

# 3D models of fractured pelvic bones for analysis of symmetry and deviation

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## Abstract

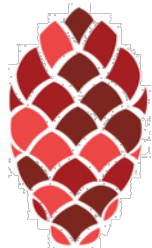
Pelvic fractures are a fairly common result of falls, automobile collisions, or other direct impact incidents. Most fractures are relatively mild and not life-threatening, but severe damage may have debilitating effects on the victim's health and quality of life. Pelvic breakage often requires surgery to alleviate, but procedures may be difficult given the complex anatomical structure of the area and the specific location of the fractures. This project aimed to make the planning stage easier for surgeons by analyzing left-right symmetry of the pelvis and using this property to create, in cases where one side is fractured and the other remains intact, 3D models of reconstructed pelvic fractures. Pelvic bone has been proven to be highly symmetrical. This method would provide surgeons with a clearer idea of how to best reassemble and otherwise correct fractures in the pelvis. First, various one-sided pelvic fractures from a batch of anonymized subjects obtained from the University of Alberta Hospital were digitized in medical imaging software. Data from six subjects in total was used in the collection of results. The digitized pelvises were then used to construct 3D models. The fractured pieces were aligned in best-fit with a mirrored intact side. Colour deviation maps, which differentiated between areas of high and low symmetry by measuring the degree of point deviance against a scale, were then generated. Deviance was generally more prevalent along the fracture lines. The predefined threshold considered a maximum of 2 mm of deviation as highly symmetrical. The average RMS value was found to be 1.65 mm and the average percentage of points within 2 mm of difference was 85.1%, indicating that the pelvic bones studied possessed a reasonably high degree of left-right symmetry. The results from this study suggest that this virtual reconstruction method is reliable for use in surgical planning for one-sided pelvic fractures. .

## Key words:

Pelvic bone, pelvic, fractures, 3D model, deviation, symmetry, geomagic, CT scans, 3D modelling, bone fractures, surgery

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## Introduction

- Pelvic bone fractures often result from accidents but surgery to recreate the original shape of the bone in certain areas, such as the acetabulum, is markedly difficult to achieve accurately.
- The pelvis has been proven to possess a reliable level of symmetry, allowing either side to serve as a reference for the other during surgery in cases where one side is fractured and one remains intact.
- The purpose of this study is to utilize the concept of symmetry in reconstructing fractured pelvises.

## Methods

- CT data was obtained from the UofA Hospital and anonymized before use.
- CT scans of pelvic bone fractures were digitized using MIMICS®.
- The digitized models were imported into Geomagic® Control.
- The intact side was mirrored and used to align the fractured pieces of the opposite side.
- Colour deviation graphs and reports were then generated.
- A deviation of less than 2 mm magnitude was considered symmetrical while a deviation greater than 2 mm was judged as not highly similar.

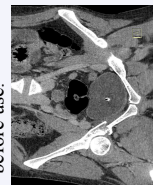


Fig. 1: The fracture on the right inferior pubic ramus is visible in this CT scan.

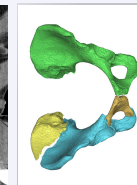


Fig. 3: Coloured masks are created for fractured segments in MIMICS®.



Fig. 2: Right-side fractures on both the iliac wing and the inferior pubic ramus can be viewed.

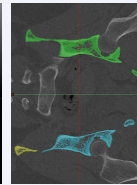


Fig. 4: The coloured masks can be seen from different views (front view example).

### Before Best Fit Alignment

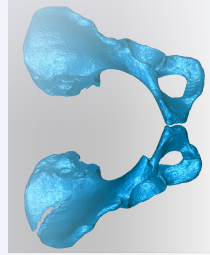


Fig. 5: The fractured pelvic bone is on the left from the viewer's perspective.

### After Best Fit Alignment

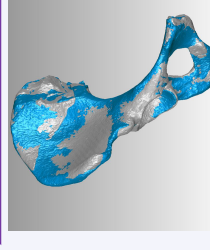


Fig. 6: The blue fractured bone and the mirrored grey intact side are superimposed.

### Aligned Fractures without Intact Side

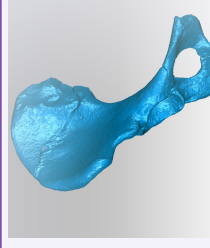


Fig. 7: The fractured bone is displayed alone.

### Colour Deviation Map

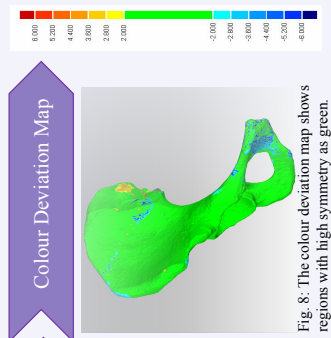


Fig. 8: The colour deviation map shows regions with high symmetry as green.

## Results

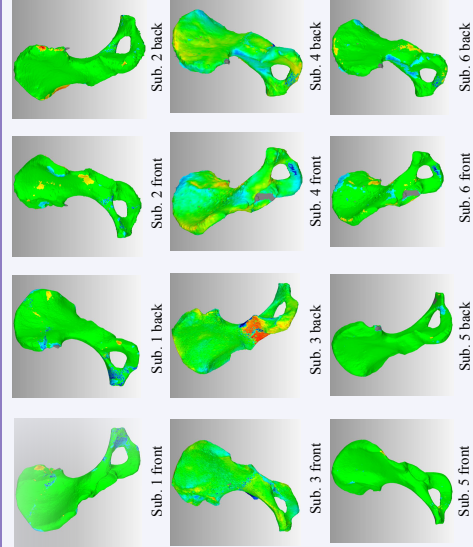


Fig. 9: Anterior and posterior views of the fractured pelvic bone in 6 different subjects in Geomagic®.

## Conclusions

- The average RMS value for the data was 1.65 mm. This is under 2 mm, the predefined threshold for symmetry used in our study.
- The average percentage of points with less than 2 mm of deviance was 85.1%. Combined with the average RMS value result, this shows that the pelvises studied possess a high degree of symmetry.
- These findings suggest that this method is reliable for virtually reconstructing pelvic fractures for surgical planning.

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