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Percutaneous iliosacral screw fixation in unstable pelvic ring lesions: The interest of O-ARM CT-guided navigation

C. Coste, Y. Asloum, P.S. Marcheix, P. Dijoux, J.L. Charissoux, C. Mabit*

* Corresponding author. Tel.: +33 5 55 05 87 69.
E-mail address: ch-mabit@unilim.fr (C. Mabit).

Dupuytren University Hospital, Orthopedic-Traumatology Department, 2, Avenue Martin-Luther-King, 87042 Limoges cedex, France

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Summary
Introduction: The reference surgical treatment for unstable posterior pelvic fracture is percutaneous iliosacral screw fixation, isolated or in association with other techniques. As there is a risk of passage outside the bone when performing screw fixation under fluoroscopy, new image-guidance techniques have been developed: fluoronavigation, peroperative 3D navigation, CT-linked navigation, etc. Since September 2011, our department has performed iliosacral screw fixation under CT control linked to navigation so as to optimize screw positioning. This innovative technology has been used in neurosurgery in our center since 2007, for disc implants, spinal fracture, vertebral arthrodesis and intracerebral localization.

Material and methods: Six patients were treated by iliosacral screw fixation for posterior pelvic ring fracture lesion. The O-ARM (Medtronic®) computer-assisted surgical navigation system was used, combining surgical navigation and peroperative 3D imaging. This kind of osteosynthesis is suitable for non-displaced or prereduced fracture. A radiation dose report is drawn up at end of surgery.

Discussion: Postoperative course does not differ from other percutaneous osteosynthesis techniques, combing the advantages of a percutaneous approach (reduced infection and blood-loss rates, etc.) while optimizing iliosacral screw positioning. To date, no radiation overexposure has been found.

Conclusion: The precision and safety of iliosacral screw fixation are now unequaled, meeting the basic computer-assisted surgery principles of reduced morbidity without overexposure to ionizing radiation. Indications for computer-assisted surgery should therefore be extended to iliosacral pathologies (arthritic, tumoral and inflammatory), non-displaced acetabular fracture, etc.

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Introduction

Surgical treatment in pelvic ring lesions aims at anatomic reduction, necessary for a good functional result, and early mobilization to limit decubitus-related complications [1, 2].

Osteosynthesis may be open or percutaneous [3, 4]. CT is required preoperatively for planning and postoperatively to assess both reduction quality and osteosynthesis positioning.

Percutaneous iliosacral screw fixation, isolated or in association with other techniques, is the reference attitude in posterior lesions [5–9], and is applicable to unstable fracture of the posterior arc.

Surgery in such high-energy trauma requires adapted management of associated lesions by an experienced team [10].

To reduce morbidity and optimize screw positioning, our department performs iliosacral screw fixation under CT control coupled to navigation: O-ARM system (Medtronic®).

Figure 1  CT acquisition after positioning reference frame.

Figure 2  A. Simulation of osteosynthesis with navigator interface: trajectory, length and diameter. B. O-ARM around patient, reference frame and navigation instrumentation.

Material and methods

Between August 2009 and May 2012, 40 pelvic ring fractures were treated by surgery in the Orthopedics-Traumatology Department of Limoges University Hospital, including 40% (n = 16) with unstable posterior arc fracture (type C on the AO-ASIF classification; B or C on the Tile classification). Several techniques were used: open (two posterior, five anterior) or percutaneous (nine percutaneous screw fixations: three under fluoroscopic and six under CT control coupled to navigation).

Since September 2011, we have used computer-assisted surgical navigation, combining surgical navigation and peroperative 3D imaging. This is an innovative technology, used in neurosurgery in our center since 2007 for disc implants, spinal fracture, vertebral arthrodesis and intracerebral localization. We here report on the six most recent procedures.

Surgical procedure

This osteosynthesis is applied to non-displaced or pre-reduced fractures: femoral traction or pubic symphysis osteosynthesis.

After antibioprophylaxis, surgery is performed under general anesthesia, in dorsal decubitus. The patient is positioned on a carbon table, within the O-ARM scanner so as to enable the operative region to be centered fluoroscopically.

The surgical field is prepared, and a reference frame is positioned at the iliac crest ipsilateral to the lesion, for

Figure 3  A. Peroperative CT control (transverse slice). B. Position of osteosynthesis on transverse, coronal and sagittal slices.
instrument navigation and CT acquisition and 3D reconstruction (Fig. 1).

Dedicated navigation instrumentation, with a percutaneous perforated cannula to orient guide-wire positioning, is used to control the trajectory, length and diameter of the osteosynthesis screw (Fig. 2).

Peroperative CT control may be performed either after introducing the guide-wire or after screwing, to check the osteosynthesis and reduction quality (Fig. 3). Reduction of the sacroiliac opening and/or fracture site compression is performed under fluoroscopic control (Fig. 4).

The peroperative radiation dose is recorded at end of surgery.

**Preliminary results**

The present series comprised six patients (five male, one female); mean age, 62 years (range, 43–73 years).

Osteosynthesis under CT-guided navigation was indicated for four Tile B and one Tile C fractures and 1 sacroiliac metasis. Trauma was high-energy: two falls from ladders (> 5 meters), two road accidents and one agricultural crushing accident.

Mean time to surgery was 7 days (range, 3–14 days), depending on general health status in terms of associated lesions and on the availability of the neurosurgery operating room. Mean surgery time was 40 min (range, 25–90 min), depending on associated procedures: one plate osteosynthesis of the pubic symphysis (Fig. 5), one iliosacral cementing procedure (Fig. 6).

Osteosynthesis systematically used an 8-mm diameter cannulated screw (length, 90–120 mm) and washer.

Sitting was allowed at D2, partial weight-bearing at D45 and complete weight-bearing at D90.

There were no local (hematoma), infectious or neurological complications or malpositioning or secondary displacement of the screw.
Discussion

Computer-assisted surgery ensures precise in-bone positioning of the iliosacral screw, reducing the risk of false passage, depending on patient conditions (obesity, digestive aeration) and anatomic joint variations [11,12].

Initial radiation dose results have been encouraging, with no overexposure, which is often a limiting factor for this CT-guided procedure. Pelvic ring osteosynthesis, in any case, requires systematic pre- and postoperative CT, performed peroperatively in computer-assisted surgery.

This technology requires considerable financial investment, as part of interdepartmental cost-sharing: a fully equipped surgery room, lead-protected, with reinforced floor and carbon table. The O-ARM system (CT scanner, navigator and ancillary) costs about €700,000.

Figure 5  A and B. Example of iliosacral screw fixation following pubic symphysis osteosynthesis for Tile B2 fracture.
Figure 6  Example of iliosacral screw fixation for iliosacral metastasis of renal origin. A. Iliosacral metastasis. B. Iliosacral screw fixation. C. Percutaneous osteosynthesis and cementing on anterior approach.

Conclusion

Percutaneous screw fixation under CT guidance coupled to navigation provides unequalled precision and safety. It meets the basic principles of computer-assisted surgery, minimizing X-ray dose, invasiveness and morbidity. Indications will likely be extended in pelvic and orthopedic surgery: arthritic or inflammatory iliosacral pathology, and acetabular fracture.

Disclosure of interest

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

References
