Technical note

The added value of intraoperative CT scanner and screw navigation in displaced posterior wall acetabular fracture with articular impaction

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ARTICLE INFO

Article history:
Received 29 March 2016
Accepted 21 July 2016

Keywords:
Posterior wall acetabular fracture
Navigation
Impaction
Intraoperative imaging

ABSTRACT

Posterior wall with transverse acetabular fractures represents the most common type of acetabular fractures and is generally associated with poorer outcomes. This is caused by improper visualization of the fragments leading to imperfect reductions. Navigation in pelvic and acetabular trauma is reserved nowadays to non-displaced or mildly displaced fractures. To add to that, perioperative control of reduction is difficult using the conventional X-ray. The described 3D imaging method allowed proper reduction control. On the other hand, screw navigation of acetabular screws enabled better control of screw position as well as screw placement in otherwise inaccessible zones. In conclusion, perioperative 3D imaging and screw navigation optimize fracture reduction promoting better radiological and functional results.

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1. Introduction

Displaced acetabular fractures creates incongruency between the acetabulum and the femoral head [1]. Anatomical reduction had been advised to obtain a favorable functional outcome [2]. In contrast, reduction and internal fixation of displaced fracture is technically demanding with a steep learning curve [3,4]. Despite specific approaches were described to manage these fractures, there are general and technical complications, in particular insufficient reduction and screw malpositioning [5].

The most common type of acetabular fracture is the posterior wall with transverse fracture associated with articular impaction [6]. Treatment consists in reduction of the fracture using the femoral head as a guide. Thereafter, the posterior wall fragment is closed like a hood and control of the reduction is then totally lost with poor reliability of fluoroscopy [7]. In addition, routine postoperative CT-scan (computed tomography) showed a number of imperfect reductions caused by fragment instability and lack of surgical control (Fig. 1).

Intraoperative imaging using CT-scan became popular in spine surgery in adjunct to navigated pedicular screw placement [3]. In trauma of pelvic bone, intra-operative imaging and screw placement navigation was evaluated for iliosacral screws and for percutaneous fixation of non-displaced acetabular fractures [3,8–10]. We describe a technical note on management of displaced posterior wall with transverse acetabular treated with open reduction and internal fixation using the 3D intraoperative imaging and screw navigation.

2. Surgical technique

The patient, who signed a preoperative consent for the use of this technique, is positioned in a ventral decubitus on a radiolucent traction table with traction applied to the injured limb with a 45° of knee flexion (to decrease tension in the sciatic nerve). The O-ARM imaging device (Medtronic, Sofamor, Broomfield, CO) is then introduced to check the absence of conflict with the patient and/or the operative table (Fig. 2). The Kocher-Langenbeck approach is used exposing the comminuted fracture and the impacted fragments. After opening of the “hood” (posterior wall fragment) and exposing the impacted articular surface, intra-articular lavage is performed. Reduction of the transverse fracture is more challenging and is done using special reduction forceps and clamps. Reduction of the articular fragments is performed followed by the closure of the hood. If reduction is deemed stable, no fixation for the acquisition is required. If not, provisional fixation could be done using Kirschner wires or small plates (2–4 holes).

The acquisition and navigation part follows: a bolt with the reference frame is inserted in the ipsilateral posterior iliac crest. The reference frame should be between the camera and the O-Arm during acquisition (camera on the head side). The O-Arm device is introduced to the surgical field after draping. Special care should be taken not to soil the device with the bloody surgical drapes. The device must be centered over the desired hemipelvis (Fig. 3).

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http://dx.doi.org/10.1016/j.otsr.2016.07.005
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A 31-year-old male was victim of a motor vehicle accident. He presented a posterior dislocation of the left hip with a posterior wall acetabular fracture. Preoperative CT-scan showed a comminuted posterior wall fracture as well as impaction of the acetabular roof (A). The patient was operated 5 days after trauma with open reduction and internal fixation without O-ARM navigation via Kocher-Langenbeck approach. Reduction of the fragments was done using the reduced femoral head as a scaffold. Fixation was carried with 2 Letournel plates (Stryker, Kalamazoo, Michigan). Postoperative X-rays showed good reduction. Nonetheless, routine postoperative CT-scan showed displacement of the acetabular roof fragment with a step off of around 4 mm (B).

The first imaging of the reduced fracture is performed using low dosage radiation mode in order to reduce the irradiation to the patient. This step should always be done after reduction of the fracture in order to make screw navigation possible. The device is then put in parking mode (towards the feet) enabling repetitive image acquisition without uncomforting the surgical team. Operative time was increased by 13 minutes for this step.

One or two Letournel plates (Stryker, Kalamazoo, Michigan) are used for internal fixation. They are bent to exact anatomy of the patient. With the use of intraoperative navigation (Medtronic, Sofamor, Broomfield, CO), screws were inserted using a navigated drill and length was measured using the passive probe.
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Fig. 4. A 56-year-old female had a simple fall while jogging. Initial X-rays showed a left posterior wall acetabular fracture. CT-scan showed a posterior wall fracture with impaction of the articular surface of more than 2 mm as well as a non-displaced transverse fracture (A). The patient was operated using the described protocol. Reduction was controlled preoperatively (B). This allowed the use of lag screws to fix the transverse fracture and buttressing screws for the impacted fragment to prevent displacement (C).

Navigation helped in obtaining the best situation of the plate with respect to the ischial tuberosity. More importantly, special screws that were impossible to place without navigation were inserted: first, a lag screw for the reduced transverse fracture and second, as a buttressing screw for the impacted fragment to prevent displacement (Fig. 4A, B and C respectively).

Post-fixation CT-scan is done intraoperatively. If articular surface reduction was imperfect, surgical reduction was started again. Final acquisition may be artefacted by hardware if low dose protocol is used. The total dose of irradiation of the patient was 343 cGy/cm for all intraoperative acquisition compared to 505 cGy/cm for preoperative helical CT-scan. Even more, with final intraoperative imaging after fixation is done, no postoperative imaging is needed.

3. Discussion

This technical note describes the use of a specific image intensifier with 3D reconstruction as well as open screw navigation for displaced acetabular fracture. There are three main advantages of its use:

- to control accurately articular reduction before fixation. As shown in the illustrative cases, impacted fragments tend to re-displace when the posterior wall fragment is reduced;
- to check intraoperatively the fixation and reduction quality after the fixation devices were applied and before the closure of the patient. One could argue that CT-guided procedures would induce increased radiation exposure for the patient. Nonetheless, initial
reports in our institution as well as in the literature showed no overexposure to the patient [8] and second acquisition saves the need of a routine postoperative scan;

- finally, the last advantage is the use of navigation. Screw navigation allows to insert “difficult” or “dangerous” screws in the periacetabular area (Fig. 4C) [5]. These screws could act as lag screws between the anterior and posterior column or as a buttress screws for the impacted articular surface analogous to the screws inserted in impacted tibial plateau fractures.

To our knowledge, there is only one report that evaluated the effects of intraoperative CT-scan and navigation in displaced acetabular fractures [10]. Oberst et al. [10] compared the outcome of acetabular fractures with and without intraoperative navigation. They found better reduction rate with navigation. Nonetheless, this study had several limitations. First, the two groups of fractures were not comparable; the first group (navigated) was formed of mainly two columns fractures (with no posterior wall fractures) where articular surface is solid to a column fragment and reduction could be controlled with the reduction of the columns, whereas the second group (without navigation) contained posterior wall fractures with articular impaction and instable articular fragments, the type of fractures that we actually think they need intraoperative control. Secondly, the fixation used in this report was not homogenous. Third, there was no intraoperative CT control, one main advantage of this technique. Thus, results from this study should be interpreted with caution.

On the other hand, many authors reported the added value of navigation with a mobile CT scanner (O-ARM) [8] on the placement of percutaneous iliosacral screws or anteroposterior acetabular screws [9]. All these techniques require a non-displaced or a pre-reduced pelvic or acetabular fracture. Even though, it is associated with less complication and bleeding, anatomical reduction is rarely achieved without open reduction [1].

This technique had several limitations. First of all, navigating the drill is difficult since soft tissue often interposes between the camera and the reference on the drill. We always used the navigation pointer to guide the screw direction and length. To add to that, this technology requires financial investment in the operating room (reinforced floor, lead protected room . . .) as well in the O-Arm system along with the navigator and ancillary [8].

In conclusion, using intraoperative imaging and screw navigation for posterior wall with transverse acetabular fracture is easy and enables better intraoperative control of the reduction and placement of important or difficult screws. Currently, all acetabular fractures surgically treated in our institution are done using intraoperative CT-scan and navigated screw placement and a prospective assessment in ongoing.

Funding

There is no external funding related to this work.

Disclosure of interest

The authors declare that they have no competing interest.

References