EVALUATION OF DYNAMIC INSTABILITY OF DYSPLASTIC HIP USING TRIAXIAL ACCELEROMETER

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INTRODUCTION
Numerous reports have implicated acetabular dysplasia as an etiologic factor in the development of osteoarthritis of the hip joint. Harris reported that symptoms of degenerative joint disease associated with acetabular dysplasia occur early in life, and that almost 50% of the patients with acetabular dysplasia in his series had their first reconstructive procedure before the age of 60 years. The reasons for degenerative changes and radiographically dysplastic hips are probably mechanical and related to increased contact stress with time. A certain over-pressure may correlate with long-term outcome. Sutherland et al. reported that instability is evident in these push-pull roentgenograms made during arthrography. Dysfunction of the hip secondary to dysplasia is a complex problem that includes excessive stresses on the cartilage, dynamic instability, labral tears, and muscular fatigue eventually leading to the degenerative osteoarthrosis if left uncorrected. Mechanical stress on dysplastic hip has been widely described, however, dynamic instability remains unclear. The purpose of this study was to investigate the dynamic instability of dysplastic hip using triaxial accelerometry.

MATERIALS AND METHODS
We evaluated 48 hips of 24 patients, 2 men and 22 women with a mean age of 35.3 years (range:14 to 55), who had unilateral dysplastic hip (Center-edge angle < 25 degree). Patients who had any functional, neurological, or morphological disorders affecting gait were not included in this study. The status of hip arthritis due to acetabular dysplasia were grade 0 or 1 by Tönnis classification. All bilateral knees and ankles were disease-free with normal radiological findings. All contralateral hips were disease-free with normal radiological findings (Center-edge angle ≥ 25degree). All 24 patients met these criteria. The study was previously approved by the institutional review board. Each participating patient signed the approved informed consent form before any study procedures. An accelerometer (Kistler, Switzerland) was used to record triaxial acceleration while walking (X-axis: supero-inferior, Y-axis: antero-posterior, Z-axis: medio-lateral). A sensor was attached to the skin above the bilateral greater trochanters with adhesive tape. To exclude involvement of pelvic movement, the sensor was also attached to the anterior superior iliac spine as reference. In attempt to minimize skin motion artifacts commonly produced when accelerometer are attached to the skin, we preloaded the accelerometer against the skin as described elsewhere[1,2]. Moreover to minimize skin motion artifacts, patients whose body mass index were more than 25 kg/m² were also excluded. Time of heel strike was confirmed visually and by a perpendicular acceleration. Signal from a sensor was recorded on a computer as digital data, through the analog/digital board. The sampling rate was 10 kHz. After each subject completed three repetitions of the ambulatory exercises for each hip, data were collected while the subject walked for about 10 gait cycles on a flat level walkway at his or her own shoes. Care was taken to ensure that subjects had sufficient practice to maintain an even gait. The peak values of middle three gait cycles were used and averaged for data analysis. The composition of acceleration was formulized as \( |\mathbf{a}| = \sqrt{(ax^2 + ay^2 + az^2)} \) to evaluate the hip instability. The composition of acceleration was compared between dysplastic hips and contralateral normal hips. The correlation of composition of acceleration with radiographic data (Center-edge angle, Acetabular-roof angle, Sharp angle, Acetabular-head index) was also examined. Student’s t-test and Pearson correlation coefficient were used for statistical analyses with the significance level at p < 0.05.

RESULTS
In all cases, the direction of acceleration in response to walking was only detected at superior(X-axis), posterior(Y-axis), and lateral(Z-axis) aspects. Each magnitude of triaxial acceleration was shown in Table 1. The composition of acceleration in ipsilateral dysplastic hips was significantly larger than that of contralateral normal hips (p < 0.0001).

Table 1: Each magnitude of triaxial acceleration.
P<0.0001 for the difference in composition of acceleration between dysplastic hip and contralateral normal hip.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Dysplastic hip (mean ±S.D.)</th>
<th>Contralateral normal hip (mean ±S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-axis (m/s²)</td>
<td>1.032±0.438</td>
<td>0.711±0.160</td>
</tr>
<tr>
<td>Y-axis (m/s²)</td>
<td>0.645±0.432</td>
<td>0.557±0.243</td>
</tr>
<tr>
<td>Z-axis (m/s²)</td>
<td>1.590±0.448</td>
<td>1.178±0.192</td>
</tr>
<tr>
<td>Composition of acceleration (m/s²)</td>
<td>2.110±0.479</td>
<td>1.529±0.161</td>
</tr>
</tbody>
</table>

Fig. 1 The correlation between composition of acceleration and Center-edge angle (r = -0.732)

DISCUSSION
The major factors causing hip arthritis secondary to dysplasia are mechanical stress and dynamic instability. Although mechanical stress on dysplastic hip has been widely investigated, dynamic instability remains unclear. Our previous study demonstrated that the accelerometry was useful to quantitatively analyse the instability of knee joint [1,2]. In this study, we investigated dynamic instability of dysplastic hip using triaxial accelerometry. We found the directions of acceleration within hip joint in response to walking were superior, posterior and lateral. The composition of acceleration was significantly different between dysplastic hip and contralateral normal hip, which elucidated the dynamic instability of dysplastic hip. Moreover, there was a significant correlation between the composition of acceleration and radiographic data. Among them, Center-edge angle showed the strongest correlation (r = -0.72 ) . This suggested that the hip instability is increased in proportion to degree of dysplasia. In conclusion, the triaxial accelerometry is helpful in evaluation of dynamic instability of dysplasia hip. Center-edge angle can be considered as an indicator of hip instability.

REFERENCES

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