Characteristics of Dysplastic Acetabulum in Neurogenic Hip Disease with Three-Dimensional Computer Evaluation

Marek Jóźwik, MD, PhD 1; Bartosz Musielak, MD 1; Michał Rychlik PhD 2, Po-Jung Brian Chen MD, PT 1,3

OBJECTIVES
Hip dysplasia is a common finding in cerebral palsy patients. The evaluation of hip morphology is mainly based on two-dimensional X-Ray and computed tomography (CT). However, the accuracy of using only two-dimensional images to claim the three-dimensional (3D) structure of hip is doubtful. More precise 3D image studies may help orthopedic surgeons understand comprehensively the true morphology of dysplastic acetabulum to make proper treatment decisions. This study presents the morphological differences between healthy and dysplastic acetabulum by using the reverse engineering technique to reconstruct detailed and precise pelvic models.

METHODS
Participants: Pelvic models of 13 cerebral palsy patients (GMFCS level IV or V) with uni- or bilateral neurogenic hip dislocation (16 dislocated hips) were analyzed retrospectively. CT examinations were done for acetabular osteotomy surgical planning.

Materials/Methods: This project developed a new universal method to determine the acetabular volume and orientation in both healthy and dysplastic acetabula. The DICOM format CT images were used to perform the 3D reconstruction of the pelvis. With the use of methods of reverse engineering and rapid prototyping (ScanIP, Rhinoceros), measurements based on the 3D reconstructions were carried. The base of sacrum was used as the reference plane during the orientation assessment. Acetabula were evaluated in frontal (inclination angle), horizontal (anteversion angle) and sagittal (tilt angle) orientations.

RESULTS
Children with Neurogenic Hip present completely reversed orientation of their acetabulum. Inclination angle is significantly higher (96.8º, whereas in healthy individuals 70.6º), while anteversion and tilt angles are reversed when comparing to mean values (in all neurogenic cases retroversion and posterior tilt, in healthy individuals 30.4º of anteversion and 31.4º of anterior tilt).

<table>
<thead>
<tr>
<th>No. of Hips</th>
<th>Tilt Angle</th>
<th>Inclination Angle</th>
<th>Anteversion Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy Hips</td>
<td>60</td>
<td>31.43°</td>
<td>70.59°</td>
</tr>
<tr>
<td>Neurogenic Hips</td>
<td>16</td>
<td>-97.23°</td>
<td>96.80°</td>
</tr>
<tr>
<td>p value</td>
<td>x</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

CONCLUSIONS
• The presented method of measurements is precise tool for assessment of 3D morphology of the acetabulum in not only neurogenic hip disease, but also in all pediatric hip pathologies.
• In children with GMFCS level IV and V, it is common to find completely reversed orientation of the acetabulum, what may be very challenging during reconstructive surgeries of this hip.

Corresponding author: Bartosz Jan Musielak, MD e-mail: bjmusielak@gmail.com