LATERAL COMPRESSION FRACTURE OF THE PELVIS REPRESENTS A HETEROGENEOUS GROUP OF COMPLEX 3D PATTERNS OF DISPLACEMENT

INTRODUCTION:
Lateral compression (LC) fractures account for more than 50% of all pelvic injuries [1,2]. LC pelvic injuries constitute a diverse group of fracture-dislocations that occur after application of laterally directed forces to the pelvis. While clear clinical and radiologic criteria exist to direct the conservative and operative treatment of other types of pelvic injuries, no such criteria exist for the majority of LC fractures [3]. Anecdotally, some surgeons believe the majority of patients with LC fractures do well under conservative treatment. More recently, some orthopaedic trauma surgeons have advocated fixation (internal and/or external) of LC injuries to improve patient comfort and to allow for earlier mobilization. No criteria exist to quantify pelvic stability nor to define the amount of motion under load which is clinically significant. Likewise, quantitative radiologic criteria do not exist to represent pelvic stability or 3D displacement patterns. The objective of this work is to describe the patterns of injury of the pelvis in LC type fractures through quantitative 3D radiographic analysis. It is hypothesized that LC fractures represent a spectrum of injury with a complex combination of translational and rotational displacement patterns.

METHODS:
Using retrospective data, CT scans of 61 patients with unilateral LC pelvic fractures were identified. The scans were segmented to generate a 3D model of the pelvis (Amira, TGS, Berlin). To quantify displacement of the fractured hemic-pelvis, the spatial orientation of three distinct anatomical landmarks (anterior superior iliac spine, posterior superior iliac spine, ischial spine) on each side of the 3D hemipelvis were identified. This allowed the spatial orientation of each hemipelvis to be calculated using the fixed axis theorem [4]. The midsagittal reference plane defined global axes representing medial/lateral, superior/inferior, and anterior/posterior directions. Translational and rotational differences (along and about the reference axes) between the intact and fractured sides were compared to determine patterns of displacement (Figure 1). Ten unfractured pelvises were analyzed using interclass correlation coefficients (ICC) to assess inter and intra-observer reliability and to determine a threshold for normal anatomical differences. Error analysis was used to quantify the effect of landmark selection errors on the final comparison of displacement and rotational descriptions of the pelvic planes. Landmark selection was deemed accurate to within ±0.5cm. Randomly generated errors between −0.5cm and +0.5cm (following a Gaussian distribution) were added to the raw data for the entire data set. Final translational and rotational errors were defined as the difference between the original data set and the error modified set.

RESULTS:
Inter/intraobserver class correlation coefficients were high (ICC > 0.5) for x and y coordinates of the selected landmarks, and lower (ICC > 0.2) for the z coordinate. The error analysis yielded translational and rotational errors of ±0.27 cm and ±2.4° respectively. The average difference in rotation and translation between the 10 normal hemipelvises was 1.9° and 0.4 cm. Summing the range of analysis errors and normal anatomical variation values, thresholds were defined for which differences between fractured and unfractured sides of less than ±1 cm and ±1° were considered non-displaced.

Fractures initially clinically diagnosed as LC actually represent a spectrum of displacement patterns, ranging from a non-displaced hemipelvis to complex translational and rotational displacements. Fractures were grouped based on pattern of rotation and translation into 5 distinct groups (Table 1).

<table>
<thead>
<tr>
<th>Group</th>
<th>Pattern of displacement</th>
<th># patients</th>
<th>Details (# of patients in subgroups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-displaced</td>
<td>22 (36.6%)</td>
<td>Non-displaced</td>
</tr>
<tr>
<td>2</td>
<td>Single axis rotation</td>
<td>22 (36.6%)</td>
<td>Isolated UE (18) or V/V (6) rotation, (Translation possible)</td>
</tr>
<tr>
<td>3</td>
<td>Pure translation</td>
<td>8 (13.5%)</td>
<td>M/L Translation (2) IS Translation (3)</td>
</tr>
<tr>
<td>4</td>
<td>Dual axis rotation</td>
<td>2 (3.3%)</td>
<td>Combined UE and V/V rotations (M/L translation possible)</td>
</tr>
<tr>
<td>5</td>
<td>Extension</td>
<td>6 (10%)</td>
<td>Rotational involvement &amp; Extension</td>
</tr>
</tbody>
</table>

Table 1: Fracture grouping by displacement pattern.
Displacements: internal/external (I/E) and varus/valgus (V/V) rotations; medial/lateral (M/L) and inferior/superior (I/S) translations.

DISCUSSION:
Current classification systems sort pelvic fractures by the assumed direction of force applied to the pelvis combined with a qualitative assessment of stability. The present study has characterized LC fractures through the quantification of displacement patterns without any assumptions about the direction of force or stability. Our findings suggest classical LC fracture classifications may yield an inhomogeneous group of fractures. In our series more than one third of the cases (36.6%) were non-displaced (group 1). Isolated I/E rotation (group 2, single axis I/E or V/V) was seen in 26.6% of the patients with all, except one, experiencing internal rotation. This displacement pattern is consistent with a laterally applied force and the traditional classification of LC fractures. Varus displacement (group 2) corresponds to a pure laterally applied force to the greater trochanter, whereas valgus displacement may be due to an impact on the cephalad aspects of the ilium. The majority of the pure translation group (group 3) (13%) demonstrated M/L translations (8.3%), again a pattern consistent with a lateral force. Pure translation occurred along the inferior/superior axis in three cases (5%). By definition, LC fractures are vertically stable indicating that pure vertical translations should not be found in this cohort. These findings suggest that, using existing clinical classification techniques, these fractures may have been misdiagnosed as LC fractures, and rather represent type C fractures.

CONCLUSION:
Quantitative 3D radiologic analyses of pelvic displacement patterns demonstrate a complexity in LC fractures which may explain the variations seen in outcomes associated with this injury. Utilizing a single label of “lateral compression” alone cannot fully describe the characteristics of these fractures. Characterization of 3D displacement patterns from imaging data should ultimately aid clinicians in making better decisions as to the need for operative versus conservative treatment of lateral compression pelvic fractures.

REFERENCES:

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