CT-Guided Transfacet Pedicle Screw Fixation in Facet Joint Syndrome: A Novel Approach

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Key words: spine, instability, fixation, CT

Summary

Axial microinstability secondary to disc degeneration and consequent chronic facet joint syndrome (CFJS) is a well-known pathological entity, usually responsible for low back pain (LBP). Although posterior lumbar fixation (PIF) has been widely used for lumbar spine instability and LBP, complications related to wrong screw introduction, perineural scars and extensive muscle dissection leading to muscle dysfunction have been described. Radiofrequency ablation (RFA) of facet joints zygapophyseal nerves conventionally used for pain treatment fails in approximately 21% of patients. We investigated a “covert-surgery” minimal invasive technique to treat local spinal instability and LBP, using a novel fully CT-guided approach in patients with axial instability complicated by CFJS resistant to radioablation, by introducing direct fully or partially threaded transfacet screws (transfacet fixation - TFF), to acquire solid arthrodesis, reducing instability and LBP. The CT-guided procedure was well tolerated by all patients in simple analogue sedation, and mean operative time was approximately 45 minutes. All eight patients treated underwent clinical and CT study follow-up at two months, revealing LBP disappearance in six patients, and a significant reduction of lumbar pain in two. In conclusion, CT-guided TFF is a fast and safe technique when facet posterior fixation is needed.

Introduction

Axial microinstability secondary to disc degeneration is a well-known pathological entity, usually responsible for low back pain (LBP).

Because of asymmetrical load at the level of the local facets joints, abnormal degeneration of the articular cartilage and bone remodelling of the joints can occur¹, being responsible for the so-called chronic facet joint syndrome (CFJS). CFJS is one of the most common causes of LBP not only in elderly patients, but even in younger people.

Although posterior lumbar fixation (PIF) has been widely used for lumbar spine instability and LBP, using transpedicular screws and posterior fixing rods to reduce the abnormal movement of a segmental functional spine unit (FSU), complications related to this open-surgery procedure, like perineural scars and extensive muscle dissection leading to muscle dysfunction, have been described². To obtain maximum stability, pedicle screws should be placed in the correct position at the very first try. However, complications related to incorrect positioning of screws with neurologic or vascular damage have also been reported³⁻⁸. Finally, possible complications related to general anaesthesia should be taken into account.

Radiofrequency ablation (RFA) of facet joint zygapophyseal nerves is conventionally used for CFJS-related pain treatment⁹. Nevertheless, there is a significant percentage of treatment failure, with persistent LBP even in patients undergoing more than one treatment.

We investigated a “covert-surgery” minimal invasive technique to treat local spinal instability and LBP, using a novel fully CT-guided approach in patients with FSU axial instability complicated by CFJS resistant to radioablation, by introducing direct fully or partially threaded transfacet screws (transfacet fixation - TFF), to acquire solid arthrodesis, reducing instability and LBP.

Materials and Method

From October 2012 to November 2013, 144 patients with CFJS-related LBP were evaluated. Referred pain was assumed to be 10 (maximum) before treatment, to be compared to

clinical result after treatment. All the patients underwent conventional axial CT study of the disc space between L3 and S1 level (General Electric, Milwaukee, MA, USA), and a lumbar MRI (1.5T, Intera, Philips – Erlangen) study including axial and sagittal T2-STIR images, and

contrast-enhanced T1SE scan with fat saturation technique, demonstrating indirect signs of local instability (i.e., black disc, facet joint deformation and/or sclerosis, peri-articular inflammatory reaction, pedicle oedema or degenerative synovial cysts). To confirm the articular origin of LBP, CT-guided introduction of 1cc of Lidocaine at the level of the zygapophyseal nerve of the presumed facets responsible for LBP was performed. All the patients underwent CT-guided zygapophyseal nerve radioablation (pulsed radioablation, 90 degrees for 180 seconds) and clinical follow-up at two months. Although most of the population referred a significant (more than 70%) reduction of LBP 60 days after RFA treatment, 21/144 (15%) patients complained of a poor decrease of lumbar pain (less than 20% of the original), and for this reason a second RFA procedure was performed. Despite the second treatment, no LBP reduction was appreciated in 11/21 (55%) cases. After being informed, eight patients agreed to undergo CT-guided TFF of the zygapophyseal joints at the presumed level of the pain (three cases at L4/L5 level, five cases at L5/S1).

TFF was obtained using a “one-step” fully percutaneous procedure (ILLICO FS® – Alphatec Spine, Carlsbad, CA, USA). With the patients lying prone on the CT table, a C-arm was positioned on the table for a lateral view and a low-dose (10 mA/120 kV) 2.5 mm study of the level to be treated was obtained. Five cc of lidocaine was injected using a 20G spinal needle to obtain local anaesthesia into deep muscular tissue and the peri-articular area. Then an 11G Jamshidi needle was introduced on an oblique orientation, the entry point being approximately at the level of the spinous process two levels above the selected joints, driving the needle to the inferior articulating process of the level above. The tip of the needle was introduced through the articular rim over 10 to 15 mm into the superior process of the level below (Figure 1A). Then the inner stylet was removed and a guidewire was placed through the targeting needle. After removing the Jamshidi cannula, firmly maintaining the guidewire into the selected place, surrounding soft tissues and muscles were dilated using coaxial dilators with a small 10 mm skin incision (Figure 1B). A manual drill was placed over the guidewire and advanced across the facet joint and into the pedicle (Figure 1C). The distance between the cortex of the inferior process of the level above and the pedicle of the level be-

low was measured *in vivo* using CT scans, and partially threaded transfacet surgical grade titanium alloy screws were selected (35 mm long in six patients, 45 mm long in two patients). Using a screwdriver, screws were introduced along the guidewire, perfectly centred to the articular process (Figure 1D,E) bilaterally. Finally, the guidewire and the dilator were removed and the skin was sutured. Post-operative CT control was always performed immediately after the procedure and 60 days later as a follow-up control. Only mild analogue sedation (Fentanyl 1 to 3 gamma/kg/h / Remifentanyl 0.2 to 0.3 gamma/kg/h) was performed during the procedure.

Results

The CT-guided procedure was well tolerated by all patients in simple analogue sedation, and mean operative time was approximately 45 minutes only. All eight patients treated underwent clinical and CT follow-up at two months, revealing LBP disappearance in six patients, and significant reduction of lumbar pain in two.

Follow-up CT study demonstrated the correct positioning of bilateral transfacet screws with fusion of the facet joints at the level of L4/L5 in three out of eight patients (Figure 2), and at L5/S1 level in five out of eight patients. No significant paraspinal and/or muscular scar was appreciated on CT scans. Moreover, no remarkable reduction of flexion/extension movement was referred by patients, and no other side-effect was noted.

In the patient with severe right L5/S1 severe joint degeneration with synovial cysts, pedicle oedema and bone sclerotic reaction (Figure 3A), despite partial introduction of the right transfacet screw related to unilateral pedicle bone sclerosis (Figure 3B), pain resolution occurred, probably related to the joint block obtained thanks to the contralateral screw.

Discussion

Facet joint disease, generally related to chronic arthritis and/or segmental degeneration, remains one of the most common causes of chronic low back pain (LBP) both in young and elderly patients. Although radiofrequency ablation of the zygapophyseal nerve is widely used for pain control in patients with chronic facet joint syndrome (CFJS), treatment failure

Figure 3 Patient n. 4, severe right L5/S1 joint degenerative/inflammatory disease with chronic drug-resistant local pain. A) Axial T2 STIR MR image at L5/S1 level showing degeneration of the right zygapophyseal joint with degenerative synovial cyst, pedicle oedema, peri-articular inflammatory reaction and bone sclerosis. B) After TFF, the transarticular right screw did not manage to overcome the dense sclerotic bone of the right S1 pedicle: nevertheless, correct positioning of the contralateral screw guaranteed posterior fixation with pain resolution after treatment.

Figure 4 Patient n. 6, CT-guided correct L5/S1 transarticular screw placement. On real-time 3D CT imaging, the correct position of the screws and sacral foramina can always be checked precisely, avoiding complications.

occurs in approximately 21% of patients, probably related to incomplete nerve radioablation determined by wide anatomical variability¹⁰. Moreover, this failure percentage significantly increases in patients who previously underwent laminectomy (59% of failure) or posterior lumbar fixation (PIF) (71%)^{11,12}. For this reason, a more aggressive approach in case of RFA fail-

ure and persistent LBP related to spinal instability should be taken into account.

Although conventional PIF is generally used in painful lumbar spinal instability to lock the vertebrae involved, reducing the LBP related to excessive movement, several drawbacks of this procedure have been reported in the literature, generally related to incorrect screw positioning.

Moreover, excessive rigidity of the spinal implant can increase stress transmitted to contiguous functional spine unit (FSUs), with accelerated disc degeneration/herniation, and generating painful subchondral bone oedema related to stress shearing impact^{13,14}.

A lateral interbody fusion (LIF) technique for lumbar interbody arthrodesis has recently been proposed, with good biomechanical stability of stand-alone cage placement compared to posterior fixation obtained with the PIF technique¹⁵. However, the LIF surgical approach remains as “aggressive” as the PIF technique, and general anaesthesia is always needed. Moreover, both PIF and LIF techniques include extensive deep paraspinal muscle dissection, leading to muscle dysfunction, increasing the general instability of the spine.

Transfacet pedicle screw fixation (TFF) provides similar acute stability to the spinal lumbar segment compared with traditional lateral interbody cage fixation or posterior interbody fusion¹⁶, and even cervical application has recently been proposed^{17,18}.

TFF proved to have near biomechanical equivalence to LIF and PIF and may significantly reduce operative time and morbidity, as no general anaesthesia is required, with a total working time under one hour¹⁹. Transfacet screws demonstrated statistically similar stiffness when compared to cyclic flexion/extension, lateral bending, and torsion of the lumbar spine in comparison to conventional PIF, and the anterior column loading during several physiologic tests showed no biomechanical differences between TFF and PIF stabilization. Moreover, TFF reduces soft tissue disruption preserving the adjacent facet joint²⁰, respecting muscle anatomy as deep dissection is not necessary with a fully percutaneous approach.

Fully CT-guided TFF has not yet been described in the literature. Using a real-time 2D CT study performed during the procedure, the optimal screw length and thickness can easily be calculated together with the desired orientation, reducing the risk of complications related to improper screw insertion, and avoiding the need to retrieve and re-introduce screws in case of initial incorrect positioning that is responsible for increasing screw instability related to bone erosion²¹. Consequently, as screws must be placed in the correct position at the very first try, a CT-guided approach is a powerful technique, reducing the failure of surgical stabilization.

In all the patients treated but one, the introduction of the screws was an easy one-step procedure, performed in approximately 15 min each side, while no pain was referred by the patients thanks to mild analogue sedation. In the patient with L5/S1 microinstability with severe right S1 pedicle bone sclerosis the introduction of the right screw was not completed because of difficulty in drilling the severely sclerotic pedicle: nevertheless, the screw overpassed the articular rim and LBP resolution after stabilization was achieved, also thanks to the fully introduced contralateral screw on the other side.

Although transfacet fixation can be performed at L3-S1 level using the simple C-arm and the “inferior endplate and medial pedicle wall of the superiorly instrumented level as anatomic landmarks in conjunction with axial and sagittal angles of insertion”^{22,23}, the CT-guided technique provides additional advantages to the conventional radioscopy approach. In fact, in case of facet joint and pedicle deformation related to long-standing axial instability, X-ray lateral and anteroposterior views can be unsafe because of difficult visualization of conventional landmarks. On the contrary, thanks to a real-time evaluation of the patient’s anatomy, the CT-guided approach allows ad hoc orientation of the Jamshidi needle and guidewire, precisely evaluating the foramina and nerves, as well as vascular structures nearby (Figure 4). Moreover, the correct length and thickness of the screws can be chosen specifically for each patient, measuring the pedicle diameter and length on 2D CT reconstructions, avoiding an incorrect choice of too short, long or thick screw sizes.

Analogue sedation using opioids was always well tolerated by all the patients: besides reducing any complications related to general anaesthesia, the technique we used significantly reduced the total working time (approximately 45 minutes only), half the time generally needed for a conventional surgical TFF, even on a lateral approach, as described in recent literature^{24,25}.

Conclusion

Transfacet pedicle screw fixation (TFF) seems to be a powerful technique for lumbar spine stabilization in patients with chronic facet joint syndrome, and no side-effects or com-

plications were observed. Mean working time was significantly reduced using a fully CT-guided technique in simple analogue sedation.

In conclusion, CT-guided TFF is a fast and safe technique when facet posterior fixation is needed.

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