INTRODUCTION

Acetabular labral tears have been described as a biomechanical cause of hip pain in active adult patients. There have been various reports about location of acetabular labral tears, but the biomechanical properties of labrum remain unclear. We therefore investigated the tensile material properties of the human acetabular labrum in the posterior-superior quadrant. Furthermore, we hypothesized that several characteristics such as age and the severity of the acetabular dysplasia might influence the tensile properties of the labrum, and such differences in the tensile properties of the labrum might influence the occurrence of acetabular labral tears in developmental dysplasia of the hip (DDH). The purpose of the present study was thus to investigate differences in the tensile material properties of the human acetabular labrum in the anterior-superior and posterior-inferior quadrants and then compare these differences with those in the posterior-superior quadrant.

MATERIALS AND METHODS

Specimens Preparation

We obtained the labra of 32 pairs in 32 patients and could ultimately use the data from 19 pairs (59%) of the specimens. The donors of these 19 pairs of specimens comprised 18 female patients and 1 male patient. The average age of the 19 patients at the time of surgery was 55.4 years (range, 41-74 years). All hips underwent hip surgery between 2003 and 2004. The preoperative diagnoses were secondary osteoarthritis due to DDH in all patients.

The labrum and acetabulum were then divided into four quadrants (Anterior-Superior, Posterior-Superior, Posterior-Inferior and Anterior Inferior). During surgery, the anterior-superior and posterior-inferior quadrants of the labrum were sectioned with a scalpel along the bony margin of the acetabular rim. All patients gave their informed consent for the use of their excised labra before surgery.

The specimens for testing were cut from each sample. To slice the labrum, we used the Dermatome and obtained specimens measuring 1.0 mm in thickness. The sliced specimens were cut into rectangle shapes measuring 4 mm in width and 20 mm in length using custom-designed equipment with two parallel fixed razors. The long axis of the specimen was oriented parallel to the circumferential direction of the labrum. Two marks were made at locations 5 mm from either edge of the specimen to designate a gauge length of 10 mm and a holding area of 5 mm. These marks could also allow for the monitoring of any slippage. The measurements of thickness and width were performed by a single author (T.K.) using a digital caliper with an accuracy of ±0.02 mm and employing an optical microscope at threefold magnification. The width and thickness of the specimens were measured in at least three locations to obtain the mean specimen width and thickness. The cross-sectional area was calculated as the product of the mean specimen width and the mean specimen thickness.

Tensile tests

Tensile tests were performed by means of a uniaxial tension testing apparatus. The specimen was mounted with a slight degree of slack on the clamps and then it was stretched to failure at a constant rate of 10 mm/min. The displacement between the clamps was simultaneously measured by the means of a High Accuracy Laser Displacement Sensor. Data indicating slippage in the clamps were excluded from the study.

Data Analysis

Stress was defined as the force divided by the initial cross-sectional area. We monitored the load to the specimen and displacement of the lower clamp simultaneously on a load-displacement chart. The strain was defined as the displacement that occurred after the beginning of the stretching of the specimen divided by the original length. A stress-strain curve was constructed based on these calculated data for each sample. The near-linear portion was used to determine the tensile (Young’s) modulus.

The CE angle and Sharp angle were measured on preoperative radiographs. All radiological measurements were performed three times in order to obtain the mean value.

RESULTS

The mean tensile stress at failure for the anterior-superior labrum and posterior-inferior labrum was each 4.0±1.6 MPa (range, 1.4-6.6 MPa) and 4.9±2.0 MPa (range, 2.2-9.3 MPa). The mean strain at failure for anterior-superior labrum and posterior-inferior labrum was each 34.3±33.5% (range, 16.1-167.8%) and 21.3±4.5% (range, 13.7-32.0%). The mean tensile (Young’s) modulus of the anterior-superior labrum and the posterior-inferior labrum was each 36.1±16.6 MPa (range, 11.4-64.0 MPa) and 50.9±26.2 MPa (range, 16.7-120.0 MPa). No significant differences in the mean tensile stress or strain at failure according to location were determined from the obtained data. However, significant differences were seen in the tensile modulus according to location from the obtained data (Table 1). No significant correlations with the CE angle, Sharp angle were found for the tensile stress, strain at failure, or the tensile modulus in the posterior-inferior labrum. No significant correlations with age were found for tensile stress, strain at failure, or tensile modulus in the posterior-inferior labrum. However, a negative significant correlation with age was found for the tensile stress (p=0.003) and tensile modulus (p=0.026) in the anterior-superior labrum.

Table 1: Tensile properties of the labrum* (n=19)

<table>
<thead>
<tr>
<th>Location of Specimen</th>
<th>Mean Stress at Failure (MPa)</th>
<th>Mean Strain at Failure (%)</th>
<th>Tensile Modulus (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant. Superior</td>
<td>4.02±1.6</td>
<td>34.3±33.5</td>
<td>36.1±16.6</td>
</tr>
<tr>
<td>Post. Inferior</td>
<td>4.91±2.0</td>
<td>21.3±4.5</td>
<td>50.9±26.2</td>
</tr>
</tbody>
</table>

DISCUSSION

In the current study, the mean tensile stress at failure for the anterior-superior labrum and the posterior-inferior labrum was 4.0±1.6 MPa and 4.9±2.0 MPa respectively, in the DDH group. It was about one half of that compared to that of the posterior-superior labrum. The mean tensile (Young’s) modulus of the anterior-superior labrum and the posterior-inferior labrum was 36.1±16.6 MPa and 50.9±26.2 MPa respectively, in the DDH group. In anterior-superior labrum, the mean tensile (Young’s) modulus was about one half of that in comparison to the posterior-superior labrum. Furthermore, a negative significant correlation with age was found for the tensile stress and tensile modulus in the anterior-superior labrum. Labrum tears associated with acetabular dysplasia have been described by Klau et al. (J Bone Joint Surg 73B, 423-429, 1991). They described that the lesions of labrum tear tended to be located in the anterior-superior quadrant of the acetabular rim. The results obtained in the current study thus supported their results. That is to say, our results suggest that degeneration of the fibers of the anterior-superior labrum with age may influence labrum tears in DDH.

REFERENCE


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