous pedicle screw fixation is, nowadays, largely employed for treatment of type A thoracic and lumbar fractures according to Magerl classification [4,16,17]. There are some limitations that have to be acknowledged about this study: the number of patients is limited and also all patients didn’t undergo CT-scan examination at intermediate and last follow-up at 12 months in order to avoid excessive radiation exposure. We don’t know if group A get some degenerative changes in the facets at 12 months.

Minimally invasive technique presents many advantages compared to open technique, which is characterised by extensive soft tissue stripping to expose facet joints. Removal of the instrumentation after fractures healing is necessary to restore lumbar spine mobility. There are only few studies concerning the “fate” of

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**Fig. 2.** Axial pre and post-operative CT-scan view of the zygapophyseal joints at 4 months showing absence of degenerative alterations.

**Fig. 3.** Axial CT-scan view showing a correct screw insertion without impingement with a consequent absence of joint degenerative alterations at one year.

**Fig. 4.** Axial pre and post-operative CT-scan view at eight months showing degenerative changes in the A zone, characterized by many hyperdense inclusions (blue arrow).

**Fig. 5.** Axial CT-scan view showing right ZJ screw violation causing yet at eight months a regressive space joint changes and modifications of the articular surface.

**Fig. 6.** Axial pre and post-operative CT-scan view at 12 months of a middle joint showing structural modification of ZJ localized in peripheral zone (blue arrows).
lumbar motion segment unit underwent fixation without fusion and there is no consensus regarding progressive changes of ZJ. In 1984, Kahnavotitz et al. [10] studied the effect of internal fixation on the canine articular cartilage and concluded that in every specimen articular cartilage showed histological changes at only two months postoperatively irreversible after instrumentation removal. Gardner and Armstrong in 1990 [6] analysed radiographic effects of long fixation and short fusion for treatment of thoracolumbar fracture using oblique X-ray images of the lumbar spine. They studied 75 ZJ after removal of instrumentation at average time of 18.3 months and found only two cases of complete fusion [6]. X-ray images do not allow to detect early modifications of joint surface that occurs after fixation. CT-scan is considered the gold standard examination in diagnosis of degeneration of zigoapophyseal, in fact allows to observe signs of arthropathy as hypertrophy of the articular process, osteophytosis, subchondral sclerosis, geodes or capsular and ligamentous calcification better then magnetic resonance [14,18].

In 1993, Lindsey et al. [7] analysed residual intersegmental spinal mobility of 57 patients after pedicle fixation of thoracolumbar fractures with open technique. Instrumentation was removed at one year after injury and residual mobility after removal was analysed at two years minimum follow-up with dynamic X-ray. Their results showed the maintenance of a residual mobility in the treated segment after instrumentation removal. Fractured level showed the maximum loss of movement [7]. Cramer et al., in 2010 [19,20] describes in rats, after only four weeks from fixation, time dependent histological changes as the development of connective tissue fiber located between different zones of the ZJ, particularly in the peripheral area. The characteristic finding of this included tissues in the periphery of ZJ is probably due to the presence of ZJ synovial folds in this site of the joint. Hase [21] attributed the development of this connective tissue to the inclusion leaked from breakdown of type A synoviacite, largely represented in the ZJ synovial fold. In the authors’ opinion, this process may result in a metaplasia of the joint capsule fibrocartilage. Early instrumentation removal allows to avoid this degenerative changes of ZJ [19]. Compared to previous studies the use of CT-scan allows the authors to analyze the early changes of the Z-joints after fixation. In our findings, the radiological modifications become visible only since eight months in 21.42% of cases and concern only the middle joints. Limit of the study is the impossibility to establish if the degenerative changes in the middle joints were caused by the trauma rather than the fixation. In our series, the pre-operative CT-scan showed always intact articular joints with a normal congruence of the articular surface. At 12 months degeneration of the ZJ was present in 76.92% of the cases. No alterations are visible at the level of the proximal and distal joint in absence of facet joint violation. These little alterations are progressive and, if mobility of the articularation is not restored, may result in the ankylosis of the joint. Violation of the facet joints is an aspect less commonly discussed in medical literature. Only few studies analyzed the alterations associated to the misplacement of percutaneous pedicle screws [13,22,23]. Generally there is a higher rate of facet violation with percutaneous screw placement compared to open access. In minimally invasive approach the anatomic structures are not visible and the surgeon has not reference points. Help came from the two-dimensional fluoroscopic images and his tactile feedback. Screw trajectory too medial or deeper tool tip insertion can lead to impingement between implant and joint space, in this situation we observed always degenerative changes with consequent zigoapophyseal ankylosis. The authors observed that, because of the different anatomy of thoracic ZJ, T12 malpositioned screw or deeper head screw insertion, may result in a deformation of the superior facet joint with consequent modification of articular congruence (Fig. 7), however thoracic spine mobility is limited, for this reason in most cases clinical effects of this modifications are not very relevant.

![Fig. 7. Sagittal pre- and post-operative CT-scan showing the effects of driving the head screw too deep as bony structure on T11-T12 joint congruence.](image)

Patel et al. in a cadaveric study described 58% of violation of the facet articulation after percutaneous screw insertion [23]. In our experience incidence of violation was 12% of all screws, this value is pretty low if related to the literature and similar to the previously reported rates with the traditional open procedure as shown by Chen et al. [24] and Shah et al. [25], who reported impingement value between 15 and 25%. Low rate of facet joint violation is probably due in this series to the absence of severe ZJ degenerative changes in the analyzed population.

6. Conclusion

Facet-joints degeneration after PPSF interests particularly the middle transfixed joints, in the joints adjacent the screws, a degeneration can be seen only associated to encroachment. In the authors’ opinion in order to prevent these degenerative alterations an instrumentation removal between 6 and 12 months, after fracture healing, could be considered in lumbar spine.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References