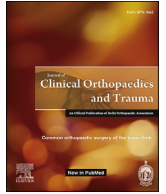




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3D printing in designing of anatomical posterior column plate

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ABSTRACT

Background: Acetabulum has a complex anatomy due to which anatomical acetabular plates are still under developmental phase. Although intra-operative contouring of reconstruction plate is done as a standard practice, it is associated with increased operative time and morbidity of patient. We have designed an acetabular plate for posterior fixation from experience of previous studies performed in our institute on acetabular fracture fixation which should be appropriate for most of the patient of Indian origin. Apart from avoiding intra-operative contouring of acetabular plates it also helps in preventing intra articular screw penetration.

Methods: We selected five consecutive patients with acetabular fracture needed to be operated from posterior approach and designed patient specific plate template from virtual surgical planning and 3D printing. These plate templates were then matched with our acetabular plate design and were used intra-operatively. Many parameters were assessed to evaluate accuracy of our plate design in those five patients.

Result: All the plate templates appear to match our designed plate and no intra-operative contouring was required with our plate design.

Conclusion: This was a pilot study and we need a large sample size to study accuracy of our acetabular plate design which might avoid intra-operative contouring, decreasing morbidity of patient and prevent wastage of resources in pre-operative planning and computer designing.

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1. Introduction

Anatomical peri-articular plates are now standard of care in most of the articular fractures. Anatomical plates for acetabular fractures are still under developmental phase. Intra-operative contouring of reconstruction plate is the standard practice.¹ Fixation of posterior column of acetabulum normally has two possibilities: Either a single or two plates. The positions of two plates are also constant; the anterior plate being adjacent to acetabular rim making a beginning from ischial tuberosity following the curve of acetabulum and ending in the supra-acetabular area. The standard fixation is by 2 screws each in

the ischial tuberosity and supra-acetabular area. The second plate runs adjacent to the greater sciatic notch and Sacro-iliac joint superiorly.

Only few studies have been done for development of posterior plate design for fixation of acetabular fractures.^{2–4} However, none of the studies came out with any conclusive plate design or any further direction on design development of acetabular plates for posterior fixation.

Over eight years of our published experience on acetabular fracture fixation has brought out few facts which have been the basis of the posterior anatomical plate design.^{5–8} We intend to share our initial experience with a new design of posterior column plate for acetabular fractures. The philosophy of this new design is an outcome of printing 3D templates of posterior fixation plates and evaluating these prototypes.

2. Methodology

It was an observational study which included consecutive five patients who came to our institute from January to March 2018 with acetabular fracture and required posterior fixation. Kocher-

Abbreviation: NCCT, Non-Contrast Computed Tomography; 3D, 3 Dimensional; DICOM, Digital Imaging and Communication in Medicine.

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langenbeck approach was used for posterior fixation. Written informed consent for the operative procedure and associated risks were taken from all the patients.

2.1. Concept development of plate design

Over last eight years, 180 cases of posterior fixation of acetabular fracture were done. All the patients were part of the ongoing research on acetabular fractures in the department.^{5–8} These patients were virtually planned and desired plate templates were 3D printed. Over the period of time it was observed that the plates had some constant features.

We observed that posterior column is invariably fixed with one 8–9 holed and one 7–8 holed 3.5 mm reconstruction plate. Also, posterior column plate has three curves in coronal and sagittal plane each. We have named them as ischial, acetabular and iliac curves (Fig. 1 a & b). Another important point is that usually the difference in the curve of plate for fixation in two different individuals will come in acetabular portion only. This difference in our experience has also been very insignificant since most of our patients were male patients of height 5 feet 5 inches to 5 feet 7 inches. This would correspond to an acetabular cup size of 50–54 mm diameter.

These 3D printed plate templates which were collected over the time period of eight years were manually evaluated by three independent observers (Figs. 2 and 3). All three observers came out

with the result that there is a fixed contour of a posterior column plates. Final design was generated from a plate template of one patient and five plates (3 for right and 2 for left side) were manufactured using the design.

These plates carried the same plate specifications of 3.5 mm reconstruction plates, so no in-vitro testing was done. An additional feature added was that there were no screw holes in the unsafe zone of the posterior column to avoid joint penetration.

Evaluation of the following parameters was done:-

- a) Pre-operative:- Matching of patient-specific plate template with our design.
- b) Intra-operative:-
 - I. Whether exposure to apply the plate was to be changed or standard one was used.
 - II. Whether the plate was positioned in anatomical area or needed to be deviated.
 - III. Requirement of intra-operative re-contouring.
- c) Post-operative:- Post operative reduction of fragments in CT scan according to MATTA and MERITT criteria.⁹

3. Observation and results

From January to march 2018 five consecutive patients with fracture acetabulum fixed with posterior approach were assessed and following data were recorded:-

- a) Pre-operative:- The contour of all the five patient specific templates matched our design.
- b) Intra-operative:-
 - I. Standard exposure was sufficient for application of our designed plate.
 - II. No deviation from anatomical area was required for positioning of our plate design.
 - III. No recontouring of our designed plate was required intra-operatively.
- c) Post-operative:- In all the patients, reduction assessed according to MATTA and MERITT criteria⁹ came out to be anatomical (Fig. 4 and Table 1).

4. Discussion

Intra-operative contouring of reconstruction plate is the standard method to match the plate contour to reduced acetabular fracture surface. However, this method has many drawbacks. Matching the contour of the reconstruction plates to the pelvis for acetabular fracture fixation is a challenging task due to the complex anatomy. It becomes even more difficult for young surgeons with limited experience of acetabular surgeries. It increases surgical duration and invasiveness.¹ Further, multiple bending attempts on the straight plate reduce the strength of the implant. Inaccurate contouring can also lead to malreduction while tightening the screws.⁴ All these reasons can lead to less favorable immediate outcome as well as long term function. One of the solutions to the above mentioned issues is pre-contoured plate. Many researchers have used diverse techniques to overcome the drawbacks of intra-operative contouring. Computer based virtual planning and rapid prototyping technology has been utilized in various ways to obtain pre-contoured plates for acetabular surgeries and yielded favorable outcomes.^{1,4,5,9–16} Kesu et al. developed a W-shaped angular plate for posterior column acetabular fracture fixation in cadavers but its efficacy in living human acetabular bone is yet to be established.² Meng xu et al. developed a custom made locking plate for acetabular fracture

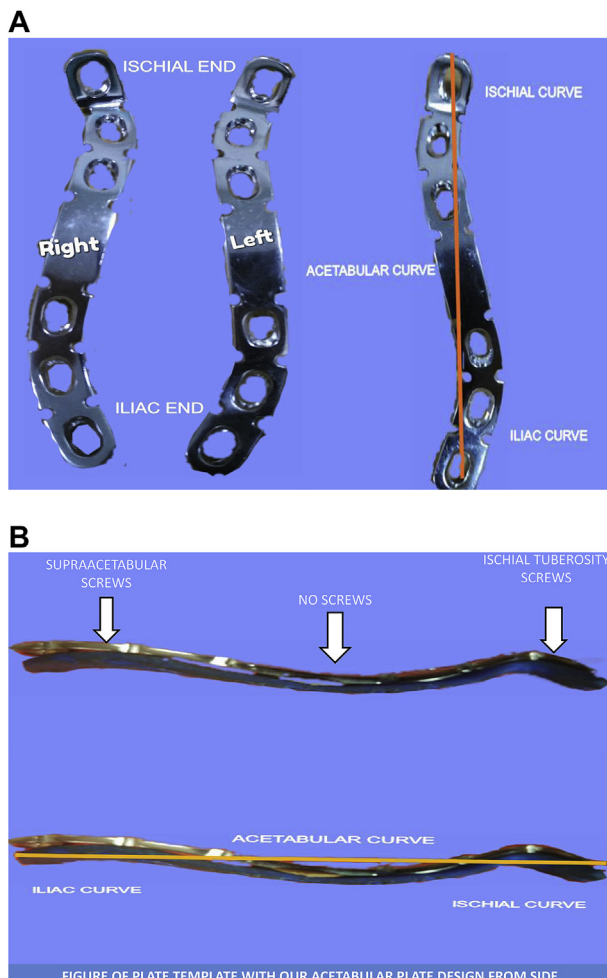


Fig. 1. A & b: Our designed plate from front and side along with plate template.

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