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고관절 이형성증 환자에서 비구순 파열의 새로운 관절경적 분류

A Novel Arthroscopic Classification of Labral Tear in Hip Dysplasia

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이 논문을 의학박사 학위 논문으로 제출함

2020 년 2 월

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Abstract

Background: Acetabular labral tear is a cause of pain in patients with symptomatic hip dysplasia. However, no structured grading system exists to evaluate labral tears in these patients. Here, we introduced a new grading system of labral tears in acetabular dysplasia.

Methods: We retrospectively reviewed the data of 66 patients who underwent hip arthroscopy for symptomatic hip dysplasia in March 2014–February 2018. Labral tears were classified into four groups according to the presence of labrochondral junction (LCJ) disruption, capsulolabral recess (CLR) disruption and labral displacement. We investigated the radiological / clinical baseline characteristics in each grade and recorded concomitant findings, including rupture of the ligamentum teres, articular cartilage damage, and presence of a paralabral cyst. The surgical options selected according to each grade and clinical outcomes were investigated at final follow-up.

Results: Labral tears without instability were classified as grade 1 or 2. A grade 1 labral tear was defined as partial delamination or blistering of the labrum with minimal fraying at the LCJ, whereas a labral tear with LCJ disruption was classified as grade 2. Seven hips (10.6%) were classified as grade 1 labral tears and 10 hips (15.2%) were grade 2 tears. Unstable labral tears with CLR disruption followed by LCJ disruption were classified as grade 3 or 4. Thirty hips (45.5%) were defined as grade 3 labral tears without labral displacement, and 19 hips (28.8%) were grade 4 tears with labral displacement. The symptom duration and preoperative Tonnis osteoarthritis grade were correlated with the baseline characteristics of tear grade ($P = 0.017$ and $P < 0.001$, respectively), cartilage damage and the presence of a paralabral cyst also correlated with the severity of the tear as a concomitant injury ($P < 0.001$ and $P = 0.001$, respectively). In all groups, the clinical score improved after surgical treatment.

Conclusions: The labral tears classification in dysplastic hips advocates the natural course of disease progression and will be useful for determining the labral tear degree in hip dysplasia and predicting treatment prognosis.

Key words: labral tear, hip dysplasia, classification

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Introduction

Acetabular labral tears are a cause of pain in patients with symptomatic hip dysplasia. Various conditions could implicate the injuries, but in most cases, labral tears are triggered by two main conditions: hip dysplasia and femoroacetabular impingement (FAI).

Labral tears in FAI are caused by abnormal and repetitive contact between the femur and the acetabulum, whereas labral tears in hip dysplasia occur mainly because of structural instability and the shear load of the hip joint [1]. Several previous studies addressed the pathomechanism of labral tears associated with FAI and their treatment [2,3]. However, the mechanisms underlying labral tears in the presence of acetabular dysplasia are not well known.

Several classification systems of labral tears are available [4–7]; however, most of them classify tears according to their location or morphological features and are difficult to apply to the specific tear features that are observed in hip dysplasia.

In this study, we analyzed the labral tears observed in patients with symptomatic hip dysplasia who underwent either hip arthroscopy alone or periacetabular osteotomy (PAO) combined with hip arthroscopy.

We classified the labral tears that were detected in dysplastic hips based on the features observed during the surgical treatment of consecutive patients with hip dysplasia. Here, we hypothesized that 1) a specific pattern of labral tear in dysplastic hips exists that is different from those stemming from other causes; 2) the tear grade in this classification has no relationship with the patient's baseline demographics because it follows the natural course of the disease; and 3) concomitant injuries (such as tears of the ligamentum teres, hip joint cartilage damage, or the presence of a paralabral cyst) are related with the grade of labral tear, which is reflected in the severity of the injury.

Methods

Patient selection

We reviewed retrospectively data that were collected prospectively, as well as intraoperative images and videos of patients who underwent hip arthroscopy alone or PAO combined with hip arthroscopy for symptomatic hip dysplasia at our institution. The study was approved by the institutional review board of our center.

A total of 73 hips that received intervention at our institution from March 2014 to February 2018 were initially included in this study. We excluded patients who had had previous surgery on ipsilateral hips (n = 3) and those who were lost to follow-up within 12 months after surgery (n = 4). After applying the exclusion criteria, a total of 66 hips (hip arthroscopy alone in 36 cases, PAO combined with hip arthroscopy in 30 cases) remained the study. Seven patients underwent surgery bilaterally. The cohort included six males and 53 females. The mean age was 39.9 years (range, 15–66 years; SD, 13.0) and the mean body mass index (BMI) was 24.3 kg/m2 (range, 18.1–36.0 kg/m2; SD, 4.0). In all cases, the enhanced pelvis MRI or MR arthrography was performed preoperatively.

Surgical technique

The procedures are performed by two attending surgeons (PWY, JSC): a hip arthroscopic specialist (PWY) and a hip preservation surgery specialist who had a high level of experience in PAO surgery (JSC). All hip arthroscopy and PAO surgeries were performed by each of these surgeons, respectively. Except the arthroscopy alone cases, all of the “hip arthroscopy – PAO “combined surgeries were planned PAO first by senior surgeon (JSC), and only the selected cases which suspected labral tear in preoperative MRI were performed combined surgery with arthroscopy.

Arthroscopy was carried out using a standard anterolateral portal, a posterolateral portal, a modified anterior portal, and an additionally secured distal-anterolateral accessory portal (if necessary). Care was taken to avoid labral penetration during initial portal placement, which

may be difficult given the presence of a elongated labrum in dysplastic patients. By venting the joint during distraction, diagnostic arthroscopy was then carried out and all intra-articular pathologies were treated arthroscopically. In the case of arthroscopy combined with PAO, the hip arthroscopy was performed first, followed by PAO surgery in the same manner as that used for arthroscopy alone. The PAO procedures were performed via dual incision, as described previously by Chang et al. [8].

For the management of labral injuries, we chose the treatment option of following the tear patterns consistently. We performed simple debridement at fraying lesions. In cases in which a labral injury was observed that could be repaired, we performed labral repair using two or three 2.3-mm suture anchors (Smith & Nephew, Andover, MA, USA) using labral base suture by the vertical mattress technique [9]. If the tear had extensively progressed and displaced, then a loop-around suture technique was used for stability. In cases in which labral repair was impossible, we performed labrum partial resection.

Labral tear classification

The authors propose a four-item classification system based on the observations of this study. The grading was defined according to the presence of 1) labrochondral junction (LCJ) disruption, 2) capsulolabral recess (CLR) disruption, 3) labral displacement, 4) and instability of the torn labrum based on arthroscopic findings.

Labral tears without instability were classified as grade 1 or 2. Grade 1 labral tears were defined as partial delamination or blistering of the labrum with minimal fraying at the LCJ, while labral tears with LCJ disruption were classified as grade 2. Unstable labral tears with CLR disruption followed by LCJ disruption were classified as grade 3 or 4. Grade 3 labral tears were defined as tears without labral displacement, whereas grade 4 included tears with labral displacement. This classification system is schematically detailed in Figure 1.

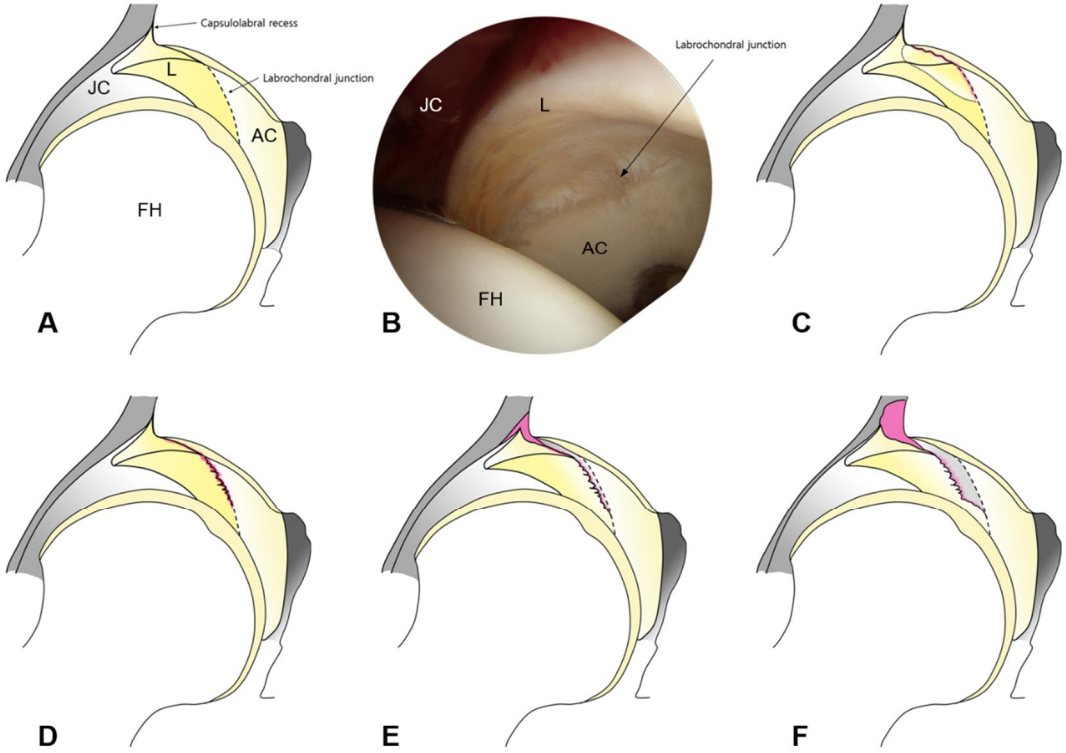

Figure 1. Schematic representation of labral tear grades in patients with hip dysplasia.

(A) The left hip joint from behind. **(B)** Arthroscopic view of the left hip through the anterolateral portal using 70° arthroscope. **(C)** Grade 1: partial delamination or blistering of the labrum with minimal fraying at the LCJ. **(D)** Grade 2: labral tears with LCJ disruption, but no instability. **(E)** Grade 3: unstable labral tears with LCJ and CLR disruption, but no labral displacement. **(F)** Grade 4: unstable labral tears with LCJ and CLR disruption, which displaced the labrum laterally.

Abbreviations: L labrum, FH femoral head, AC: acetabulum.

Data collection

Based on the current classification, we graded the labral tears. This classification was reviewed by two orthopedic surgeons specialized in hip conditions (PWY and CHK). The location of labral tear was assessed using six acetabular zone previously described by Ilizaliturri et al. [10].

For comparing the baseline characteristics between each discrete stage, we 1) measured lateral center-edge angle (LCEA), sharp angle, Tonnis angle and acetabular depth to width ratio (AD/WR) on plain radiographs, 2) reviewed BMI, and 3) investigated the duration of the symptoms (the time from symptom onset to the date of surgery).

The radiological parameters that were used to establish a diagnosis of hip dysplasia included a LCEA≤20° in a standing pelvic anteroposterior radiograph. The pelvic AP view was considered true when the coccyx tip and the pubic symphysis were in line, the distance between them was between 1- and 3-cm and both teardrops, and the iliac wing and the obturator foramen were symmetrical. Both hips were internally rotated 15°–20°, to improve the evaluation of femoral neck geometry.

Based on the arthroscopic operative findings, we compared the prevalence of the concomitant injuries of labral tears in each grade: 1) ligamentum teres (LT) tear, 2) femoral head (FH) cartilage damage, 3) acetabular cartilage damage, and 4) the presence of a paralabral cyst.

To compare prognoses and treatment results, we investigated which surgical procedure was selected according to grade and compared the clinical scores (modified Harris hip score (mHHS) and WOMAC score in the pre- and post-operative final follow-up period). At the final follow-up period, we investigated the number of patients who needed revision hip arthroscopy or conversion hip arthroplasty because of the failure of treatment for the progression of osteoarthritis (OA).

We also reviewed the Tonnis OA grade in preoperative and final follow-up period, not only to evaluate the relationship between the labral tear grade and the severity of OA, but to evaluate the change of OA grade in each stage following surgical treatment.

Statistical analysis

To measure the interobserver agreement for the grading defined by the operating surgeon (PWY), the grading was reviewed by an orthopedist specialized in hip conditions who did not participate in the surgeries (CHK). Cohen's kappa coefficient was used to measure this agreement. Agreement between reviewers was correlated with kappa values a priori: $\kappa = 1$, corresponding to ″perfect″ agreement; $1.0 > \kappa \geq 0.8$, ″Almost perfect″ agreement; $0.8 > \kappa \geq 0.6$, ″Substantial″ agreement; $0.6 > \kappa \geq 0.4$, ″moderate″ agreement; $0.4 > \kappa \geq 0.2$, ″Fair″ agreement; and $\kappa < 0.2$, ″Slight″ agreement. To assess the presence of a linear relationship between the baseline characteristics (mean LCEA, BMI, and symptom duration) and labral tear grade, to compare the incidence of concomitant injuries with tear grade and to evaluate the relationship between the labral tear grade and the severity of OA, a Spearman correlation analysis was performed. For the comparison of treatment results according to pain score, a Wilcoxon test for paired data was used. PASW Statistics version 18.0 (IBM Corp., Armonk, NY, USA) was used for the analyses. Statistical significance was set at $P < 0.05$.

Results

Arthroscopic classification

The details of the labral tears observed in the 66 hips are shown in Table 1. All of the tears observed in zone 2 or 3, the 45 of 66 was observed in zone 2 (68.2%), and 21 of 66 was zone 3 (31.8%). The kappa value for observer agreement, was 0.72, which indicated the presence of substantial agreement.

Grade 1 labral tears were found in 7 cases (10.6%) which showed partial delamination or blistering of the labrum with minimal fraying at the LCJ, but mostly no definite labral pathology on MRI (Fig 2).

Grade 2 labral tears were found in 10 cases (15.2%) which only involved disruption of the LCJ. There was no CLR disruption and the labrum was stable in these tears. On MR arthrography, labral tears were confirmed by a contrast material-filled defect at the LCJ (Fig 3).

Grade 3 labral tears were found in 30 cases (45.5%) which showed the instability of the torn labrum with disruption of the LCJ and CLR. Because there was no displacement of the torn labrum, the joint space width maintained on the AP radiograph. These were the most common type of tears in our patients. On MRI, the CLR disruption can be well identified on the sagittal views which include increased intrasubstance signal intensity or contrast material-filling paralabral cyst at the CLR (Fig 4).

Grade 4 labral tears were found in 19 cases (28.8%) which showed anterolateral displacement of the torn labrum with extensive disruption of the LCJ and CLR. There was joint space narrowing on preoperative AP radiograph in patients with grade 4 tears (Fig 5).

Table 1. Arthroscopic classification of labral tear and number of patients in each type

Type	Labrochondral junction	Capsulolabral recess	Labral stability	Total = 66 (%)	Combined PAO (%)
1	Delamination	Intact	Stable	7 (10.6)	3/7 (42.9)
2	Disrupted	Intact	Stable	10 (15.2)	5/10 (50.0)
3	Disrupted	Disrupted	Unstable	30 (45.5)	7/30 (23.3)
4	Disrupted	Disrupted	Displaced	19 (28.8)	15/19 (78.9)

Abbreviations: PAO periacetabular osteotomy.

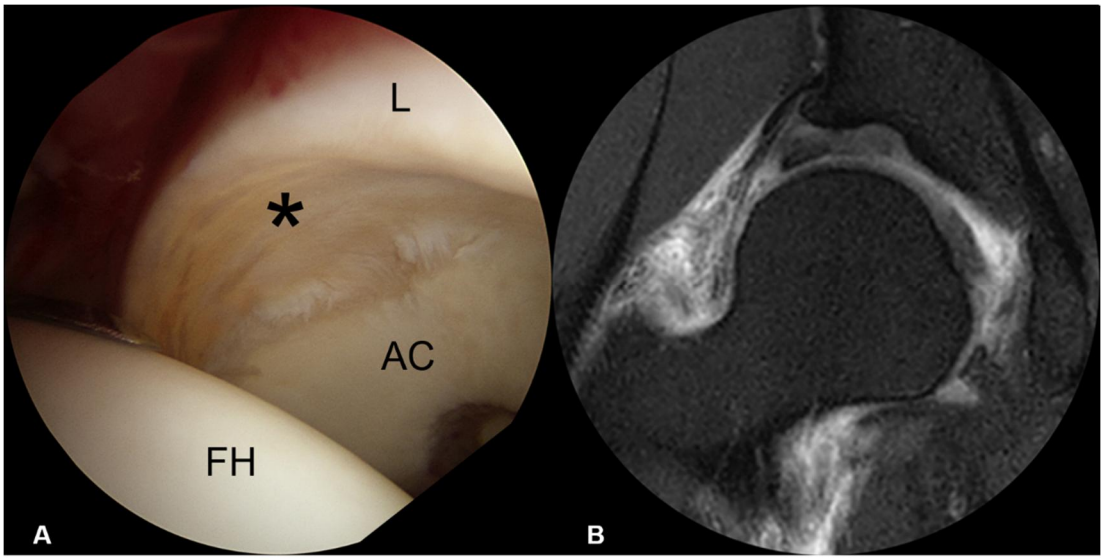

Figure 2. The arthroscopic finding and MRI feature of grade 1 labral tear.

(A) The partial delamination with fraying at LCJ was seen in arthroscopic finding, **(B)** but the no definite labral pathology on MRI.

Abbreviations: L labrum, FH femoral head, AC acetabulum.

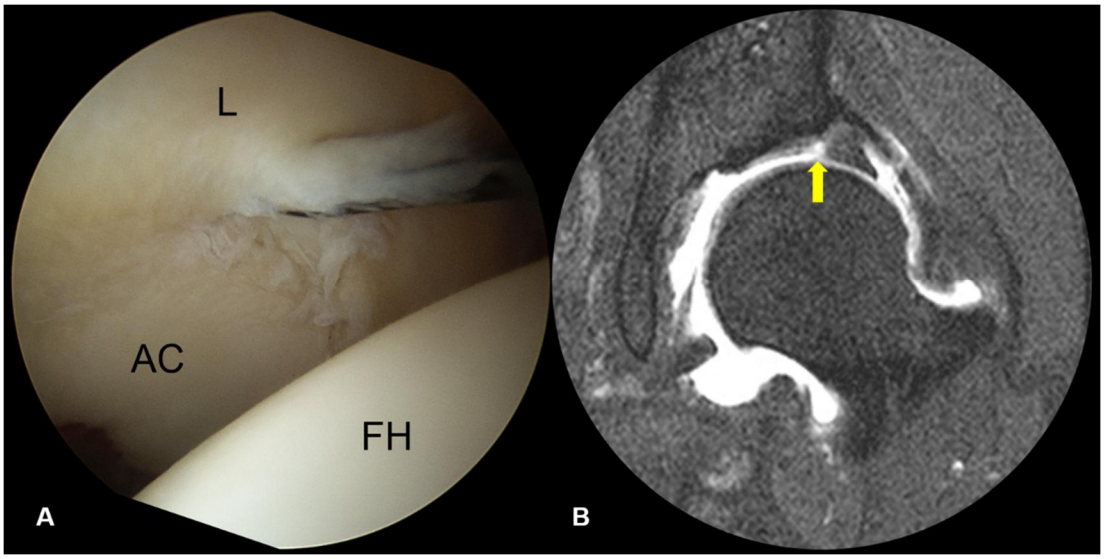

Figure 3. The grade 2 labral tear showed LCJ disruption but stable CLR.

(A) The arthroscopic finding of grade 2 labral tears was shown, and **(B)** MR arthrography which confirmed by a contrast material-filled defect at the labrochondral junction was shown (arrow).

Abbreviations: L labrum, FH femoral head, AC acetabulum.

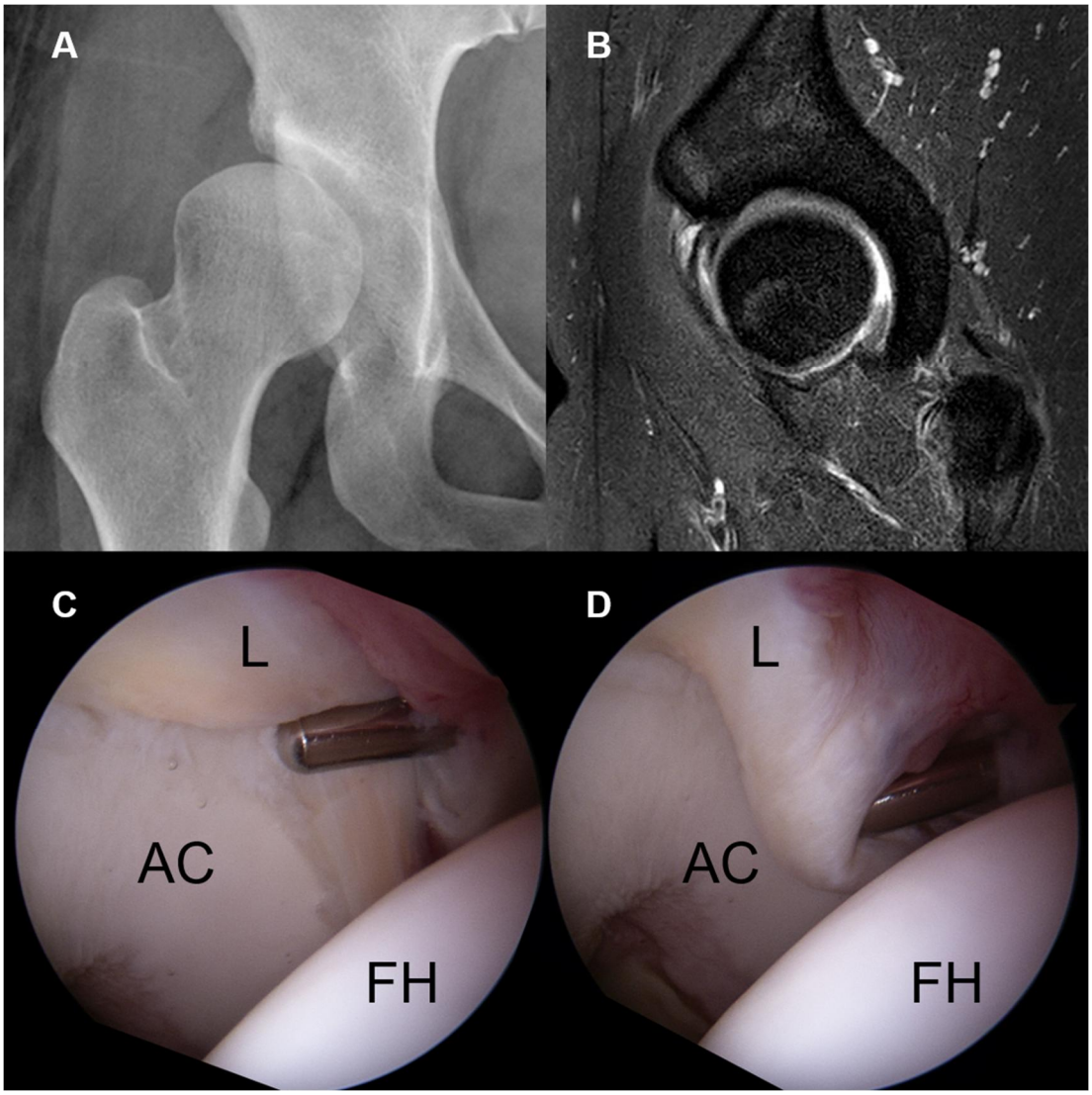

Figure 4. The grade 3 labral injury in 26-years old female patient.

(A) The simple X-ray showed definitely dysplastic acetabular structure, and **(B)** the sagittal hip MRI showed increased intrasubstance signal inteinsity and contrast material-filling paralabral cyst at the chondrolabral junction. **(C)** The arthroscopic findings showed unstable labrum between chondrolabral juction and **(D)** capsulolabral recess, without labral displacement.

Abbreviations: L labrum, FH femoral head, AC acetabulum.

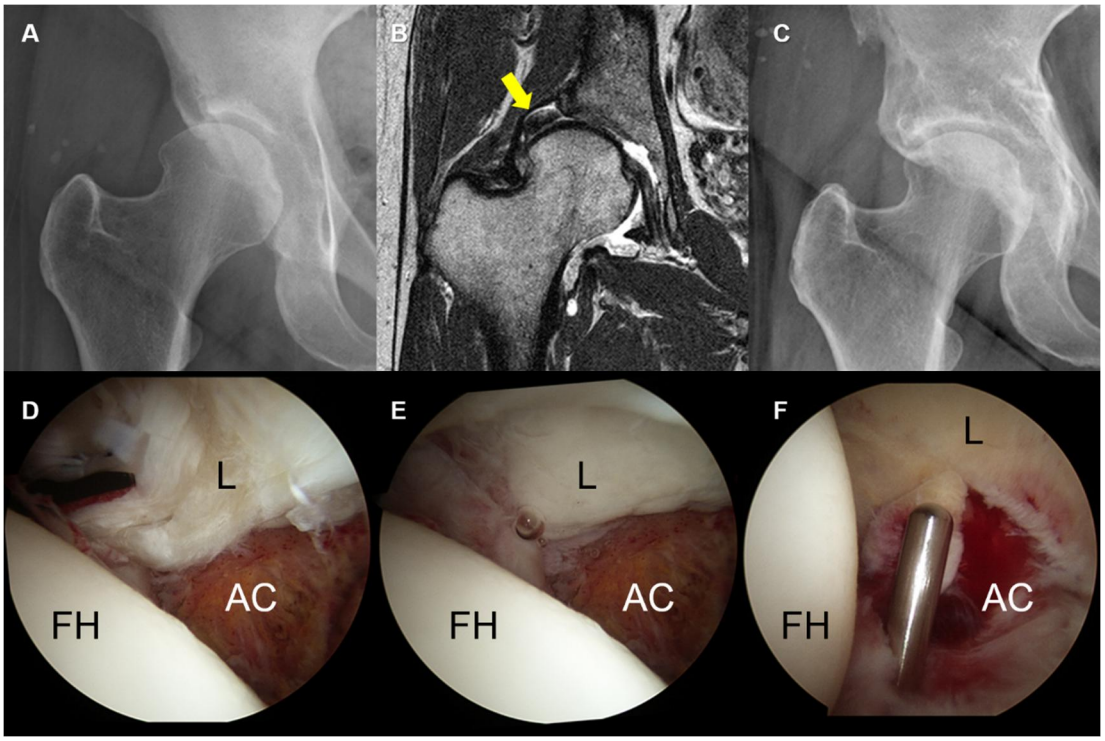

Figure 5. (A) The simple X-ray showed joint space narrowing in 45-year female patient. **(B)** Complete lateral displacement of labrum showed on coronal MRI image (arrow). **(C)** The patient underwent arthroscopy combined PAO and postoperative 3-years follow-up X-ray was seen. **(D, E)** Arthroscopically, the labral displacement was shown like "bucket-handle tear", and **(F)** the partial resection was performed to unstable degenerative labral tear.

Abbreviations: L labrum, FH femoral head, AC acetabulum.

The relationship of baseline characteristics with labral tear classification

The comparison of the baseline characteristics according to each tear grade revealed that the AD/WR was the only factor which exhibited a linear relationship with tear grading in 4 radiologic parameters, and symptom duration was the only factor which showed a linear relationship in clinical parameters (Table 2): we observed a negative relationship between AD/WR and labral tear grade ($P = 0.023$), and a positive relationship between symptom duration and labral tear grade ($P = 0.017$). The mean LCEA, Sharp angle, Tonnis angle and BMI were not correlated with the tear grade ($P = 0.065$, 0.101, 0.121 and 0.078, respectively).

The concomitant injuries according to labral tear classification

The presence of concomitant injuries according to tear grade are shown in Table 3. The investigation of the relationship between each variable and labral tear classification revealed the existence of a positive linear relationship between FH and acetabular cartilage damage and the incidence of paralabral cysts ($P < 0.001$, < 0.001, and $= 0.001$, respectively). The incidence of complete LT tear was not significantly correlated with tear grade ($P = 0.513$).

The surgical modalities according to labral tear classification

Regarding the choice of surgical modality according to grade, three of the 7 hips that were classified as grade 1 underwent simple labral debridement combined with PAO, whereas the remaining four hips received all-arthroscopic labral base repair via mattress suture. In turn, five of the 10 hips that were classified as grade 2 underwent hip arthroscopy (simple labral debridement in two hips and labral repair in three) combined with PAO. The remaining five hips received all-arthroscopic labral base repair. All cases of labral repair of grade 2 tears were performed using the mattress suture technique, as mentioned previously. Moreover, all 30 grade 3 labral tears were repaired using the mattress suture technique, seven of which underwent combined PAO surgery. Nine of 23 all-arthroscopically treated cases also received capsular plication. In 19 hips that were classified as grade 4, 15 out of 19 cases underwent hip arthroscopy combined with PAO. Labral repair was not possible in the eight of the 19 grade 4 hips; therefore, partial resection and marginal debridement were performed (Fig 5).

Table 2. Baseline characteristics in each labral tear grade.

Variables	Data	P value
Mean LCEA (degree)		0.065
1	14.3 (range 6 to 20, SD 5.7)	
2	13.4 (range 6 to 19, SD 4.5)	
3	13.3 (range -3 to 24, SD 5.8)	
4	10.9 (range 6 to 20, SD 4.3)	
Sharp angle (degree)		0.101
1	45.3 (range 41 to 48, SD 2.6)	
2	45.9 (range 40 to 51, SD 3.5)	
3	46.1 (range 35 to 55, SD 4.6)	
4	48.2 (range 39 to 55, SD 4.7)	
Tonnis angle (degree)		0.121
1	23.0 (range 13 to 30, SD 5.7)	
2	19.1 (range 12 to 28, SD 5.6)	
3	18.9 (range 8 to 34, SD 6.4)	
4	24.2 (range 14 to 35, SD 5.8)	
AD/WR		0.023
1	0.20 (range 0.16 to 0.25, SD 0.03)	
2	0.21 (range 0.16 to 0.26, SD 0.39)	
3	0.21 (range 0.10 to 0.26, SD 0.03)	
4	0.18 (rnage 0.15 to 0.29, SD 0.03)	
BMI (kg/m^2)		0.078
1	23.3 (range 20.7 to 24.9, SD 1.5)	
2	24.4 (range 19.1 to 36.0, SD 5.0)	
3	23.5 (range 18.1 to 34.6, SD 4.2)	
4	25.9 (range 21.6 to 35.3, SD 3.7)	
Symptom duration (month)		0.017

1	16.3 (range 7.1 to 29.3, SD 7.5)
2	25.0 (range 11.2 to 43.2, SD 11.8)
3	31.7 (range 7.9 to 85.2, SD 22.5)
4	40.4 (range 18.0 to 108.2, SD 30.6)

Abbreviations: LCEA lateral center-edge angle, AD/WR acetabular depth-to-width ratio, BMI body mass index.

Table 3. Comparison of prevalence of concomitant injuries for labral tear classification in arthroscopic finding.

Variables	Data	P value
Complete LT tear (n=21/66, 31.8 %)		0.513
1	3 of 7 (42.9 %)	
2	1 of 10 (10.0 %)	
3	10 of 30 (33.3 %)	
4	7 of 19 (36.8 %)	
FH cartilage damage (n=23/66, 34.8 %)		<0.001
1	2 of 7 (28.6 %)	
2	1 of 10 (10.0 %)	
3	5 of 30 (16.7 %)	
4	15 of 19 (78.9 %)	
Acet. cartilage damage (n=16/66, 24.2 %)		<0.001
1	0 of 7 (0 %)	
2	0 of 10 (0 %)	
3	2 of 30 (6.7 %)	
4	14 of 19 (73.7 %)	
Paralabral cyst (n=37/66, 56.1 %)		0.001
1	1 of 7 (14.3 %)	
2	2 of 10 (20.0 %)	
3	20 of 30 (66.7 %)	
4	14 of 19 (73.7 %)	

Abbreviations: LT ligamentum teres, FH femoral head, Acet acetabulum.

Treatment details & Clinical outcomes

In grade 1, one of 5 patients underwent simple debridement and 4 of 5 patients underwent labral repair in arthroscopy only group, and combined PAO group, two of 3 patients underwent simple debridement and 1 of 3 patient underwent labral repair. In grade 2, five of 6 patients underwent simple debridement and 1 of 6 patients underwent labral repair in arthroscopy only group, and three of 5 patients underwent simple debridement and 2 of 5 patient underwent labral repair in combined PAO group. In grade 3, all patients underwent labral repair, and grade 4, labral repair was performed in all of 4 arthroscopy only cases while five of 15 hips underwent labral repair (one performed by loop around suture technique), and other 10 of 15 hips were underwent partial labral resection in combined PAO group.

In all grades, the mean final mHHS was higher compared with the preoperative value, and the final WOMAC score was lower than the preoperative mean score; however, no statistical significance was observed (Table 4 and 5).

There were three cases which received total hip arthroplasty (THA) conversion, and all of three cases were classified grade 4 labral tear. Of three patients, two underwent hip arthroscopy procedure only, and one underwent arthroscopy combined PAO. There was no patient who needed revision hip arthroscopy.

Tonnis OA grade in preoperative & final follow-up period

The details for Tonnis OA grade in preoperative and final follow-up period were described in Table 6. In preoperative period, all of the hips except 3 were included Tonnis grade 0 or 1, but in final follow-up period, there were 13 hips which included Tonnis grade 2 or 3. The OA progression to Tonnis grade 2 or 3 was most common in grade 4 labral tear.

We also performed the Spearman correlation analysis between preoperative OA grade and labral tear grade, there was positive linear relationship ($P < 0.001$, $rho = 0.560$).

Table 4. The comparison modified Harris Hip Score between preoperative and postoperative status following each grade.

Gr	mHHS (pre)			mHHS (final)		
	A/S only	w/ PAO	Total	A/S only	w/ PAO	Total
1	65.7 (SD 12.9)	82.0 (SD 7.1)	71.5 (SD 15.2)	78.0 (SD 12.7)	89.7 (SD 2.3)	83.5 (SD 9.8)
2	55.5 (SD 4.4)	86.0 (SD 7.1)	62.6 (SD 16.3)	67.8 (SD 13.5)	87.2 (SD 3.8)	71.8 (SD 14.8)
3	59.1 (SD 13.2)	68.3 (SD 20.1)	58.6 (SD 15.9)	72.8 (SD 13.8)	83.9 (SD 9.0)	73.8 (SD 14.5)
4	59.0 (SD 19.2)	61.0 (SD 14.9)	57.9 (SD 16.5)	64.8 (SD 17.4)	77.6 (SD 13.0)	59.4 (SD 17.5)

Abbreviations: Gr grade, mHHS modified Harris Hip Scores, A/S arthroscopy, w/PAO Arthroscopy with Periacetabular osteotomy.

Table 5. The comparison WOMAC score between preoperative and postoperative status following each grade.

Gr	WOMAC (pre)			WOMAC (final)		
	A/S only	w/ PAO	Total	A/S only	w/ PAO	Total
1	24.3	10.5	20.5	22.5	2.0	12.8
	(SD 12.5)	(SD 7.8)	(SD 13.5)	(SD 24.7)	(SD 3.5)	(SD 18.4)
2	51.0	19.7	41.0	19.2	5.4	19.2
	(SD 10.9)	(SD 16.9)	(SD 24.3)	(SD 16.0)	(SD 6.6)	(SD 16.0)
3	23.4	31.3	26.9	20.9	18.4	18.2
	(SD 14.7)	(SD 23.9)	(SD 17.9)	(SD 16.0)	(SD 20.8)	(SD 20.2)
4	27.8	30.7	29.0	14.8	13.6	19.0
	(SD 23.1)	(SD 5.8)	(SD 16.8)	(SD 11.3)	(SD 12.0)	(SD 13.9)

Abbreviations: Gr grade, A/S arthroscopy, w/PAO Arthroscopy with Periacetabular osteotomy.

Table 6. The comparison of Tonnis OA grade between preoperative and final follow-up period following each grade.

Tear grade	Tonnis OA grade (pre)				Tonnis OA grade (final f/u)			
	Gr 0 (n, %)	Gr 1 (n, %)	Gr 2 (n, %)	Gr 3 (n, %)	Gr 0 (n, %)	Gr 1 (n, %)	Gr 2 (n, %)	Gr 3 (n, %)
1	6 (85.7)	1 (14.3)	0	0	5 (71.4)	2 (28.6)	0	0
2	9 (90.0)	1 (10.0)	0	0	4 (40.0)	6 (60.0)	0	0
3	20 (66.6)	10 (33.3)	0	0	8 (26.7)	16 (53.3)	6 (20.0)	0
4	3 (15.8)	13 (68.4)	3 (15.8)	0	0	6 (31.6)	7 (36.8)	6 (31.6)

Abbreviations: OA osteoarthritis, Gr grade.

Discussion

A schematic representation of our grading system is shown in Figure 1. In the current study, we staged labral tears according to the presence of 1) LCJ disruption, 2) CLR disruption, 3) labral displacement, and 4) instability of the torn labrum in patients with dysplastic hips. We believe that labral tears in dysplastic hip might initiate LCJ and progress to CLR by the shear load of the hip joint.

In the normal hip joint, the acetabular labrum merged with the articular cartilage through a transition zone of 1- to 2-mm, and attached firmly to the articular side of the consistent thin tongue of bone extended from the edge of the bony acetabulum via a zone of calcified cartilage [7]. Although multiple studies have confirmed that labral enlargement may act to compensate for the relative lack of acetabular bony coverage to maintain the femoral head within the joint in the setting of dysplastic hips, the transition zone is also a weak point and vulnerable to injury, especially in the anterior segment [11].

Several terminologies have been used previously to describe the labral pathology associated with acetabular dysplasia: inverted labrum [12], bucket-handle type tear [13], incarceration of torn labrum [14], limbus [15], and hypertrophied labrum [16].

One embryological study of the acetabular labral-chondral complex reported a marginal attachment of the anterior labrum to the acetabular cartilage with an intra-articular projection [17]. In our opinion, the different injury patterns are caused not only by the difference in injury mechanism between the abnormal contact in the FAI and shear loading force in acetabular dysplasia, but also by the structural characteristics of the labrum, which extends widely into the acetabular chondro-labral junction in dysplastic hips.

In the current study, even the AD/WR showed negative relationship with tear grading, the most underlying patient demographics, such as mean LCEA, Sharp angle, Tonnis angle or BMI, did not exhibit a linear relationship with tear grade. However, the symptom duration and Tonnis OA grade showed a significant positive linear relationship with the tear grade. These findings suggest the various tear grades were not different entities regarding injury mechanism,

as they may follow the natural course of labral tear and severity. In support of our hypothesis, our classification may match the progression of labral tears in dysplastic hip.

Historically, in an attempt to classify acetabular labral tears, Lage's classification [4], which is based on arthroscopic findings, was introduced in 1996. This system classified labral tears as radial flap, radial fibrillated, longitudinal peripheral, and unstable types, which is similar to the classification of meniscal injuries of the knee. Lage's classification is the system that is used most commonly for the categorization of hip labral tears [18]; however, it is not sufficient to describe labral tears in acetabular dysplasia and it has the limitation of a poor correlation with MR arthrography [19].

Based on MR arthrogram findings, Czerny's labral tear classification [5] was introduced. Although it is cited often in the literature, this classification represents a poor tool regarding treatment planning, as it only highlights the visualization of the labrum itself, without addressing the recess located between the joint capsule and the labrum.

In 2001, Seldes et al. [7] classified acetabular labral tears into two types in their cadaveric study. Those authors identified histologically one type that consisted of a detachment of the labrum from the articular cartilage surface, as well as a second type that consisted of one or more cleavages within the substance of the labrum. This was the first study to investigate the histological features and microvasculature structure associated with labral tears; however, it did not address the clinical findings of each type and did not fit labral tears in acetabular dysplasia.

More recently, the Multicenter Arthroscopy of the Hip Outcomes Research Network (Mahorn) classification was introduced [6]. This system reflects the size of labral tears, tear patterns, and intrasubstance changes. However, the limitations of all previously published classification systems include the lack of consideration of injury mechanism and of a systematic staged approach. In patients with acetabular dysplasia in particular, labral tears cannot be classified using previous criteria in some cases.

To assess the concomitant injuries of labral tears in acetabular dysplasia, we investigated the occurrence of LT tears, FH and acetabular cartilage damage, and paralabral cysts.

These concomitant findings are commonly accompany labral tears in patients with hip dysplasia, and numerous studies have investigated each of these findings in the setting of labral tears in acetabular dysplasia [1,20–22]. However, none of the previous classification systems considered them to be factors that were related to labral tears. In our opinion, these factors could be related with labral tears following the application of shear load force in dysplastic hips; thus, we investigated the relationship between tear grading and the occurrence of these concomitant injuries.

With the exception of LT tears, all variables analyzed showed a positive linear relationship with tear grading. Although an extended study with a larger sample size is necessary to define this relationship, the results obtained here suggest that LT tear is a concomitant feature that occurs mostly in early-stage labral tears in patients with hip dysplasia compared with the other variables investigated.

According to our grading system, we also proposed a treatment plan. The retrospective review of the medical records of the patients revealed that simple debridement or combined labral base repair was performed for grade 1 or 2 injuries. All hips that were classified as grade 3 underwent labral repair, whereas grade 4 hips were treated with labral repair or partial labral resection. Labral base repair was attempted, when possible. In all groups, the mean modified HHS was higher in the final follow-up period compared with the preoperative period, and the WOMAC score was lower, which implies the success of the treatment results; however, these results were not significant.

Of note, an improvement in modified HHS of only 1.5 points was observed in patients with grade 4 tears when comparing the preoperative with the final follow-up scores. Moreover, we found three cases of THA conversion at the final follow-up, both of which had received an initial classification of grade 4 labral tear. Also, compared the OA grade between preoperative and final follow-up period, there were no progression to Tonnis grade 2 or 3 in grade 1 / 2 labral tears, but in grade 3 tear, 20% of patients progress Tonnis grade 2 OA and even grade 4 labral tear, almost 70% of patients progress Tonnis grade 2 or 3 at final follow-up period. Thus, arthroscopic treatment should be carefully considered as a treatment choice for grade 4 labral tear injury in dysplastic hips.

Our study had several limitations. First, the sample size was small, which may have affected the results. Second, we did not fully provide an imaging correlation (such as MRI or MR arthrography) for all cases, due to the limitation of retrospective nature of our data collection, we could not standardize the imaging modality. Although all patients underwent MRI, we were unable to standardize the series. Third, we could not randomize the factor of combine PAO surgery, because the hip arthroscopy was the assisted procedures in initially planned PAO. Additional studies using a larger number of patients are necessary to confirm the results reported here and to correlate them with imaging data.

Conclusion

The arthroscopic findings of labral tears in patients with hip dysplasia differed from the conventional classification. It is expected that the classification proposed here will be useful for determining the degree of labral tear in patients with hip dysplasia and for predicting treatment outcomes.

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국문 요약

배경: 고관절 비구순 파열은 유증상의 대퇴비구 이형성증 환자에서 가장 흔한 통증의 원인 중 하나이다. 그러나 현재까지 대퇴비구 이형성증 환자의 비구순 파열에 대한 체계적인 분류법은 소개된 바가 없다. 이에 본 연구에서는 대퇴비구 이형성증의 새로운 분류법을 소개하고 그 의미를 분석해 보고자 한다.

방법: 2014 년 3 월부터 2018 년 2 월까지 단일 기관에서 고관절 관절경술을 시행받은 유증상의 대퇴비구 이형성증 환자 66 명의 자료를 후향적으로 분석하였다. 비구순 파열의 분류는 연골-비구순 접합부의 파열 유무, 비구순-관절막 연접부의 파열 유무 및 비구순의 전위 여부를 기준으로 총 4 단계로 분류하였다. 각각의 파열 단계에 따른 기저 지표 및 원형인대의 파열 여부, 관절내 연골손상의 여부, 비구순 주위 낭종의 존재 여부를 포함한 영상의학적 / 임상적 지표를 분석하였으며, 각각의 파열 단계에서 시행된 수술적 치료를 비교하고, 최종 추시시의 임상결과를 분석하였다.

결과: 비구순에 불안정성이 관찰되지 않으며 부분적인 박리 혹은 경미한 외연의 유리 현상만 관찰되는 경우를 grade 1, 반면에 연골-비구순 접합부의 파열이 관찰되는 경우를 grade 2 로 분류하였다. 7 명 (10.6%) 의 환자가 grade 1 으로, 10 명 (15.2%) 의 환자가 grade 2 로 분류되었다. 비구순의 불안정성이 있으나 전위는 관찰되지 않는 경우를 grade 3, 비구순의 불안정성과 더불어 전위가 관찰되는 경우를 grade 4 로 분류하였다. 총 30 명 (45.5%) 의 환자가 grade 3, 19 명 (28.8%) 의 환자가 grade 4 에 포함되었다. 증상 기간과 수술 전 Tonnis 골관절염 grade 가 저자들의 파열의 단계와 유의한 양의 선형관계 (각각 $P = 0.017$ 및 $P < 0.001$) 를 나타내었으며, 동반 손상으로는 연골 손상의 빈도 및 비구순 주위 낭종의 존재 여부가 파열의 단계와 유의한 양의 선형관계를 나타내었다 (각각 $P < 0.001$ 및 $P = 0.001$). 모든 파열 단계에서 수술 후 임상 지표는 호전되었다.

결론: 본 연구에서 제안한 대퇴비구 이형성증 환자에서의 새로운 비구순 파열 분류법은 질병의 자연경과를 적절하게 반영하는 것으로 사료되며, 추후 파열의 정도를 정량화하고 치료의 예후를 예측하는데 도움이 될 것으로 사료된다.

중심단어: 비구순 파열, 대퇴비구 이형성증, 분류