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Rotational acetabular osteotomies: a rabbit model

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Abstract We investigated the morphological changes in the articular cartilage after rotational acetabular osteotomy in 16 adolescent rabbits. Radiological and histological studies were conducted at 12 and 24 weeks postoperatively. The radiological evaluations at 12 and 24 weeks showed significantly increased femoral head coverage. No cases of osteonecrosis of the acetabulum or femoral head nor narrowing of the joint space was observed. The histology of the articular cartilage at 12 weeks postoperatively showed cloning and hypercellularity of the chondrocytes in the medial portion of the acetabular roof, indicating remodelling due to the increased weight-bearing stress caused by the osteotomy. The histology at 24 weeks postoperatively showed less cloning of the chondrocytes, indicating that the remodelling process in the articular cartilage induced by this procedure was almost complete at 24 weeks. Degeneration of the articular cartilage was not observed within 24 weeks of the operation.

Introduction

The postoperative results of pericapsular osteotomies to transfer the position of the acetabulum en bloc in degenerative arthritis secondary to dysplastic hip, such as Steel's triple osteotomy [8], Wagner's spherical acetabular osteotomy [9], Eppright's dial osteotomy [2] and Tagawa's rotational acetabular osteotomy [7], are theoretically superior to those of earlier acetabuloplasties and pelvic osteotomies such as Chiari's osteotomy. This operative procedure has become more common in recent years. We have performed Tagawa's rotational acetabular osteotomy on approximately 100 patients with dysplastic hips from 1987 with excellent results. However, histological changes of the articular cartilage due to the osteotomy remain to be

elucidated clinically. The purpose of this study was to examine the histological changes in the rotated acetabulum using a rabbit model.

Materials and methods

The procedure was performed on the left side of immature Japanese white rabbits at about 10 weeks of age. Each animal weighed approximately 2000 g and was anaesthetized with an intravenous administration of pentobarbital (60 mg/kg). Osteotomies of the ilium, ischium and pubis were made and the acetabulum was rotated laterally with the ilium-ischium axis as the centre of rotation and then fixed with Kirschner wires (Fig. 1). Following the procedure, the rabbits were not immobilized and were allowed to move freely in the cage. The right side was used as control. Six rabbits were killed 12 weeks postoperatively (group A) and 10 rabbits 24 weeks postoperatively (group B) for radiological and histological evaluation of the articular cartilage with haematoxylin-eosin and safranin O staining. Mankin's histological-histochemical grading [3] was used to score the changes. Tissue sections were obtained in a plane almost perpendicular to the rotation axis of the acetabulum. Sections were taken of the weight-bearing dome of the acetabular roof and of the femoral head, divided into medial, central and lateral thirds. In group B, immunohistological staining [5] was performed using three types of monoclonal antibodies for proteoglycan (anti-

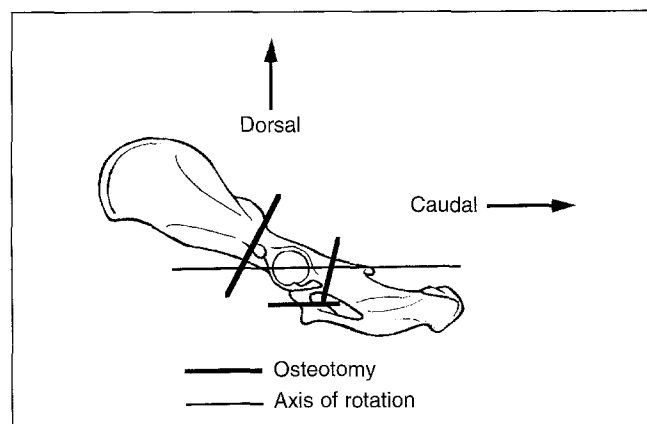


Fig. 1 Rotational acetabular osteotomy in rabbit model. This schematic diagram illustrates the pelvic cuts and the axis of rotation used in the acetabular rotational osteotomy

Table 1 Radiological evaluation

	Group A (n = 6)		Group B (n = 10)	
	Control	Operated side	Control	Operated side
Center-edge angel (deg)	7.0 ± 2.1	34 ± 5.2*	6.0 ± 1.9	29 ± 3.3*
Angle of roof obliquity (deg)	19 ± 4.4	-6.0 ± 3.9*	17 ± 4.5	-3.6 ± 3.5*

* $P < 0.01$ (control versus operated side, Mann-Whitney U-test)

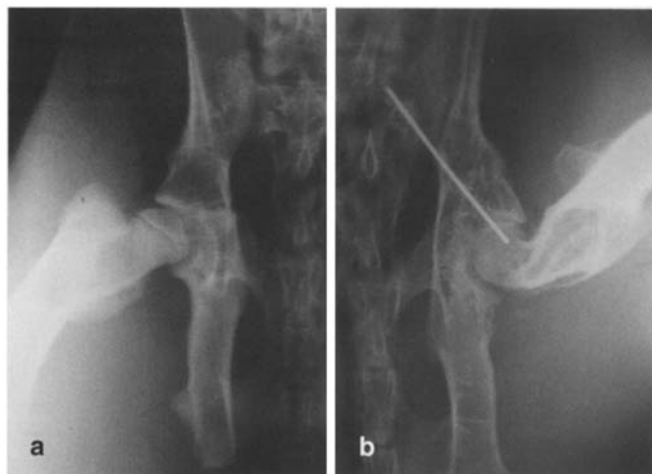


Fig. 2 **a** Radiograph of the control side at 24 weeks; **b** radiograph of the operated side at 24 weeks

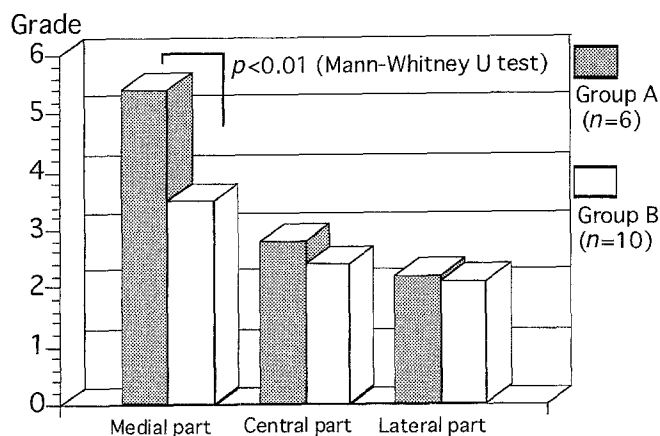


Fig. 3 Histological evaluation of acetabular cartilage (mean grades at three parts). Note the significant change in the grade of the medial articular cartilage between 12 and 24 weeks postoperatively (by Mann-Whitney U-test)

4 sulphated chondroitin proteoglycan: 2-B-6, anti-6 sulphated chondroitin proteoglycan: 3-B-3 and anti-dermatan sulphate proteoglycan: 6-B-6; Seikagaku, Tokyo, Japan).

The protocol of this experimental study was approved by the Ethics Committee of Hiroshima University, and the principles of laboratory animal care [1] were observed.

Results

Radiological evaluation

A significant increase in the center-edge angle and a significant decrease in the angle of roof obliquity, as de-

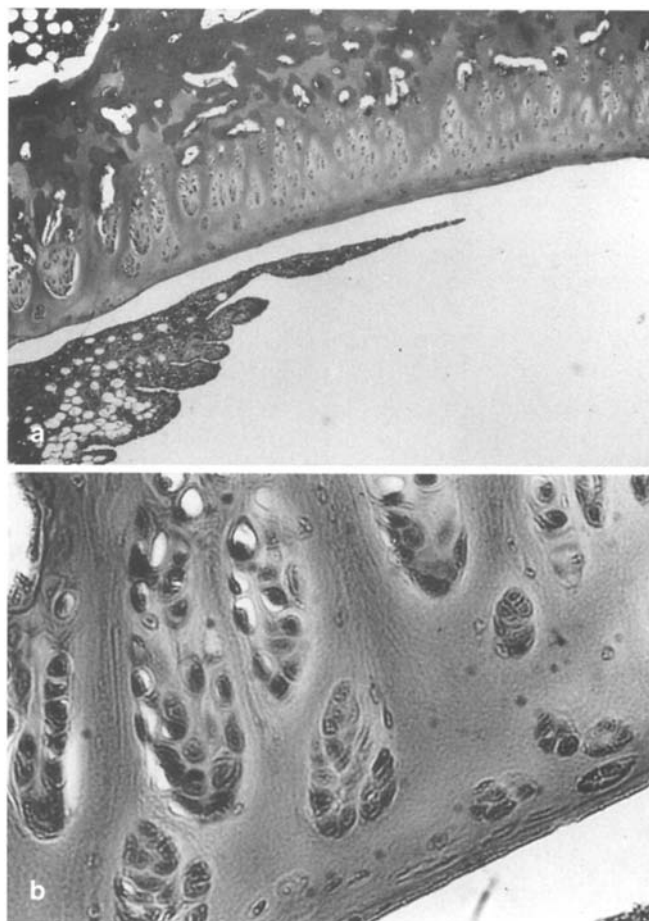


Fig. 4 **a** Photomicrograph of the medial third of the acetabulum. At 12 weeks postoperatively, several chondrocyte clones are demonstrated in the intermediate or deep zone under a relatively normal surface. Safranin O, × 40. **b** Enlarged view of **a**. Safranin O, × 200

scribed by Massie and Howorth [4], were observed in both groups on the operated side when compared with the intact side. A remarkable increase in femoral head coverage was also observed (Table 1). No cases of osteonecrosis of the acetabulum or femoral head, narrowing of the joint space or subchondral bone formation in the acetabular fossa were observed in either group (Fig. 2).

Histological evaluation

In group A, the histological grade of the medial articular cartilage was higher than that of the central or lateral thirds in all the operated hips (Fig. 3). Hypercellularity or cloning of chondrocytes in the intermediate or deep zone was observed at the most medial articular cartilage of the

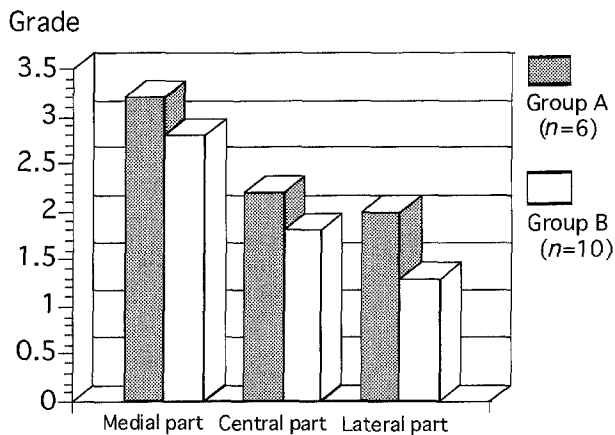


Fig. 5 Histological evaluation of femoral head cartilage (mean grades at three parts). No significant changes were noted in the femoral head articular cartilage between 12 and 24 weeks postoperatively

acetabular roof in all cases (Fig. 4). Although a slight proliferation of fibrous tissue was observed in the acetabular fossa, there was no transformation into fibrocartilage. The grading score was high in the medial third of the joint in group B, similar to group A, but there was no hypercellularity of the chondrocytes, and the histological changes were reduced. In the femoral head, the articular histological grade was the highest in the medial third of the joint in both groups but was lower than on the acetabular side (Fig. 5).

On the control side of both groups, a high amount of staining by safranin O was observed in the central part of the acetabular roof and femoral head.

Immunohistological staining in group B was positive for monoclonal antibodies 3-B-3 and 2-B-6 in the acetabulum and femoral head cartilage. No difference was observed between the control side and the operated side. Staining with 6-B-6, demonstrating degenerated proteoglycan, was not observed (data not shown).

Discussion

The medial part of the acetabular roof in a normal rabbit hip is assumed to be a secondary weight-bearing area because of the low amount of staining by safranin O. This medial part changed from a secondary weight-bearing area to a main weight-bearing area following osteotomy. Our histological results support a role of this procedure in remodelling in the early postoperative period of the medial articular cartilage secondary to increased stress after rotational osteotomy.

Mitchell et al. [5] have classified the clones of chondrocytes in degenerative arthritis of the hip into synthetic and destructive forms. The chondrocytes observed in the medial part of the acetabular roof of our early postoperative group were considered to represent the synthetic clones as classified by Mitchell et al. In view of degree of staining of the cartilage matrix and the degree of cartilage degeneration in the late postoperative group, it is assumed that desired remodelling of the articular cartilage due to increased weight-bearing stress was achieved by this type of osteotomy.

Clinically, radiological joint remodelling has been observed to depend on the degree of dysplasia of the hip and may reflect articular cartilage remodelling. In humans with low-grade dysplasia, the joint is maintained immediately after the operative procedure, and radiological remodelling is not observed. However, in patients with high-grade dysplasia, subchondral bone formation is observed from the medial acetabular roof to the acetabular fossa [6]. Because normal rabbits were used in the present experiment, changes in the position of the acetabulum were comparatively small. It is possible that the histological changes were insufficient to induce radiological remodelling. The changes in the present experiment reflect the histological findings following rotational acetabular osteotomy for low-grade dysplasia of the hip.

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