

The limbus in developmental dysplasia of the hip

An obstacle to reduction and its images changed by the femoral head position

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Abstract

This study aimed to describe the shape of the limbus arthroscopically and via arthrogram and magnetic resonance imaging (MRI), and to determine whether it prevents concentric reduction of the femoral head in developmental dysplasia of the hip (DDH).

Twelve patients (mean age, 10.2 months; range, 3–31 months) who underwent arthroscopic-assisted reduction for DDH were retrospectively reviewed. Limbus shapes were captured on arthrogram before reduction, after closed reduction, and after arthroscopic-assisted reduction and categorized according to the Miyake classification.

On arthrogram, the superior limbus was blocked in 2 hips, inverted in 2, intermediate in 5, and everted in 3 after attempted closed reduction. After arthroscopic-assisted reduction, the limbus was everted in 7 hips and normal in 5. On arthroscopy, in all cases, the limbus appeared as a whitish, cartilage-like ring with a variably blunted edge before reduction, without inversion or eversion. On postoperative MRI, 10 of 12 superior limbi showed hypertrophy or globular compression by the femoral head with intermediate or mixed MRI signal intensities and blunted edges. The remaining 2 hips had hypertrophied superior limbi with sharp edges. On transverse plane MRI, the posterior limbus of all hips showed sharp margins with low MRI signal intensity. Residual subluxation was observed in 7 of the 12 hips with interposition of the anteroinferior limbus.

The appearance of the limbus varied according to the femoral head position, and it was neither inverted nor everted. Interposed anteroinferior limbi with residual subluxation suggest impeded concentric reduction in DDH.

Abbreviations: DDH = developmental dysplasia of the hip, MRI = magnetic resonance imaging.

Keywords: arthrogram, arthroscopy, developmental dysplasia of the hip, limbus

1. Introduction

The fibrocartilaginous acetabular labrum is an important structure in the hip that serves many functions, including

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improving joint surface congruity, containing the femoral head, and providing stability to the hip by deepening the acetabular cavity.^[1,2] In patients with developmental dysplasia of the hip (DDH), the labrum becomes a pathological structure, referred to as a limbus, which is hypertrophied and surrounded by fibrous tissue.^[3] Previous studies have stated that the limbus can invert or evert, acting as a potential impediment to the concentric reduction of a dislocated dysplastic hip.^[3,4]

The limbus in DDH has been described using various terms based on autopsy, arthrography, magnetic resonance imaging (MRI), and surgical reduction findings. Ponseti^[4] reported everted labrum with a co-existing acetabular cartilage ridge in 3 hips and inverted labrum covering the ridge formed by a bulge of acetabular cartilage in another 3 hips among 6 infants at autopsy who had unilateral dysplasia of the hip shortly after birth. Leveuf et al^[5] also reported that the limbus could be everted or inverted, potentially hindering the reduction of the femoral head. He also indicated that cases of inverted limbi are very rare and are typically only seen in extremely severe teratologic dislocations. However, other authors contended that an infolded limbus is the most common cause of impeded reduction and that an inverted limbus was found in all cases of open reduction.^[6] Forlin et al^[7] described 8 different limbus shape patterns representing progressive obstruction to the femoral head, which was proposed as an important prognostic factor in the treatment of DDH. Some authors have recommended resecting the limbus to achieve concentric reduction.^[9] However, preservation of the acetabular labrum is recommended for normal acetabular development and prevention of degenerative arthritis.^[1,10]

Some authors have reported that the labrum was always positioned on top of the femoral head and never inverted.^[11,12]

Recently, Eberhardt et al^[13] also reported that an inverted labrum was not found during arthroscopic reduction procedures and that the limbus does not act as an obstacle to reduction. Given the conflicting data, this study sought to comprehensively ascertain the shape of the limbus as observed on arthroscopy and associated arthrogram and magnetic resonance images and to determine whether the limbus prevents concentric reduction of the femoral head in DDH.

2. Materials and methods

2.1. Subjects

The study was approved by the institutional review board of our hospital. Between July 2008 and April 2016, 12 hips in 12 children (10 girls, 9 first babies, and 3 breech position babies; mean age at the time of arthroscopic-assisted reduction, 10.2 months [range, 3–31 months]; mean postoperative follow-up, 3.7 years [range, 1.3–8.0 years]) were retrospectively reviewed.

2.2. Intraoperative arthrogram

Arthrogram was performed at the following 3 time points: prior to attempting reduction, in the neutral position; during the closed reduction attempt, in the flexion and abduction position; and immediately after arthroscopic-assisted reduction. The shape of the limbus on arthrogram was observed in the anteroposterior view and classified according to the Miyake classification.^[14] The Miyake classification defines various shapes of the labrum as follows: “everted,” with a blunted and turned-out appearance; “intermediate,” with a blunted and infolded shape causing a minimal block to reduction; “inverted,” which is infolded and interposed between the femoral head and the acetabulum; “blockaded,” which prevents the entrance of dye into the true acetabulum and has an ill-defined shape; and “impossible,” which completely obstructs reduction. The shape of the limbus was evaluated using a picture archiving and communication system (Infiniti PACS; Infiniti Healthcare, Seoul, Korea) by 2 authors (a musculoskeletal radiologist with 16 years of experience [KSA] and an orthopedic surgeon with 12 years of experience [WYJ]), who were blinded to the patient information. Two observers independently evaluated the shape of the limbus. The intraclass correlation coefficient was calculated to analyze interobserver reproducibility.

2.3. Arthroscopic-assisted reduction

Arthroscopic-assisted reduction of DDH was performed as previously reported.^[15] The arthroscopic procedure was performed through 2 arthroscopy portals that were made between the palpable femoral and acetabular edges, with 1 located just anterior to the femoral head and the other above the femoral head. A hypertrophic ligamentum teres was removed by dividing it from the acetabular end and then from the opposite end. The freed ligament was removed from the capsule through the surgical portal or debrided. At that point, the limbus was identified and examined using a probe. After pulvinar removal and resection of the transverse acetabular ligament, reduction was attempted by flexion and abduction of the hip. Following the confirmation of reduction via arthrogram, a spica cast was applied to the hip in 100° flexion and 40° to 50° abduction combined with neutral rotation.

2.4. Postoperative magnetic resonance imaging

MRI was performed within 1 day of the reduction. All MRI examinations were performed using 1 of 2 3.0T MRI systems (Achieva, Philips Healthcare, Best, the Netherlands; and Tim Trio, Siemens, Erlangen, Germany) with 16-channel phased-array receiver coils. Both hips were examined using the same protocol. MRI examination was carried out without any sedation or general anesthesia. Interpositions in the acetabulum and anterior, superior, and posterior portions of the limbus were evaluated.

3. Results

The shape of the superior limbus according to the Miyake classification on arthrogram was inverted in 2 hips and everted in 2 hips in the neutral position. After attempted closed reduction, 2 hips became blockaded, 2 inverted, 5 intermediate, and 3 everted. After arthroscopic-assisted reduction, 7 hips appeared everted and 5 were normal (Table 1 and Fig. 1). The interrater intraclass correlation coefficients for the shape of the limbus on arthrogram indices ranged from 0.519 to 0.992 (Table 2).

On arthroscopy, the limbus appeared as a ring-shaped structure with a variably blunted edge that was neither inverted nor everted in all cases. The inferior part of the ring became slender, especially at the transverse acetabular ligament. In

Table 1
Shape of the limbus according to femoral head position and after reduction.

Cases	Sex	Age (mo)	Arthrogram			MRI		
			Neutral	CR	After operation	Superior	Antero-inferior	Posterior
1	M	3	Inverted	Blockaded	Everted	Hypertrophied blunt edge with mixed signal	Sharp	Sharp
2	M	5	Inverted	Intermediate	Everted	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
3	F	7	Inverted	Inverted	Everted	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
4	F	6	Inverted	Blockaded	Everted	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
5	F	7	Inverted	Intermediate	Everted	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
6	F	16	Inverted	Intermediate	Everted	Hypertrophied blunt edge with mixed signal	Sharp	Sharp
7	F	18	Inverted	Intermediate	Normal	Hypertrophied with sharp edge	Sharp	Sharp
8	F	31	Everted	Everted	Normal	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
9	F	4	Everted	Everted	Normal	Hypertrophied blunt edge with mixed signal	Infolded	Sharp
10	F	3	Inverted	Intermediate	Normal	Hypertrophied blunt edge with mixed signal	Sharp	Sharp
11	F	9	Everted	Everted	Normal	Hypertrophied with sharp edge	Sharp	Sharp
12	F	15	Inverted	Inverted	Everted	Hypertrophied blunt edge with mixed signal	Infolded	Sharp

CR=closed reduction, MRI = magnetic resonance imaging.

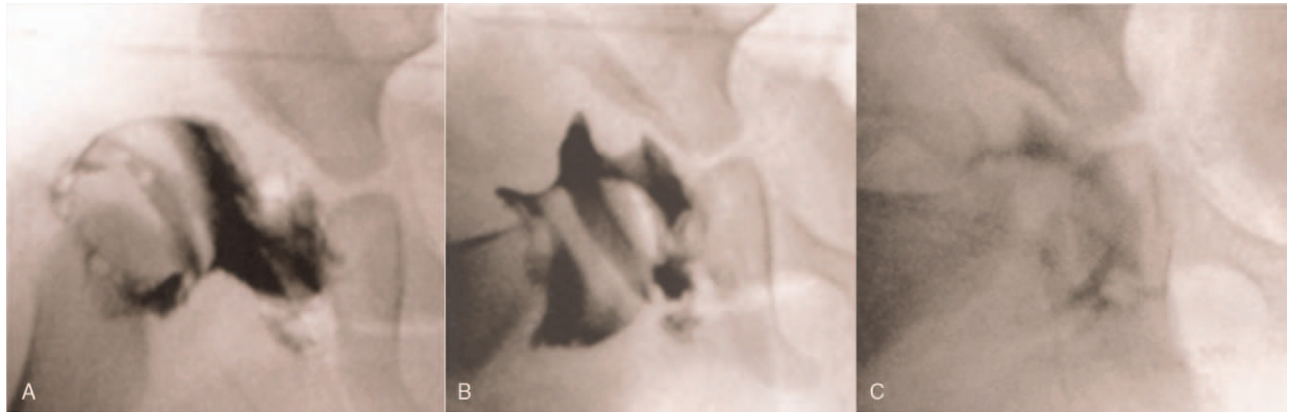


Figure 1. The shape of the superior limbus on arthrogram in a 7-month-old female infant appeared inverted before the reduction (A). It shifted to an intermediate shape after attempted closed reduction (B) and became everted after arthroscopic-assisted reduction (C).

Table 2
Intraclass correlation coefficients (ICC) for the shape of the limbus on arthrogram.

Variables	ICC
Neutral	0.907 (0.825, 0.992)
During the closed reduction	0.604 (0.519, 0.689)
Immediately after operation	0.845 (0.760, 0.930)

general, the limbus had a whitish, cartilage-like appearance, and it was difficult to differentiate it from acetabular floor cartilage. Fine blood vessels were frequently observed in both the limbus and acetabular floor cartilage (Fig. 2).

On coronal plane magnetic resonance images after arthroscopic reduction, the superior limbus showed a hypertrophied or globular shape compressed by the femoral head with blunted edges in 10 of 12 hips. Magnetic resonance signal intensities in the limbus were intermediate or mixed on T2-weighted images. In 6 of the 12 hips, the limbus and acetabular cartilage were discontinuous due to concave recesses at the junction of the limbus and acetabular cartilage on MRI (Fig. 3).

The remaining 2 hips showed hypertrophied superior limbi, but with sharp edges. On transverse plane magnetic resonance images, the anteroinferior labrum was interposed under the femoral head, resulting in residual subluxation in 7 of 12 hips (Fig. 4). The posterior labrum showed sharp margins with low signal intensity in all the hips.

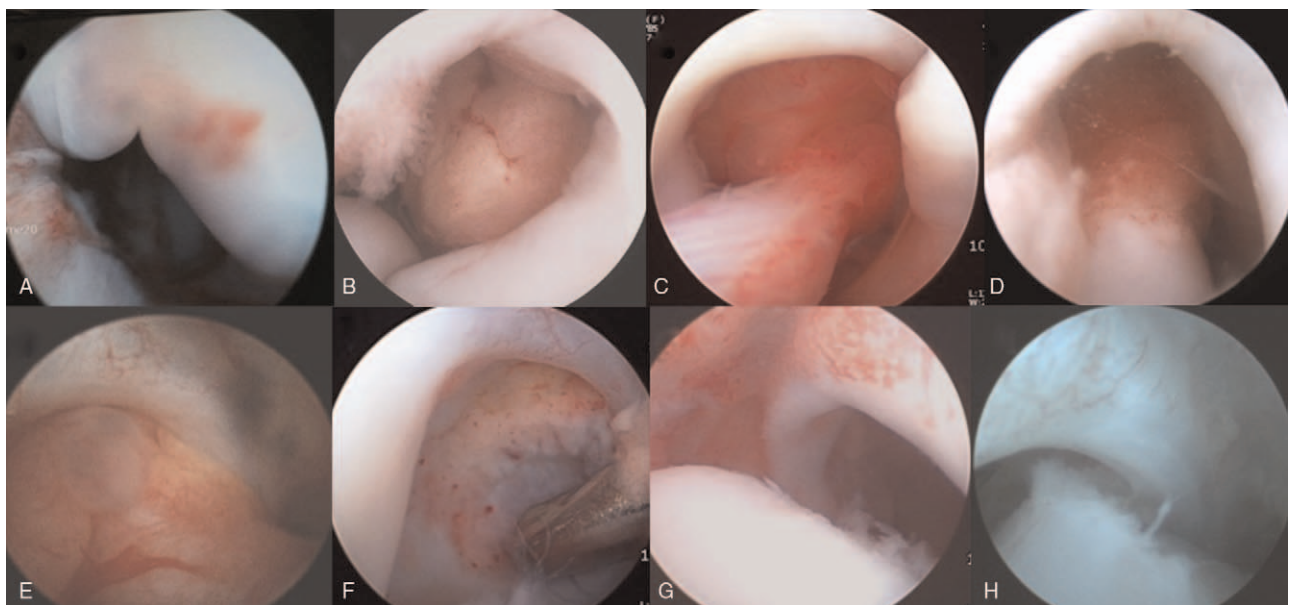


Figure 2. The limbus shape on arthroscopy showed a ring structure with blunted margins and a variable degree of hypertrophy, which appeared to narrow the acetabular introitus (A, B, C, D). Fine blood vessels were observed on the limbus and acetabular floor cartilage (E, F, G, H).



Figure 3. The superior limbus on coronal plane magnetic resonance imaging showed a globular shape with blunted edges and mixed signal intensities on T2-weighted images (A, B, C). Acetabular cartilage recesses were noted (arrow).

4. Discussion

In this study, from an arthroscopic perspective, the limbus was a ring-shaped structure with variably blunted margins that showed neither inversion nor eversion. The limbus shape on arthrography differed according to the position of the femoral head. Even after other obstacles were addressed using arthroscopic-assisted reduction, the anteroinferior labrum was frequently interposed under the femoral head.

In terms of the shape of the limbus on arthrogram, many authors have described it differently.^[5,14,16,17] However, the shape of the limbus on arthrogram is a two-dimensional representation of a three-dimensional, ring-shaped structure that focuses on the superior limbus. Studer et al^[18] reported that on postoperative MRI, the labrum was interpreted as inverted and acted as a main obstacle in 37% of the hips, which resulted in hip subluxation after closed reduction, although the pathological labrum was not identified via intraoperative arthrography in all cases. Fleissner et al^[19] and Mitani et al^[20] reported that an inverted limbus on arthrogram, particularly the superior and posterior portions in complete dislocations, is flexible and can shift according to leg position.

The normal labrum is roughly triangular, with a laterally down-tilted orientation on coronal images and low signal

intensity on both T1- and T2-weighted images.^[21] In contrast, the limbus appears heterogeneous in signal intensity and globular morphology.^[22] In this study, superior limbi with hypertrophy or globular compression by the femoral head, intermediate or mixed MRI signal intensities, and blunted edges were observed. According to a previous report,^[21] intermediate-intensity signals of the limbus on MRI may represent degenerating fibrocartilaginous tissue. In our cases of arthroscopic reduction, the limbus and acetabular floor cartilage were frequently covered by blood vessels, which may also indicate a pathological condition.

According to postoperative MRI, many authors have reported that the limbus is an obstacle to reduction in patients with DDH. On MRI after closed reduction, 37% of patients showed hip subluxation caused by an inverted limbus.^[18] Furthermore, even after open reduction, residual subluxation was noted in 58%,^[23] and an inverted limbus was noted in the reduced hip.^[24] The present study also showed residual subluxation with the anterior-inferior portion of the limbus interposed between the femoral head and acetabulum on postoperative MRI in 7 of 12 hips after arthroscopic-assisted reduction. However, no changes in signal intensity and sharp margins were observed in the posterior limbus in all hips, indicating that the posterior labrum maintained its normal shape and fibrocartilaginous structure. We believe that

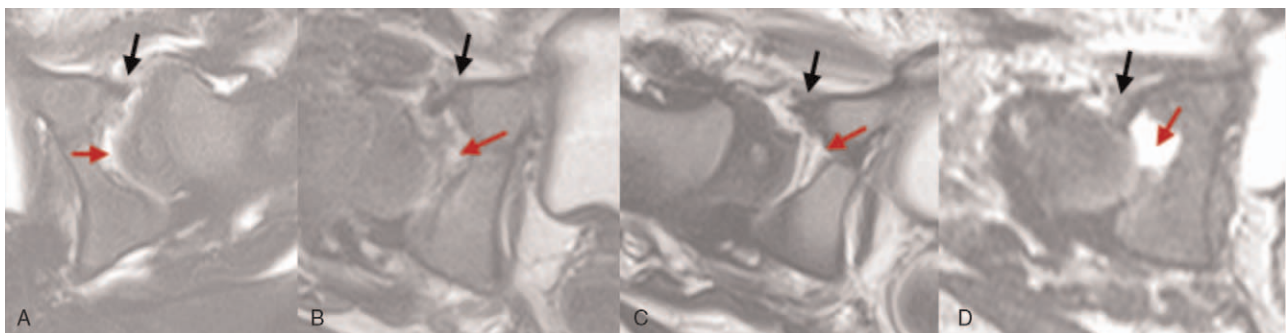


Figure 4. The shape of the posterior limbus on transverse plane magnetic resonance imaging showed a sharpened wedge shape with low signal intensity on T2-weighted images (A, B, C, D). The anterior limbus was interposed (black arrow), and residual subluxation was observed (red arrow).

these differences between the posterior labrum and anteroinferior limbus were caused by morphohistological differences between the anterior and posterior labral chondral complexes. In a previous study, while the posterior labrum was attached and continuous with the acetabular cartilage, the anterior labrum had a somewhat marginal attachment to the acetabular cartilage with an intra-articular projection.^[25] Therefore, the marginal attachment of the anterior labrum may be more prone to damage than that of the posterior labrum, in which the collagen fibers are anchored in the acetabular cartilage. We contend that the interposition of the anteroinferior labrum is inevitable, even if all intra-articular impediments to reduction are removed, owing to disparities in head-acetabular morphology caused in part by the blunted margins of the limbus that contribute to the narrowing of the acetabular introitus.

This study has some limitations. First, the number of cases was small, which precludes generalization of the outcomes of this study. Second, the changes in the limbus shape from before to after the operation were evaluated on arthrogram using the anteroposterior view, but the lateral view is necessary to fully assess changes in the shape of the anterior and posterior limbus.

The shape of the superior limbus on the arthrogram changed based on the mechanical impacts of the femoral head and its elastic structural property. Arthroscopically, in all patients, the limbus was a ring-shaped structure with variably blunted edges that were neither inverted nor everted. On postoperative MRI, the superior, posterior, and anterior limbus showed different MRI signals and were affected differently by the mechanics of the femoral head. We should keep in mind that the anteroinferior limbus under the femoral head can be interposed even after arthroscopic-assisted reduction.

Author contributions

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