The Novel Method Of External Fixation In Unstable Pelvic Ring Fracture

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Introduction: Unstable pelvic ring fractures are always associated with high rate of mortality due to excessive bleeding and involvement of surrounding organs. Early stabilization of the pelvic using an external fixation can be used to reduce the pelvic volume and consequently control the hemorrhage. External fixation is one of the most practical and has been widely used for early treatment in an emergency situation. This study is conducted to introduce a new method of fixation defined as lateral supra-acetabula fixation method (LSA / Half pins are applied at the location of superior to the acetabula with 30 degree tilt from horizontal plane / Figure 1).

The purpose of this study is to compare three external fixation methods for unstable pelvic ring structure. These three methods are high route fixation method (H / Half pins are applied posterior from the anterior superior iliac spine to the direction of the femoral head), low route fixation method (L / Half pins are applied at the anterior inferior iliac spine) and LSA. H and L are the most common used for the fixation. In addition, L is divided into two groups, which are L1 and L2. L1 is one half pin insertion at each side, L2 is two half pins insertion. Recent literature have suggested supra-acetabular as the excellent location for the placement of pins for external fixation. However, inadequate biomechanical stability for unstable pelvic fracture is still a considerable disadvantage. Newly proposed LSA comes into picture to address this inconvenience.

Methods: Four plastic pelvic models (SAWBONES, Pacific Research Laboratories) with fracture of type 61-C1.2 were employed. External fixator (Hoffmann II, Stryker Co.) was applied accordingly to each method. (Table 1) Vertical compression force was loaded axially in both standing and sitting position for all methods. The actuator was gradually moved along vertical direction until the breaking force where failure of the bone model was observed. Three repetition were made for each of the method for both position. The breaking force was defined as the maximum load the specimen can withstand at the point where sacroiliac (SI) joint failure of the bone model occurs. Meanwhile, failure condition was defined as 5 mm separation of the SI joint. The breaking force was measured for each test cycle and the average value for three cycles was calculated.

For standing position, bilateral femur models (SAWBONES) were employed. In case of sitting position, the boundary condition was to fix only bottom part of the ischial tuberosity. The fixing platform was constructed low-friction and horizontal axis rails. The force was applied to the specimen via a custom interface made of thermoplastic resin at the tip of the actuator. The interface was also made to fit the position of standing and sitting since the angle of contact area varies between each position.
Evaluation of SI joint separation distance was performed with three dimensional (3D) camera (Xbox Kinect, Microsoft). This device made accurate measurement realize for XYZ way. (Figure 2)

**Results:** The mean force of 5 mm separation of the SI joint and breaking force of SI joint failure was measured for both sitting and standing position. L2 was significantly higher than L1, H and LSA at the breaking force situation both standing and sitting position. LSA was the next to L2. In case of the mean force of 5mm separation of SI joint, LSA force was the highest among the four methods for sitting position. However there are no significantly differences between LSA and L2. L2 force was the highest, and LSA and L1 were almost same for standing position. H is low failure force for both standing and sitting position, and the situation of the mean force of 5mm separation and breaking force of SI joint. (Figure 3)

**Discussion:** The biomechanical study of unstable pelvic ring fracture using external fixation has been going for more than three decades. Various fixation methods test for mechanical and clinical situation. Through the result of these investigation, H and L became major fixation tools for easy and convenience technique.

The results of this study indicated that LSA was inferior to L2 about the breaking force and 5mm separation force of SI joint. However, LSA was superior to H and L1 which were employed in clinical situation. LSA may become one of the options of the primary care of unstable pelvic ring fracture. Supra-acetabular area, in which L and LSA half pin insert is strong and sufficiently thick bone structure. Number of half pin and diameter of half pin and rod are also related to fixation and stability of pelvis. Generally, there are some limitations in this study. The plastic pelvic models do not produce accurate result as comparable to human pelvis, because they ignore the soft tissues, which are ligaments, muscles and so on.

**Significance:** The newly fixation method LSA performed as well as the other methods H and L. LSA may become one of the options of the primary care of unstable pelvic ring fracture.
Figure 1

Figure 2

a: actuator
b: load cell
c: low-friction and horizontal axis rails
d: 3D camera
e: aluminum flame
Figure 3

5mm separation force

![Bar graphs showing 5mm separation force for sitting and standing positions with comparison indicators.]

Breaking force

![Bar graphs showing breaking force for sitting and standing positions with comparison indicators.]

* p < 0.05
<table>
<thead>
<tr>
<th>Table 1</th>
<th>High route (H)</th>
<th>Low route (L,H)</th>
<th>Low route 3 (L,3)</th>
<th>Lateral-extramedullary (L-E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of half pin (mm)</td>
<td>6-180</td>
<td>5-180</td>
<td>5-180</td>
<td>6-180</td>
</tr>
<tr>
<td>No. of half pins on each side</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Insertion position of half pin</td>
<td>Anterior inferior iliac spine (ASIS)</td>
<td>Anterior inferior iliac spine (ASIS)</td>
<td>Anterior inferior iliac spine (ASIS)</td>
<td>Anterior inferior iliac spine (ASIS)</td>
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<tr>
<td>Insertion angle of half pin</td>
<td>15° to horizontal plane</td>
<td>30° to horizontal plane</td>
<td>30° to horizontal plane</td>
<td>30° to horizontal plane</td>
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<tr>
<td>Insertion depth of half pin</td>
<td>50mm distal to bone or percutaneous</td>
<td>10mm</td>
<td>10mm</td>
<td>Perforated pin 20 mm</td>
</tr>
<tr>
<td>Position of connection</td>
<td>90 mm distal from bone</td>
<td>90 mm distal from bone</td>
<td>90 mm distal from bone</td>
<td>90 mm distal from bone</td>
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<tr>
<td>No. of connections</td>
<td>2 long, 1 small</td>
<td>2 small</td>
<td>2 middle</td>
<td>2 small, 9 small</td>
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<tr>
<td>No. of rods</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
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