

# TRUE MAGNITUDE OF DISPLACEMENT IN PELVIC RING FRACTURES

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## INTRODUCTION

Accurate assessment of pelvic ring disruptions is an integral first step in the diagnosis and treatment of these potentially devastating injuries and is routinely obtained from initial plain radiographs or computer tomographic scans (Burgess et al., 1990). Treatment decisions are often predicated on the belief that certain degrees of injury severity can be inferred from the amount of displacement on plain radiographs and that once disrupted, the pelvic ring remains displaced (Tile et al., 1980). However, these static images, obtained post injury, cannot reveal the dynamic injury history and maximal fracture displacement. Therefore, estimation of injury severity and concomitant soft tissue injuries is largely confined to extrapolation of fracture displacement on an empirical basis. To gain better understanding of the correlation between maximal pelvic ring disruption and residual fracture displacement, we simulated distinct pelvic fractures in human cadaveric specimens and quantified the time-history of fracture displacement.

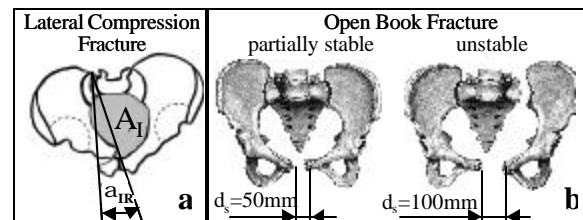
## METHODS

Two distinct pelvic ring fracture scenarios were modeled in a biomechanical study on 15 fresh frozen human cadaveric specimens. In eight specimens, monolateral lateral compression fractures were induced, and in seven further specimens, monolateral open book pelvic fractures were created.

### Lateral Compression Fracture Model:

Unilateral lateral compression fractures of the pelvis were created by means of a custom-built compression lever that allowed for controlled internal rotation of the hemipelvis (Fig. 1a). The femoral heads were replaced in the acetabula by the prosthetic heads of a lever device that applied a controlled lateral force through each acetabulum until defined and reproducible internal rotation of one hemipelvis occurred.

Open Book Fracture Model: Partially stable 'open book' pelvic fractures (symphysis diastasis=50 mm) were created by forced external rotation of each hemipelvis after symphysiotomy (Fig. 1b). These fractures were subsequently expanded into unstable pelvic fractures (symphysis diastasis=100 mm).



**Figure 1:** Pelvic fractures models: a) lateral compression fracture, characterized by  $A_f$  and  $\alpha_{IR}$  and b) partially stable and unstable open book fracture.

Outcome Parameters: The pelvis of each specimen was instrumented with an electromagnetic motion tracking system (pcBird, Ascension Technology, Burlington, VT). The resulting data stream allowed

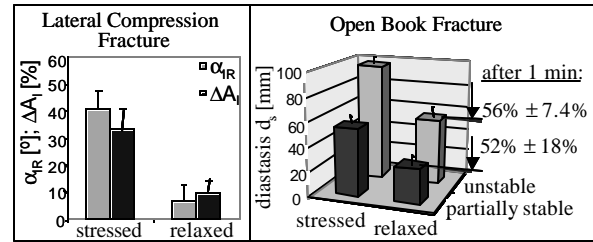
computation of the initial pelvic orientation and the relative rotation of the unstable hemipelvis, expressed in terms of internal / external rotation ( $\alpha_{IR}$ ,  $\alpha_{ER}$ ).

Measurements of pelvic deformity, as well as standard radiographs (AP, inlet, and outlet views) were taken of each specimen prior to injury, at the moment of maximal displacement, and 60 seconds after cessation of the deforming force. Utilizing numerical image analysis software, we furthermore computed the inlet area ( $A_I$ ) of the pelvis at each time point.

## RESULTS

Clinically relevant pelvic ring injuries were created in all 15 specimens. The lateral compression fracture model was characterized by a  $33 \pm 7.5\%$  decrease in  $A_I$  and by  $\alpha_{IR} = 41 \pm 6.8^\circ$  (Fig. 2a). After removal of the compressive load, the collapsed pelvic ring passively expanded to a remaining decrease in  $A_I$  of  $10.1 \pm 4.3\%$  and to  $\alpha_{IR} = 7.5 \pm 5.5^\circ$ . This represents a passive correction of the maximal rotational deformity of  $> 80\%$ .

For the ‘open book’ injury, maximal symphysis diastasis  $d_s$  was  $56.2 \pm 6.4$  mm (partially stable) and  $99.0 \pm 5.8$  mm (unstable) (Fig. 2b). The unstable open-book fracture was furthermore characterized by a  $33 \pm 10.7\%$  increase of the inlet area  $A_I$  and by  $\alpha_{ER} = 37 \pm 11.2^\circ$  external rotation of the unstable hemipelvis. 60 seconds after removal of the disruptive force, the symphysis diastasis  $d_s$  decreased to 52% (partially stable) and 56% (unstable) of its maximal value. For the unstable open book fracture, the expanded pelvic ring relaxed to a remaining  $A_I$  increase of  $25 \pm 2.1\%$  and  $\alpha_{ER} = 25 \pm 10.5^\circ$ .



**Figure 2:** Rotational deformity of pelvic ring at maximal disruption (stressed) and after passive relaxation (relaxed).

## DISCUSSION

This research demonstrates dramatically, that the degree of displacement seen on planar radiographs obtained post-injury represent only a portion of the maximal displacement at the time of injury. The displaced pelvis appears to retain residual elastic constraints, and therefore has an inherent tendency towards correction. This elastic re-coil effect was found more pronounced for lateral pelvic fractures as for open book type pelvic fractures. The complex pelvic anatomy, dependant on multiple ligamentous connections for its inherent stability, likely accounts for much of the observed elastic behavior. Albeit only two types of pelvic fractures have been modeled, these fracture models represent the two most common types of pelvic ring fractures. While, the type of injury pattern seemed to affect the amount of recoil that occurred, a significant passive correction of rotational pelvic deformity was observed in each fracture. This quantitative information on injury biomechanics of pelvic ring fractures is directly applicable to estimate injury severity in a clinical setting.

## REFERENCES

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## ACKNOWLEDGEMENT

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