Fibrous Cartilage Formation in the Acetabular Fossa after Periacetabular Osteotomy: Evaluation of the Related Factors and Clinical Outcomes

Satohiro ISHII, Koichi KINOSHITA, Tetsuro ISHIMATSU, Shunsuke AKIHO, Takuaki YAMAMOTO

Department of Orthopaedic Surgery, Faculty of Medicine, Fukuoka University

Abstract

Background: We performed second-look arthroscopy at approximately 1 year after periacetabular osteotomy (PAO) to evaluate fibrous cartilage formation in the acetabular fossa, and to explore the related factors such as the hip morphological features associated with such fibrous cartilage formation.

Methods: We performed PAO combined with hip arthroscopy in 64 patients (63 women, 1 man; mean age, 38.3 years at the time of primary operation) who underwent second-look arthroscopy and were included in this study. Patients with a Perthes disease were excluded. Patients were divided into two groups based on the presence or absence of fibrous cartilage formation (formation group, 37 hips; non-formation group, 27 hips). The formation group and non-formation group were compared for age, body mass index (BMI), period between primary operation and second-look arthroscopy, Harris hip score (HHS), and radiographic parameters, including the lateral center-edge (CE) angle, acetabular roof obliquity (ARO), vertical-center-anterior (VCA) angle, and depth of the acetabular fossa (DAF).

Results: We found that patients in the formation group had superior postoperative HHS to patients in the non-formation group ($P<0.05$). DAF was significantly higher in the non-formation group than in the formation group ($P<0.05$). There was no significant difference between the two groups in terms of age ($P=0.40$), BMI ($P=0.45$), lateral CE angle ($P=0.62$), ARO ($P=0.35$), or VCA angle ($P=0.26$) at the time of primary PAO as well as at the time of second-look arthroscopy.

Conclusion: Patients who showed fibrous cartilage formation in the acetabular fossa had a better HHS than those without fibrous cartilage formation.

Key words: Second-look arthroscopy, Periacetabular osteotomy, Developmental dysplasia of the hip, Acetabular fossa, Fibrous cartilage formation

Introduction

Periacetabular osteotomy (PAO) is one of surgical treatment options for patients with symptomatic acetabular dysplasia. The survival rate for these patients at the 10-year follow-up is reported to be about 84% to 90% with arthroplasty as the endpoint. PAO reportedly reduces the stress on the hip caused by a significant increase in the weight-bearing surface of the hip joint. A previous study of a rabbit model indicated that chondrocytes have been activated in the early postoperative stage in response to load stress. Similarly, in humans, adjusting this weight-bearing surface tends to result in fibrous cartilage formation in the acetabular fossa and they reported the fibrous cartilage formation is good sign to express the remodeling of the hip joint. However, few reports have investigated the acetabular fossa by hip arthroscopy at 1 year after PAO, and the incidence and potential pathological consequences of this fibrous cartilage formation have never been examined. The present study aimed to evaluate fibrous cartilage formation in the acetabular fossa after
PAO, and to explore the potential factors for such fibrous cartilage formation.

Patients and Methods

This retrospective study was approved by our institutional review board (approval number: 16-108).

From September 2011 to September 2015, PAOs were performed at our institution in patients who presented with symptomatic acetabular dysplasia of the hips. We performed PAO combined with hip arthroscopy in 114 patients. Two patients with a Perthes disease were excluded. Sixty-four (56%) of 112 patients underwent second-look arthroscopy at a mean of 15 months (range, 11 to 27 months) after primary operation; these patients were included in this study. No patient had any other orthopedic disorders, such as skeletal dysplasia or neuromuscular disease.

Cartilaginous damage was assessed according to the modified Outerbridge classification system: grade 1, normal cartilage; grade 2, superficial fibrillation, softening, or both; grade 3, fragmentation and deep fissuring; and grade 4, erosion down to the subchondral bone.

Nine of 64 patients underwent osteochondroplasty at the same time as PAO. Labral tears were not treated at the time of primary operation.

Data Collection

Preoperative, intraoperative, and postoperative findings were recorded. We also examined the clinical features, radiological and arthroscopic findings. Age, body mass index (BMI), the period between primary operation and second-look arthroscopy (days), and Harris hip score (HHS) which is an indicator of clinical outcome, were assessed. Radiographic parameters, including the lateral center-edge (CE) angle, acetabular roof obliquity (ARO), and vertical-center-anterior (VCA) angle, were evaluated on anteroposterior pelvic radiographs. All pelvic computed tomography (CT) scans were performed 1 month before PAO. We used a 64-channel multidetector CT system (Aquilion TSX-101A/HA; Toshiba Medical Systems Co.), and the scan protocol had a slice distance of 0.5 mm from the anterior superior iliac spines to below the knee. All images were digitally acquired using the picture archiving and communication system.

On CT scans, the depth of the acetabular fossa (DAF) was measured using the supine functional pelvic plane as a reference. First, we confirmed the acetabular roof loaded part (sourcil) along the coronal plane. Second, we confirmed the CT slice of the inner margin of the sourcil along the axial plane. Third, we measured DAF using perpendicular lines from the line linking the front and back of the acetabular fossa to the deepest part of the acetabular fossa (Figure 1a, b).

We observed the acetabular fossa during second-look arthroscopy and performed palpation with a probe at second-look. Fibrous cartilage formation was assessed as present when (1) the tissue was a different color from that of the original acetabular cartilage; (2) the tissue had formed more than 2 mm from the acetabular fossa; and (3) the tissue was softer than the acetabular cartilage by palpation with a probe.

All operations were performed by the same operator (K.K.). Measurements of all radiographic parameters, and histogenetic evaluations of the acetabular fossa were performed by two investigators (S.I. and S.A.).

At the time of second-look arthroscopy, fibrous cartilage formation was observed in the acetabular fossa in patients in the formation group, whereas it was absent in patients in the acetabular fossa (non-formation group). This study was performed by dividing the patients into these two groups to evaluate the difference in the hip morphologic features.

Histopathology

Hematoxylin and eosin-stained image of tissue was obtained from the acetabular fossa during second-look arthroscopy. We collected the chondroid tissues from the first patient and the second patient among the patients of the formation group, and submitted to pathology.

Statistical Analysis

The unpaired t-test was used to compare two groups, with the significance level set at $P < 0.05$. Statistical analyses were performed using SPSS version 20.0 software (IBM Corp.).

Source of Funding

No external funding was received for this study.

Results

The 64 patients comprised 63 women and 1 man, with a mean age of 38.3 years (range, 16 to 64 years) at the time of primary operation. The mean BMI at the time of primary operation was $22.1 \pm 3.8 \text{kg/m}^2$ (range, 15.6 to 34.1 kg/m$^2$).
Figure 1. Computed tomography (CT) scans of the left hip showing the depth of the acetabular fossa (DAF).
a. The CT slice matching with the step of the acetabular roof in the coronal plane.
b. The enlarged image in the axial plane. DAF (red arrow) was measured using perpendicular lines from the line linking the front and back of the acetabular fossa (yellow line) to the deepest part of the acetabular fossa.

The interobserver intraclass correlation coefficient (ICC) were 0.948–0.962 for radiographic parameters. The intraobserver ICC were 0.942–0.957 for CT parameter. The coefficients for intra- and inter-observer correlations indicated good reliability.

At the time of the primary operation, cartilaginous damage was found on the acetabular side in 36 hips (grade 1, 18 hips; grade 2, 10 hips; grade 3, 8 hips; grade 4, 0 hips) and on the femoral side in 18 hips (grade 1, 13 hips; grade 2, 6 hips; grade 3, 4 hips; grade 4, 0 hips). Some patients showed the formation of chondroid tissue in the acetabular fossa. The histopathological examination revealed this to be fibrous cartilage (Figure 2).

At the time of second-look arthroscopy, fibrous cartilage formation was observed in 37 hips (formation group) (Figure 3a, b) and absent in 27 hips (non-formation group) (Figure 4a, b).

We found that patients in the formation group had a
superior postoperative HHS to those in the non-formation group \( (P < 0.05) \). The pain score for HHS was significantly better in the formation group than in the non-formation group \( (P < 0.05) \). DAF was significantly higher in non-formation group than in the formation group \( (P < 0.05) \).

There was no significant difference between the two groups in terms of age \( (P = 0.40) \), BMI \( (P = 0.45) \), lateral CE angle \( (P = 0.62) \), ARO \( (P = 0.35) \), or VCA angle \( (P = 0.26) \) during PAO and at the time of second-look arthroscopy (Table 1).

**Discussion**

Joint remodeling is a biological reaction caused by a change in the balance of the joint mechanics in response to changes in intraarticular load stress \(^{7,10,13}\). Treating symptomatic acetabular dysplasia with PAO changes the distribution of the load stress on the acetabulum and medializes the femoral head. In turn, however, these biomechanical and anatomical changes can cause an increase in stress to the medial side of the acetabular roof \(^{14,15}\). Indeed, previous studies have found that enlargement of the weight-bearing area is beneficial to the long-term outcome of this procedure \(^{10,11}\).
In light of the findings of others, we hypothesized that redistribution of the load after PAO would encourage regeneration of the degenerative cartilage and cartilaginous metaplasia within the acetabular fossa. We found a significant difference in post-HHS (particularly the pain score) and the DAF between the two groups, suggesting that cartilage regeneration may be associated with the shape of the acetabular fossa (particularly the depth) rather than the degree of developmental dysplasia of the hip. There was no significant difference between the groups in terms of age, BMI, period between primary operation and second-look arthroscopy, and other radiographic parameters. In the fibrous cartilage formation group, redistribution of the load was thought to be carried out in the region that includes the acetabular fossa. There is an individual difference in the shape of the acetabulum. Pun et al. clearly indicated that dysplastic hips are globally deficient in both cartilage and fossa dimensions on MRI and CT scans. We believe that patients with hip dysplasia who also have a deep fossa may not see improvement in postoperative pain as quickly as others who have a shallower fossa. We acknowledge that there could be other factors contributing to our postoperative results after PAO. However, this result indicates that fibrous cartilage formation is a contributing factor to better postoperative results.

If indeed the degree of postoperative pain from PAO is influenced by fibrous cartilage of the acetabular fossa, surgeons may need to induce microfracturing in the lateral margin of the acetabular fossa in patients to promote fibrous cartilage formation.

The present study has several limitations. First, this study had a small sample size, with few participants in each group. However, this number of patients was sufficient to conduct a preliminary investigation, such as the present study and other former works. Second, we performed pathological examinations only in some of the patients who were allocated to the formation group. This is due to the possibility that sampling of the fibrous cartilage may adversely affect the patients, and thus, we could not perform pathological examination in all patients. Third, we measured the DAF but were unable to measure the dimension of the acetabular fossa. This dimension would provide a better assessment of the outcome.

In conclusion, after performing second-look arthroscopy following PAO, patients with postoperative fibrous cartilage formation in the acetabular fossa had a better clinical outcome than those without this formation.

Table 1. Demographic Features, Pain, and Radiographic Parameters for the Formation and the Non-formation Groups

<table>
<thead>
<tr>
<th>Demographic Features</th>
<th>Formation group (n = 37)</th>
<th>Non-formation group (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>39.1 ± 12.0</td>
<td>36.6 ± 12.0</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>22.3 ± 3.4</td>
<td>21.1 ± 3.6</td>
</tr>
<tr>
<td>Period between primary surgery and second-look arthroscopy (days)</td>
<td>444 ± 94</td>
<td>465 ± 134</td>
</tr>
<tr>
<td>DAF</td>
<td>6.67 ± 1.41</td>
<td>8.61 ± 1.46*</td>
</tr>
<tr>
<td>Change in lateral CE angle</td>
<td>18.4 ± 6.7</td>
<td>17.0 ± 7.4</td>
</tr>
<tr>
<td>Change in ARO</td>
<td>17.2 ± 5.6</td>
<td>15.5 ± 6.1</td>
</tr>
<tr>
<td>Change in VCA angle</td>
<td>17.4 ± 8.0</td>
<td>14.5 ± 9.6</td>
</tr>
</tbody>
</table>


*indicates a significant difference between two groups.
References


(平成 29.8.28 受付，平成 29.10.2 受理)

「The authors declare no conflict of interest.」