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Evaluation Study

TREATING THE MICRO INSTABILITY WITH PERCUTANEOUS CT GUIDED TRANSFACETAL FIXATION: A 15-YEAR EXPERIENCE

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ABSTRACT

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). Despite posterior lumbar fixation has been widely used for lumbar spine instability and LBP, a complication related to wrong screw introduction, perineural scars, and extensive muscle dissection leading to muscle dysfunction has been described. Radiofrequency ablation of facet joints zygapophyseal nerves conventionally used for pain treatment fails in approximately 21% of patients. We investigated the "covert-surgery" minimally invasive technique in treating local spinal instability and LBP, using a novel fully-CT-guided approach in patients affected by axial instability and complicated by CFJS resistant to radio ablation. We introduced fully- or partially-treated trans-facet screws directly to achieve solid arthrodesis, reducing instability and LBP, thus a retrospective study was performed. All patients in simple analogue sedation perfectly tolerated the CT-guided procedure, and the mean operative time was approximately 45 minutes only. All 67 patients treated underwent clinical and CT study follow-up at 2 months, revealing LBP disappearance in 50 patients and a significant reduction of lumbar pain in 17 patients. In conclusion, CT-guided trans-facet screws is a fast and safe technique when posterior facet fixation is needed.

KEYWORDS: *spine, instability, fixation, CT*

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INTRODUCTION

Many factors, including axial micro-instability secondary to disc herniation, can cause low back pain (LBP). Among the causes of the so-called chronic facet joint syndrome (CFJS) are asymmetrical load at the level of local facet joints, abnormal degeneration of the articular cartilage and bone remodelling of the joints (1). In turn, CFJS is regarded as one of the most common causes of LBP in patients of older age and even in younger people.

Posterior lumbar fixation (PIF) has been adopted as one of the most recurring therapies for lumbar spine instability and LBP. This method uses transpedicular screws and posterior fixating rods to reduce the abnormal movement of a segmental functional spine unit (FSU). However, in literature, complications linked to PIF are documented, such as perineural scars and extensive muscle dissection, up to the point of muscle dysfunction (1).

The correct placement of pedicle screws on the very first try is required to obtain maximum stability. However, complications related to incorrect position of screws with neurologic o vascular damage have also been reported (2-8). Finally, possible complications related to general anaesthesia should be taken into account.

Another therapy used in pain treatment related to CFJS (9) is radiofrequency ablation (RFA) of facet joint zygapophyseal nerves. However, a significant percentage of treatment failure is reported, with persistent LBP even in patients undergoing more than one treatment.

In this study, we intended to investigate a "covert-surgery" minimally invasive technique in treating local spinal instability and LBP, using a novel fully-CT-guided approach in a patient affected by FSU axial instability complicated by CFJS resistant to radio ablation by introducing direct fully or partially treated trans-facet screws (trans-facet fixation - TFF), to acquire solid arthrodesis, reducing instability and LBP.

MATERIALS AND METHODS

From March 2006 to November 2021, we treated 304 patients affected by LBP related to CFJS. Referred pain was assumed to be 10 (maximum) before the treatment, compared to clinical results after the treatment. All the patients underwent conventional axial CT (General Electric, Milwaukee, MA) study of the disc space between L3 and S1 level 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 joints deformation and/or sclerosis, peri-articular inflammatory reaction, pedicle oedema or degenerative synovial cysts). To confirm the articular origin of LBP, we performed a CT-guided introduction of 1cc of lidocaine at the level of the zygapophyseal nerve of the presumed facets responsible for LBP. In addition, all the patients underwent CT-guided zygapophyseal nerve radio ablation (pulsed radio ablation, 90 degrees for 180 seconds), and clinic follow-up at 2 months was performed. Although most of the population referred significant (more than 70%) reduction of LBP 60 days after RFA treatment, a pool of patients complained about a poor decrease in lumbar pain (less than 20% than the original), and for this reason, a second RFA procedure was performed. However, despite the second treatment, no LBP reduction was appreciated. After being informed about it, the remaining 67 patients were accepted to undergo CT-guided trans-facets fusion (TFF) of zygapophyseal joints at the presumed pain level (25 cases at L4/L5 level, 42 cases at L5/S1).

TFF was obtained using a "one-step" fully percutaneous procedure (ILLICO FS ® – Alphatec Spine, Carlsbad, CA). For the patient lying prone on the CT table, a C-arm was positioned for lateral view, and a low-dose (10mA/120kV) 2.5mm study was obtained. First, a 5cc lidocaine injection using a 20G spinal needle was performed to obtain local anaesthesia into deep muscular tissue and peri-articular area. After that, the 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 needle tip was then introduced through the articular rim over 10 to 15mm and into the superior process at the level below. Then, the inner stylet was removed, and a guidewire through the targeting needle was placed. 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 10mm skin incision. A manual driller was placed over the guidewire and advanced across the facet joint and into the pedicle. In-vivo measurement of the distance between the cortex of the inferior process of the level above and the pedicle

of the level below was performed using CT scans and partially treated trans-facet surgical-grade titanium alloy screws were selected (35mm length in 50 patients, 45mm length in 17 patients). Using a screwdriver, screws were introduced along the guidewire, perfectly centred to the articular process bilaterally (Fig. 1-2-3-4). Finally, the guidewire and the dilator were removed, and the skin was sewn. Post-op CT control was always performed immediately after the procedure and 60 days after as a follow-up control. Only mild analogue sedation (Fentanil 1 to 3gamma/kg/h / Remifentanil 0.2 to 0.3gamma/kg/h) was performed during the procedure.

After 2 months, all patients underwent MRI scan follow-up (Fig. 5).

RESULTS

All patients perfectly tolerated the CT-guided procedure in simple analogue sedation, and the mean operative time was approximately 45 minutes only. All 67 patients treated underwent clinical and CT study follow-up at 2 months, revealing

Fig 1. *L5-S1 microinstability. Sagittal 2D reformatted scan: the delivery system with a 6mm diameter muscle dilator allows the correct positioning of L5-S1 transfaccettal screw.*

Fig 2. *Coronal scan at the level of L5-S1. The screw crowns are symmetrically oriented.*

Fig 3. *Post-op axial 2D recon at L5-S1 level. To obtain the maximal fixation effect, screws must be symmetrical and divergent.*

LBP disappearance in 50/67 patients and a significant reduction of lumbar pain in 17/67 patients.

In 25/67 patients, a follow-up CT study demonstrated the correct position of bilateral trans-facet screws with a fusion of the facet joints at the L4/L5 and L5/S1 levels in 42/67 patients. No significant para-spinal and/or muscular scar was appreciated on CT scans. In addition, none of the patients reported a remarkable reduction of flexion/extension movement, and no other side effect was noted.

Pain resolution occurred in the patient affected by severe right L5/S1 joint degeneration with synovial cysts, pedicle oedema and bone sclerotic reaction, despite the partial introduction of the right TFF related to unilateral pedicle bone sclerosis. This effect was probably related to the joint block obtained thanks to the contralateral screw.

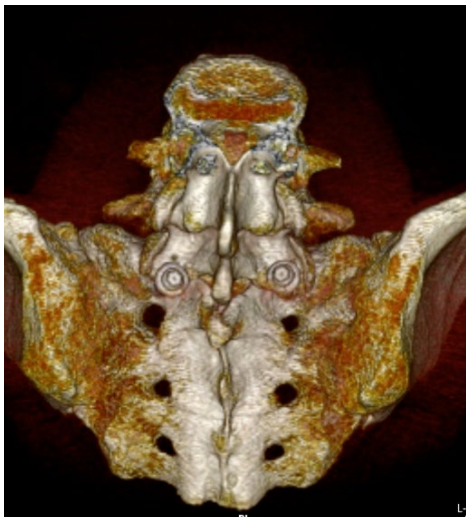

Fig 4. *L5-S1 transfaccettal fixation 3D recon. The external crown and screws are clearly depicted above the inferior L5 facet surface.*

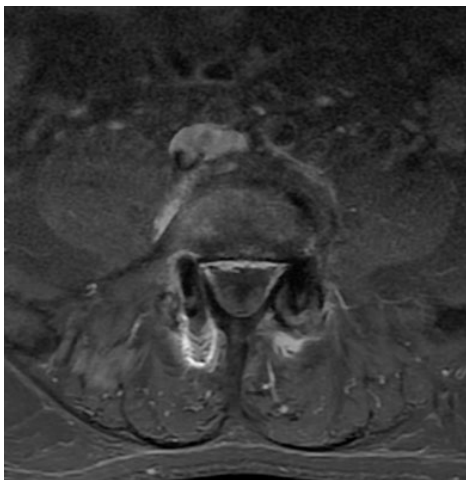

Fig 5. *Axial contrast enhanced MRI follow-up at 2 months: the MRI clearly shows normal bone signal around the screws, that are hypo intense according to the titanium structure.*

DISCUSSION

Among the causes of chronic lumbar pain in young and elderly patients, facet joint disease, generally related to chronic arthritis and/or segmental degeneration, remains among the most common. Despite the wide use of radiofrequency ablation of the zygapophyseal nerve for pain control in patients affected by CFJS, treatment failure occurs in approximately 21% of patients, probably because of incomplete nerve radio ablation determined by wide anatomical variability (10). In addition, this failure percentage significantly increases in patients who previously underwent laminectomy (59% of failure) or PIF (71%) (11-12). For this reason, a more aggressive approach should be considered in case of RFA failure and persistent LBP related to spinal instability.

Conventional PIF is generally used in painful lumbar spinal instability to lock the vertebras, reducing the LBP related to excessive movement. However, in the literature several drawbacks of this procedure have been pointed out, generally related to incorrect screw positioning. In addition, excessive rigidity of the spinal implant can increase stress transmitted to contiguous FSU, with accelerated disc degeneration/herniation, as well as generating painful subchondral bone oedema related to stress shearing impact (13-14).

The lateral interbody fusion (LIF) technique for lumbar interbody arthrodesis has been recently proposed, with good biomechanical stability of stand-alone cage placement compared to posterior fixation obtained with the PIF technique (15). However, LIF surgical approach remains as "aggressive" as PIF one, and general anaesthesia is always needed. Moreover, both therapy techniques include extensive deep paraspinal muscles dissection, leading to muscle dysfunction and increasing general instability of the spine.

Trans-facet pedicle screw fixation provides similar acute stability to the lumbar spinal segment compared to traditional lateral interbody cage fixation (Fig. 6) or posterior interbody fusion (16), and even cervical application has been recently proposed (17-18).

TFF has been shown to provide near biomechanical equivalence to LIF and PIF. Because no general anaesthesia is required and its total working time is inferior to one hour, this therapy significantly reduces operative time and morbidity (19). Trans-facet screws demonstrated statistically similar stiffness to cyclic flexion/extension, lateral bending, and torsion of the lumbar spine compared to conventional PIF. 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 joint (20), respecting muscle anatomy as deep dissection is not necessary with a fully percutaneous approach.

Fully CT-guided TFF has not been described yet in the literature. Using a real-time 2D CT study performed during the procedure, it was easy to calculate optimal screw length, thickness and 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; an action that is responsible for increasing screw instability related to bone erosion (21). Consequently, as screws must be placed in the correct position on the very first try, CT guided approach is a useful and powerful technique, for it reduces the failure of surgical stabilization.

In all the patients treated but one, introducing the screws was an easy one-step procedure, performed in approximately 15 min on each side, and no pain was referred, thanks to mild analogue/sedation. In the patient affected by 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. However, the screw overpassed the articular rim and LBP resolution after stabilization was achieved, thanks to the fully introduced contralateral screw on the other side.

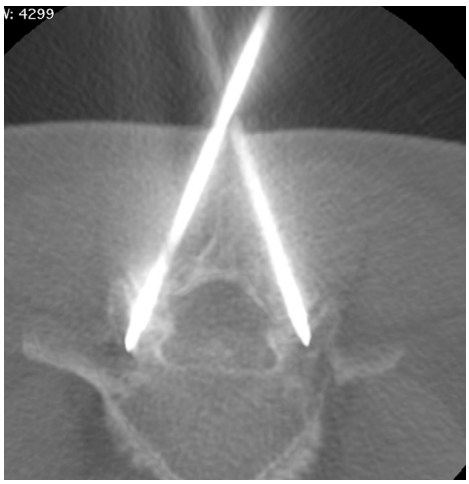

Fig. 6. *L5-S1 transfaccettal fixation: first step. Two 13G trocars are introduced passing through the inferior facet of L5 and the superior S1 one, to prepare the coaxial introduction of the guide wire and screws.*

Although trans-facet fixation can be performed at L3-S1 level by 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), CT guided technique provides additional advantages to conventional radioscopic approach. In the case of the facet joint and pedicle deformation related to long-standing axial instability, X-ray lateral and antero-posterior views can be unsafe because of the difficult visualization of conventional landmarks. On the contrary, the CT-guided approach (thanks to a real-time evaluation of the patient anatomy) allows the ad-hoc orientation of the Jamshidi needle and guidewire to be adopted, evaluating the foramina and nerves, as well as vascular structures nearby (Fig. 4). Moreover, the correct length and thickness size of the screws can be explicitly chosen in each case, for every patient, measuring the pedicle diameter and length on 2D CT recons, avoiding incorrect choice of screw size too much short, long or thick.

All patients tolerated well analgo-sedation using opioids: besides reducing eventual complications related to general anaesthesia, the technique allowed to reduce significantly the total working time (approximately 45 minutes only), which is half the time generally needed for a conventional surgical TFF, even on a lateral approach, as described in the recent literature (24-26).

CONCLUSION

It appears that TFF can be a powerful technique in the case of lumbar spine stabilization in patients suffering from CFJS, and no side effects or complication was observed. Mean working time was significantly reduced using a fully CT-guided technique in simple analgo-sedation. In conclusion, CT-guided TFF is a fast and safe technique when posterior facet fixation is needed.

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