Case report

The use of a 3D-printed personalised drill guide for posterior column lag screw fixation in displaced transverse acetabular fracture: A case report

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A R T I C L E   I N F O

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A B S T R A C T

Introduction and importance: Anterior column plate combined with posterior column screws have been effectively used for treatment of displaced transverse acetabular fractures. This article presents the use of 3D-printed technology for customising a guide template to appropriately place posterior column screw.

Case presentation: A 50-year-old female suffered displaced juxtatectal fracture of the right acetabulum. A personalised guide for antegrade posterior column screw placement was designed based on the data of her pelvic CT-scan. This guide and a prototype of her right acetabulum - created by mirroring the intact left acetabulum - were 3D-printed for preoperative evaluation and pre-contouring of reconstruction plate. Modified Stoppa approach and additional lateral window were used for direct reduction, anterior column plate and posterior column lag screw fixation. Post-operative CT-scan showed good reduction and nearly ideal screw position.

Clinical discussion: Anterior column plate and antegrade posterior column screw could provide joint stability and early mobilisation for displaced transverse acetabular fractures. However, determination of optimal entry point, direction and length for screw insertion is still technically demanding. The 3-D reconstruction images of hemipelvic specimen allowed us to identify the safe bone corridor, design a drill guide to put the proper guide pin and conduct preoperative trial. All those resulted in appropriate real screw fixation with reduction of soft tissue damage, X-ray exposure and time of operation.

Conclusion: The use of 3D-printed personalised guide for posterior column screw fixation is a promising alternative option for treatment of displaced transverse acetabular fracture where 3D-navigation system is not available.

1. Introduction and importance

Acetabular fractures often require experienced surgeons to treat, especially in the type of fractures involving both columns, such as transverse fractures, T-type fractures, anterior column with posterior hemitransverse fractures and two-column fractures. Although being classified as one of five elementary fractures [1], transverse acetabular fractures may lead to osteoarthritis and poor clinical outcome if not reduced anatomically [2–4]. Recently, Jang et al. [5] have identified risks factors for poor outcomes in surgically treating transverse acetabular fractures, including dome impaction, residual gaps of more than 3 mm and step of more than 1 mm. Therefore, anatomical reduction and stable fixation are essential requirements for avoiding post-traumatic arthritis in management of transverse acetabular fracture, especially in the juxtatectal and transtectal subtypes [3]. Various strategies for stabilising these types of fractures have been proposed. Some authors preferred open reduction and plate fixation for the anterior column and minimally invasive lag screw fixation for the posterior column under guidance of intraoperative fluoroscopy [6–8]. There were also reports [9,10] using 3D navigation system for percutaneous screw fixation of the acetabular and pelvic fractures. While the results from these reports of 3D navigation system were demonstrated to reduce the rate of screw malposition, the system is not widely available. In this report, we present an application of 3D-printed technology to customise

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an individual guide for minimally invasive screw fixation of the posterior column in a patient with displaced transverse acetabular fracture.

This case report has been reported in line with the SCARE 2020 criteria [11].

2. Case presentation

A 50-year-old female with no past medical history was admitted to our hospital due to motor vehicle accident. She was diagnosed with subarachnoid haemorrhage and right acetabular fracture. While she was receiving supplemental support as the conservative treatment of subarachnoid haemorrhage, her right acetabulum was planned to operate on. Initially, the right tibial traction was applied to facilitate later acetabular reduction. Her pelvic CT-scan showed that she had 62B1.2 type fracture according to AO/OTA classification [12] (Fig. 1).

The CT-scan DICOM data was exported to STL model using Invesalius (CTI, Brazil). The mirrored model of the right hemipelvis from the left-sided one was created and 3D-printed. The prototype was used as a template for pre-contouring 14-holes reconstruction plate. A drill guide for posterior column screw fixation was designed based on the 3D data of the right hemipelvis. This drill guide includes two parts; each part took specific anatomic landmarks for positioning (Fig. 2): iliac tubercle, template for pre-contouring 14-holes reconstruction plate. A drill guide was tested with the prototype (Fig. 2D).

The reconstruction images from CT-scan data illustrated juxtatectal type fracture of the right acetabulum. A) Anterior – posterior view; B) Intrapelvic view of the right acetabulum; C) Posterior – anterior view.

Precisely, the anatomical reduction of fragments is prerequisite to optimise precision of the drill guide as the virtually planned fixation. In this case, we used modified Stoppa approach for direct visualisation and reduction of two main fragments. As in a systematic review, Meena et al. [15] found that modified Stoppa approach had better reduction and lower complication rates with less operative time when compared to ilioinguinal approach.

Fig. 1. The reconstruction images from CT-scan data illustrated juxtatectal type fracture of the right acetabulum. A) Anterior – posterior view; B) Intrapelvic view of the right acetabulum; C) Posterior – anterior view.

3. Clinical discussion

Open reduction and internal fixation remain the gold-standard for treatment of displaced acetabular fractures [13]. Lag screw fixation has been proved to achieve inter-fragmentary compression, maintenance of reduction with good clinical outcome [14]. In our presented case, plate fixation of the anterior column combined with a lag screw fixation of the posterior column was planned. The lag screw placement in the posterior column of the acetabulum has a narrow corridor of safety due to its close vicinity to the hip joint, neurovascular and visceral structures. Therefore, the anatomical reduction of fragments is prerequisite to optimise precision of the drill guide as the virtually planned fixation. In this case, the anatomical reduction of fragments is prerequisite to optimise precision of the drill guide as the virtually planned fixation. In this case, we used modified Stoppa approach for direct visualisation and reduction of two main fragments. As in a systematic review, Meena et al. [15] found that modified Stoppa approach had better reduction and lower complication rates with less operative time when compared to ilioinguinal approach.

It is essential to preoperatively identify the safe corridor for screw placement because it would determine not only the screw entry point and its direction but also the screw size as well. Previous studies showed differences of reference points. Pierannunzii et al. [16] proposed the drill entry point is about 2.5 cm above the pelvic brim and 1 cm anterior to the coronal plane passing through the anterior aspect of the sacrum. The drill should point to the midpoint between the ischial spine and the posterior profile of the obturator foramen. In Stockel's study [14] with 51 cases of acetabular fractures, the stabilising screws for the posterior column were inserted from the inner aspect of the ilium towards the ischium under visual and X-ray control. Feng et al. [17] analysed the 3D pelvic data of fifty-nine Chinese human subjects and found that while the safe zone and the direction of antegrade lag screw fixation were determined, it was not easy to directly use the results intra-operatively. Because the range and standard deviation of the results are relatively large, it is recommended that individual preoperative planning be implemented for each patient.

In our design, the iliac tubercle (first part) together with the ASIS and AIIS (second part) were used as anatomical landmarks for positioning this drill guide template. Intraoperatively, when applying the first part through the lateral window, however, we found that this part fitted well with the iliac tubercle and there was no need to dissect more soft tissue to insert the second part. Chen et al. [18] introduced an adult universal guide template for the placement of posterior column lag screw, using the quadrilateral surface and iliac fossa as the anatomical landmarks for its placement. This template requires deeper soft tissue dissection and more technical demanding for the surgeon to hold the template before stabilising it by adjacent K-wires.

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The patient's postoperative CT-scan showed that the anatomical reduction was achieved, and the lag screw was in good position. However, there was a 3.75 mm medial deviation of the real 6.5 mm cannulated screw entry point when comparing to the planned one. It could be caused by the interference of residual soft tissue. Meesters et al. [19] conducted a cadaveric study with 3D-printed drill guides for 4.5 mm posterior column screw. He found that the deviation of its entry point is ranging from 2 mm to 5 mm. Chui et al. [9] reported the mean deviation of 1.91 mm with 3D-navigation system. The advantages of our method are to individualise plan of treatment in detail, reduce X-ray exposure while identifying screw entry point, its direction and result in less soft-tissue damage. The total blood loss and operative time were significantly reduced when comparing to the similar cases we treated previously with conventional methods using anatomical reference points to define the screw insertion and its trajectory. It may be a good alternative to conventional methods while there has been a widely unavailable of 3D-navigation system. And these results suggested that even after accurately positioning the drill guide, intraoperative fluoroscopic control is still needed to confirm the screw placement.

The method showed in this report is feasible for future clinical settings. However, it took us 4 days for preoperative planning, designing, and 3D-printing of all the needed models. Therefore, the available time should be considered from patient admission to surgery before this method could be widely applied.

4. Conclusion

The application of 3D-printed personalised drill guide for insertion of posterior column lag screw allows to simplify the complex traditional technique. It is a promising alternative option in the treatment of transverse acetabular fractures. However, it should be noted that intraoperative fluoroscopic control is still needed to confirm the screw position even when the accurate placement of the drill guide is achieved.

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Ethical approval

This report was conducted in accordance with the World Medical
Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Research registration

Research Registry was not required.

Guarantor

Associate Professor Hung Do Phuoc MD, PhD.

Provenance and peer review

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Fig. 5. A) The postoperative CT-scan slice illustrates the screw with two reduced fragments of the right acetabulum. B) By superimposing the preoperative and postoperative CT-scan data, we measured the real entry point and the planned one (the planned 2.0 mm K-wire was marked with red star). There was a 3.75 mm (2.75 mm as illustrated and 1.0 mm from the radius of the 2.0 mm K-wire) medial displacement of the real screw’s entry point. The green arrowhead and the blue arrow illustrated the drain tube and the reconstruction plate, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
CRediT authorship contribution statement

Hung Do Phuoc: conceptualising the plan for surgery, performing the surgery, writing the literature review for case report, reviewing the manuscript.

Huong Cao Ba: Assisting the surgery, designing the drill guide template.

Phu Nguyen Hoang: Designing the drill guide template, assisting the surgery, writing the draft for case report.

Declaration of competing interest

The authors declare no conflicts of interest in this work.

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