

# Inverted Acetabular Labrum: An Analysis of Tissue Embedment in Hip Joint in 15 Patients with Developmental Dysplasia of the Hip

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## INTRODUCTION

The acetabular labrum is a triangular fibrocartilaginous structure that forms a horseshoe-shaped attachment to the acetabular rim, which connects the acetabulum to the underlying transverse acetabular ligament [Figure 1a].<sup>[1]</sup> Up to 90% of symptomatic patients with developmental dysplasia of the hip (DDH) are found to combine with lesions of acetabular labrum.<sup>[2]</sup> The most common presentations of the acetabular labrum lesions are hypertrophy, laceration, and/or cyst formation.<sup>[3,4]</sup> Nevertheless, a unique hip joint condition is observed recently in several symptomatic DDH patients [Figure 1b]. A layer of abnormal disk-shaped soft tissue embedded in the acetabulum. The outer layer was connected to the acetabular labrum, whereas the inner layer could be lifted and separated from the acetabular cartilage by surgical probe.

Ross *et al.*<sup>[3]</sup> suggested that gradually increased shear stress at the acetabular margin was due to anterolateral migration of the femoral head in dysplastic hips. The continuous effect of this chronic outward shear stress could lead to hypertrophy of the acetabular labrum, and secondary damage to the acetabular cartilage connected to the labrum. Meanwhile, the labrum-cartilage complex is always integrate. Ganz *et al.*<sup>[5]</sup> proposed that cam deformity at the junction of the femoral head and neck in some DDH patients could result in impingement on the rim of the acetabulum during hip flexion. Shering caused by impingement led to an inward delaminating injury of the acetabular cartilage. This mechanism would also cause the acetabular cartilage delaminated from the subchondral bone, while the labrum

was still attached to the torn cartilage. However, it remains unclear whether tissue damage is primarily caused by acetabular cartilage tears or inverted acetabular labrum.

Therefore, this study aimed to assess whether abnormal tissue embedded in the hip joint is avulsed acetabular cartilage, inverted acetabular labrum, or other types of tissues such as aberrant ligamentum teres, we harvested the disk-like abnormal tissue from the hip joint during surgery and performed histological staining to investigate its property.

## METHODS

### Patients

Fifteen DDH patients, who were hospitalized in Department of Orthopedics, the First Affiliated Hospital of the Chinese PLA General Hospital from June 2013 to December 2014, were included in this study. The tissue embedments in the hip joint of all patients were detected by magnetic resonance imaging. The findings were confirmed by hip joint incision during surgery. One male and 14 females (average age: 23 years; range: 15–30 years) were included in the study. Nine left hip joints and six right hip joints were involved.

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In addition to the 15 young adult cases, five cases with avascular necrosis of the femoral head were also studied as normal controls (including three males and two females; average age: 51 years; range: 45–61 years).

### Source of specimen and specimen preparation

The hip surgeries were performed on 15 DDH patients. Seven patients were treated by anterior hip dislocation. The other eight patients were treated by surgical hip dislocation. Embedded tissues in the acetabulum were harvested and labeled for further histological study.

Normal acetabular labrum in five patients with avascular necrosis of the femoral head was observed during total hip arthroplasty. The normal acetabular labrum, acetabular cartilage, and ligamentum teres of the femur were harvested and labeled for further histological studies.

The following steps were taken to prepare the specimens for study: (1) fixation: Specimens collected from the above patients were immersed in 10% formalin; (2) dehydration and clearing: Tissue samples were dehydrated gradually by graded ethanol (low to high concentration) and cleared in xylene; (3) paraffin embedding: Samples were embedded in paraffin and cooled to solidified blocks; (4) sectioning: The tissues were sectioned into 5–8  $\mu\text{m}$  sections and placed onto glass slides to dry in a 45°C incubator; and (5) dewaxing: Paraffin was removed by xylene, rehydrated in gradient ethanol (high to low concentration), and washed in distilled water.

### Hematoxylin and eosin staining

Hematoxylin and eosin (HE) staining was used to enhance the differentiation of various parts and structures in tissues to allow better tissue examination. Hematoxylin is a basic dye that stains the nuclei and ribosomes of basophilic cells blue and purple. Meanwhile, eosin is an acidic dye that stains the cytoplasm of eosinophilic cells red or pink. Stained slides were observed under the microscope and images of the tissue sections were recorded.

## RESULTS

### Raw observation of embedded tissues in hip joint

While the disk-shaped tissue was connected with the acetabular labrum to the acetabular rim, the labrum cartilage complex was normal and showed no direct connection with

the articular cartilage in acetabulum. These tissues were identified in various sites of the acetabulum, including the anterosuperior quadrant in two cases, both anterosuperior and anteroinferior quadrants in five cases, anterosuperior and posterosuperior quadrants in seven cases, and posterosuperior quadrant in one case. Thinning, roughness, darkness, and degeneration of the acetabular cartilage at the corresponding sites of tissue embedment were observed in all 15 patients after tissue excision [black arrow in Figure 1c].

### Observation of stained embedded tissues from hip joint under the microscope

The matrix for each of the 15 tissue samples was rich in parallel or staggered collagen fiber bundles (pink). Small numbers of round hyaline cartilage cells (nuclei stained blue) were distributed among collagen fiber bundles in the cartilage lacuna as single cells or isogenous groups. All characteristics were consistent with stained structures of fibrous cartilage [Figure 2a].

### Observation of stained normal acetabular labrum under the microscope

The matrix, stained color, shape of the cells, and shape of fibers from acetabular labrum samples in five normal cases appeared no pathologically differences from stained embedded tissues [Figure 2b].

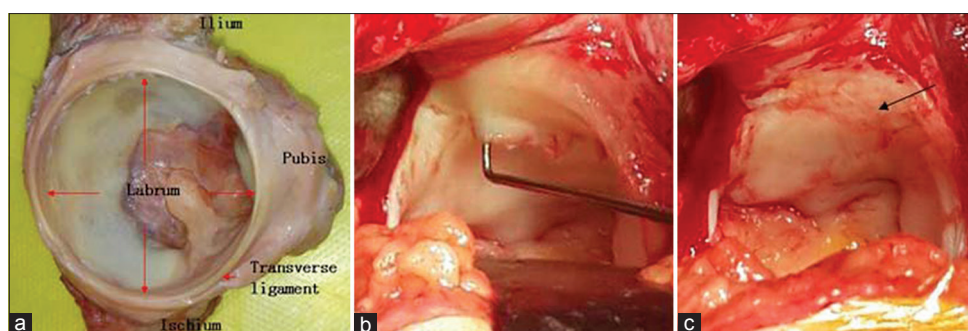
### Observation of stained acetabular cartilage under the microscope

The matrix of acetabular cartilage samples demonstrated numerous round hyaline cartilage cells (nuclei stained blue) in the cartilage lacuna as single cells or isogenous groups [Figure 2c].

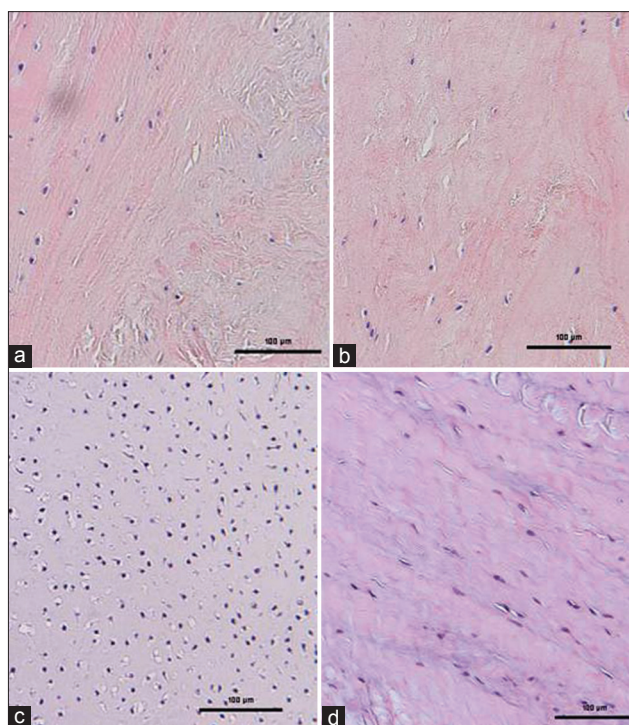
### Observation of stained ligamentum teres of femur under the microscope

The matrix of acetabular cartilage samples was filled with regularly or irregularly oriented collagenous fibers (pink), whereby some demonstrated scattered spindle-shaped fibroblasts (nuclei stained blue). There was no cartilage lacuna around fibroblasts that could be distinguished from chondrocytes. These characteristics were consistent with stained structures of fibrous connective tissues [Figure 2d].

HE staining demonstrated that embedded tissue structures from hip joints of 15 DDH patients were the same as normal



**Figure 1:** Appearance of normal acetabular labrum (a) and abnormal acetabulum with embedded tissues (b). The appearance of acetabulum after embedded tissues excised (c). The black arrow shows the acetabular cartilage which was abraded by the embedded tissue.



**Figure 2:** Embedded tissues from hip joint (a) and normal acetabular labrum under (b) under the microscope. Acetabular cartilage (c) and ligamentum teres of femur (d) under the microscope. Scale bar = 100 µm (Hematoxylin and eosin staining).

acetabular labrum while being consistent with stained fibrous cartilage structures. However, this tissue was different from acetabular hyaline cartilage and ligamentum teres of the femur since acetabular cartilage is made up of hyaline cartilage cells, whereas the ligamentum teres of the femur is comprised of fibrous connective tissues. These findings demonstrated that embedded tissues we identified in hip joints of symptomatic DDH patients were inverted acetabular labrum rather than torn acetabular cartilage or aberrant ligamentum teres of femur.

Thinning, roughness, darkness, and degeneration of the acetabular cartilage were observed at sites of tissue embedment in all 15 patients after excision of tissue from hip joints.

## DISCUSSION

In a recent multicenter and large-scale study, Sankar *et al.*<sup>[6]</sup> summarized the morphological characteristics of acetabular labrum in 942 symptomatic DDH patients (972 hips). In 553 hips, the morphology of the labrum was categorized as hypertrophic, normal, hypoplastic, and ossified. Among those 553 hips, 355 hips demonstrated labral tears. The majority of labral damages in these cases were degeneration (52.3%), delamination (38.7%), full-thickness tear (7.2%), and ossification (0.6%) according to the Beck classification. Moreover, Haene *et al.*<sup>[7]</sup> studied 128 radiographs of arthroscopically-diagnosed acetabular labral tears, and found that 59 (46.1%) cases could be classified as DDH. Among these 59 cases, 27 (45.8%) could be described as the radial

flap type, 13 (22.0%) longitudinal peripheral, 14 (23.7%) radial fibrillated, and 5 (8.4%) unclassified, using the classification described by Lage *et al.*<sup>[8]</sup>

To date, no studies have reported the observation of disk-shaped abnormal soft tissue in symptomatic DDH patients. It always located between the acetabulum and the femoral head and connected to the labrum. Ross *et al.*<sup>[3]</sup> hypothesized that one type of injury in DDH involved a partial dislocation injury of the acetabular cartilage while the labrum cartilage complex still remained intact. Ganz *et al.*<sup>[5]</sup> suggested that cam impingement may cause tearing of the acetabular cartilage from the subchondral bone at the anterosuperior acetabular region without affecting the labrum, while the torn cartilage remains connected with the labrum.

The present study suggested that abnormal disk-shaped tissue, which was found overlying the surface of the acetabulum and connected with the labrum during surgery, were inverted acetabular labrum rather than torn acetabular cartilage or other tissues (e.g., aberrant ligamentum teres of the femur). We demonstrated that the labrum-cartilage complex remained intact, thereby excluding the possibility that the disk-shaped tissue was the result of inner tearing of the complex. This study showed a novel type of intra-articular lesion, as characterized by inverted acetabular labrum, in symptomatic DDH patients.

In a recent prospective study, Fukui *et al.*<sup>[9]</sup> examined nine patients with rapidly destructive hip osteoarthritis (OA) and found that the anterosuperior portion of the acetabular labrum had inverted into the articular space in each patient, which was accompanied by numerous articular cartilage fragments on the surface in each case. Moreover, subchondral insufficiency fractures of the femoral head was observed under the inverted labra in eight of nine patients, suggesting that the inverted acetabular labrum may be involved in the rapid narrowing of the joint space associated with subchondral insufficiency fractures in rapidly destructive hip OA. Nevertheless, radiographic hip scans of all nine patients did not show any adverse changes in hip joint development.

While performing surgery on eight patients with idiopathic degenerative arthritis of the hip, it was found that the labrum was located between the femoral head and the acetabulum in each patient. Although no patient had a history or current radiographic evidence for DDH or hip dislocation, following exposure of the acetabulum during surgery, the labrum was found to penetrate into the joint overlying the acetabular rim. After excising the inverted labrum, a crescent-shaped surface could be observed at the corresponding sites in the acetabulum as well as in the areas above the femur head. Histological results of the inverted labrum demonstrated that the tissues were fibrous cartilage, which suggested that the inverted acetabular labrum was the cause of the degenerative arthritis. Although this study also found a pistol grip-like deformity in the femoral neck, it remained unclear whether this abnormality is associated with the inverted acetabulum labrum.



Similarly, other studies have demonstrated that thinning, roughness, darkness, and early cartilage degeneration occurred at corresponding areas in the acetabular cartilage after excising the inverted labrum from all 15 patients. These indicated that the inverted acetabular labrum, as a foreign intra-articular structure, was wearing down the acetabular cartilage during hip movement, and thereby accelerated the degeneration of dysplastic hip.

Embryological studies on the hips of 11 fetuses aged from 8 weeks to full term by Cashin *et al.*<sup>[10]</sup> demonstrated that the anterior acetabular cartilage was covered by a hat-shaped anterior margin of the labrum cartilage complex, while the intra-articular projection of the labrum into the joint resulted in the formation of a crypt between the acetabular cartilage surface and the labrum. However, the posterior labrum was directly attached to the acetabular cartilage in the absence of an intra-articular projection. Therefore, the study suggested that the anterior intra-articular projection of the labrum may be a normal type of structural variation. Moreover, an animal study demonstrated that inverted labrum could affect the development of the acetabulum and occurrence of acetabular dysplasia by causing damages to the metaphyseal cartilage at the acetabular rim. As a result, the acetabulum lost its contact with the femoral head, leading to femoral head subluxation.

These data suggested that the inverted acetabular labrum was caused by incorrect fitting between the femoral head and the acetabulum in the dysplastic hip. As a result, the labrum was pushed into the femoral head-acetabulum space during femoral head movement, while gradually becoming hyperplastic and hypertrophic. Although filling of the intra-articular space by the inverted labrum provides stabilization in the early period, the inverted labrum could eventually wear down the cartilage at the surface of the hip joint, inducing hip OA.

To the best of our knowledge, this study has identified a new type of hip joint pathology in symptomatic DDH patients. This unique hip joint pathology was characterized by the presence of abnormal disk-shaped soft tissue that overlaid the acetabulum and connected to the labrum. Our histological study suggested that this tissue was inverted acetabular labrum. This study observed that cartilage wearing and degeneration occurred in the corresponding attachment sites of the inverted labrum in the acetabulum

of patients, suggesting that inversion of the acetabular labrum was an adverse pathological change of the hip joint, leading to accelerated occurrence of hip OA. Thus, we suggested that it is necessary to excise any identified inverted labrum when correcting skeletal deformity of the hip.

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### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Crawford MJ, Dy CJ, Alexander JW, Thompson M, Schroder SJ, Vega CE, *et al.* The 2007 Frank Stinchfield Award. The biomechanics of the hip labrum and the stability of the hip. *Clin Orthop Relat Res* 2007;465:16-22. doi: 10.1097/BLO.0b013e31815b181f.
2. Wenger DE, Kendall KR, Miner MR, Trousdale RT. Acetabular labral tears rarely occur in the absence of bony abnormalities. *Clin Orthop Relat Res* 2004;(426):145-50. doi:10.1097/01.blo.0000136903.01368.20.
3. Ross JR, Zaltz I, Nepple JJ, Schoenecker PL, Clohisy JC. Arthroscopic disease classification and interventions as an adjunct in the treatment of acetabular dysplasia. *Am J Sports Med* 2011;39 Suppl:72S-8S. doi: 10.1177/0363546511412320.
4. Gupta A, Chandrasekaran S, Redmond JM, Hammarstedt JE, Cramer TL, Liu Y, *et al.* Does labral size correlate with degree of acetabular dysplasia? *Orthop J Sports Med* 2015;3:2325967115572573. doi: 10.1177/2325967115572573.
5. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock KA. Femoroacetabular impingement: A cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003;(417):112-20. doi: 10.1097/01.blo.0000096804.78689.c2.
6. Sankar WN, Beaulé PE, Clohisy JC, Kim YJ, Millis MB, Peters CL, *et al.* Labral morphologic characteristics in patients with symptomatic acetabular dysplasia. *Am J Sports Med* 2015;43:2152-6. doi: 10.1177/0363546515591262.
7. Haene RA, Bradley M, Villar RN. Hip dysplasia and the torn acetabular labrum: An inexact relationship. *J Bone Joint Surg Br* 2007;89:1289-92. doi: 10.1302/0301-620X.89B10.17319.
8. Lage LA, Patel JV, Villar RN. The acetabular labral tear: An arthroscopic classification. *Arthroscopy* 1996;12:269-72. doi: 10.1016/S0749-8063(96)90057-2.
9. Fukui K, Kaneuji A, Fukushima M, Matsumoto T. Inversion of the acetabular labrum triggers rapidly destructive osteoarthritis of the hip: Representative case report and proposed etiology. *J Arthroplasty* 2014;29:2468-72. doi: 10.1016/j.arth.2014.06.017.
10. Cashin M, Uthoff H, O'Neill M, Beaulé PE. Embryology of the acetabular labral-chondral complex. *J Bone Joint Surg Br* 2008;90:1019-24. doi: 10.1302/0301-620X.90B8.20161.