Lateral Acetabular Coverage Predicts the Size of the Hip Labrum

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Lateral Acetabular Coverage Predicts the Size of the Hip Labrum

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Background: Bony morphological abnormalities of the hip joint are often accompanied by adaptive soft tissue changes. These adaptive changes, if better understood and characterized, may serve to inform clinical decision making.

Purpose: To investigate the correlation between the size of the hip labrum and lateral acetabular coverage in patients at our hip preservation clinic.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A cohort of 236 patients seen at a dedicated hip preservation service between June 2013 and June 2015 were retrospectively analyzed. Patients were grouped according to the degree of acetabular coverage, as measured by the lateral center-edge angle (LCEA): normal acetabular coverage (25°-39.9°), acetabular overcoverage (≥40°), borderline dysplasia (20°-24.9°), and frank dysplasia (<20°). Preoperative magnetic resonance imaging was utilized to measure the length of the labrum at 3 locations: laterally, anteriorly, and anteroinferiorly.

Results: Frankly dysplastic and borderline dysplastic hips exhibited larger values of labral length at all locations when compared with hips with normal acetabular coverage ($P < .001$) or acetabular overcoverage ($P < .001$). Interestingly, mean labral length values in frank dysplasia were statistically similar to corresponding measurements in borderline dysplasia. In hips with frank dysplasia, borderline dysplasia, or normal acetabular coverage, labral length was consistently greatest at the lateral labrum and correspondingly lowest at the anteroinferior labrum ($P < .001$). In hips with acetabular overcoverage, labral length did not vary significantly between the lateral, anterior, and anteroinferior locations. Multivariate analyses confirmed LCEA to be the strongest predictor of labral length, irrespective of measurement location.

Conclusion: Patients with borderline dysplasia and frank dysplasia exhibited increased values of labral length in the weightbearing zone, potentially indicating a compensatory reaction to the lack of bony coverage. Labral length may serve as an instability marker and inform clinical decision making for patients with borderline dysplasia.

Keywords: hip; femoroacetabular impingement; hip arthroscopic surgery; dysplasia; labrum

The acetabular labrum is a ring of fibrocartilage, triangular in cross-section, originating from the rim of the acetabulum and semi-circumferentially enveloping the femoral head, thereby creating a suction seal.[23] In the normal hip, the labrum functions to improve joint lubrication within the central compartment and stabilize the hip joint against distractive forces.[2] In the setting of acetabular dysplasia, increased shear forces within the hip give rise to adaptive hypertrophy of the labrum.[14] In this setting, the labrum may be exposed to 10 times the normal load placed on the hip during ambulation.[6,13] The dysplastic labrum may also contribute to the articulating surface area of the hip and thereby partially compensate for the lack of bony support.[24] In the setting of global acetabular overcoverage or protrusio acetabuli, the opposite effect is seen, and the labrum is characteristically hypoplastic with partial or complete osseous metaplasia.[11] In both cases, abnormal joint biomechanics expose the labrum to supraphysiological stresses, giving rise to degeneration and tearing.[6,11]

Although secondary changes in labral size and composition have been qualitatively described for extremes of

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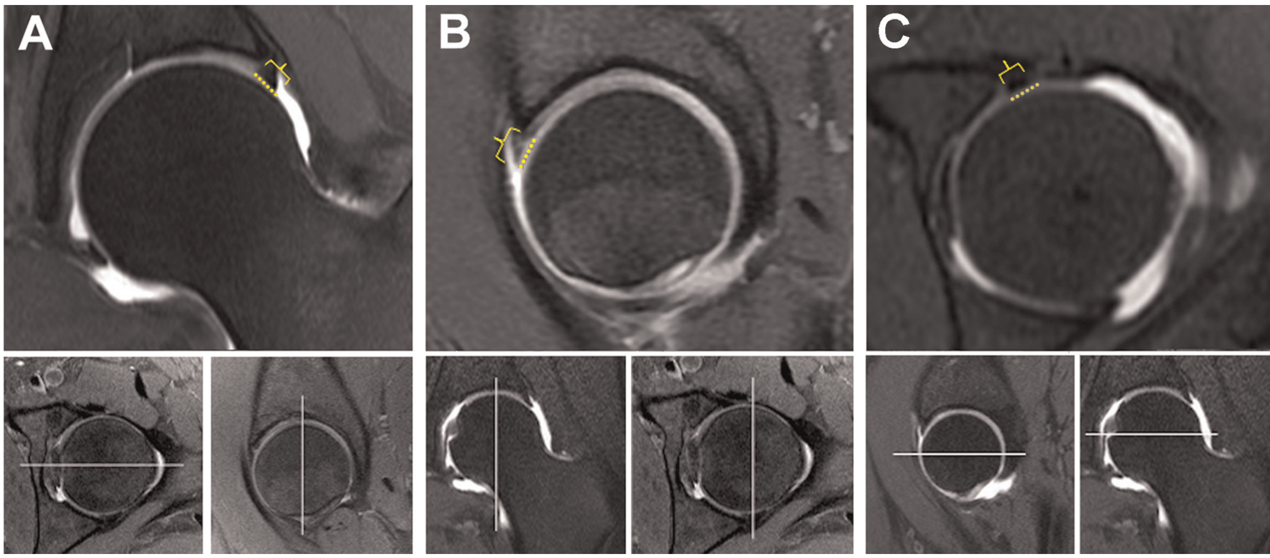

Figure 1. (A) Lateral labral length measurement technique on coronal magnetic resonance imaging (MRI) utilizing a fat-saturated proton density (FSPD) sequence. The lateral labrum is defined as the labrum at the level of the central coronal MRI scan cross-referenced to the axial and sagittal planes (insets). The dotted line and bracket denote the length of the lateral labrum from the acetabular rim to the free edge. (B) Anterior labral length measurement technique on sagittal MRI utilizing an FSPD sequence. The anterior labrum is defined as the labrum at the level of the central sagittal MRI scan cross-referenced to the axial and coronal planes (insets). The dotted line and bracket denote the length of the anterior labrum from the acetabular rim to the free edge. (C) Anteroinferior labral length measurement technique on axial MRI utilizing an FSPD sequence. The anteroinferior labrum is defined as the labrum at the level of the central axial MRI scan cross-referenced to the sagittal and coronal planes (insets). The dotted line and bracket denote the length of the anteroinferior labrum from the acetabular rim to the free edge.

coverage, little is known about the extent of these changes in the setting of borderline acetabular dysplasia or pincer femoroacetabular impingement (FAI). Because of the paucity of research studies investigating borderline dysplasia, there is wide variability in the approach to treatment, with options ranging from arthroscopic-only approaches to those involving pelvic and femoral realignment osteotomies.[4,8] Furthermore, a rigorous and quantitative comparison of labral size among hips with widely varying degrees of femoroacetabular coverage has not been previously conducted.

The purpose of the present study was to determine whether a correlation exists between lateral acetabular coverage and labral length in patients with a wide range of hip morphological types. Our main hypothesis was that the labrum would exhibit adaptive hypertrophy in hips with deficient acetabular coverage, underlying a continuum in which frankly dysplastic hips would exhibit the largest labral length and hips with acetabular overcoverage would exhibit the smallest labral length. A secondary aim was to delineate characteristics unique to hips with borderline dysplasia, given the paucity of current knowledge on this clinical entity.

METHODS

After institutional review board approval, we retrospectively analyzed a cohort of 236 patients with hip pain at our dedicated hip preservation clinic between June 2013 and June 2015. Common indications for referral included FAI, hip instability, acetabular dysplasia, and associated abnormalities of femoral torsion or acetabular version. To be included in this study, patients had to demonstrate the following factors: (1) persistent hip pain and mechanical symptoms unresponsive to nonoperative treatment for greater than 3 months, (2) clinical examination findings suggestive of impingement and/or instability, and (3) joint space width exceeding 2.5 mm on all views of plain radiography and cross-sectional imaging. Patients undergoing surgical treatment for diagnoses of slipped capital femoral epiphysis, Legg-Calve-Perthes disease, osteochondromatosis, or postdislocation syndrome were excluded from this study. Patients were also excluded if preoperative radiographic or magnetic resonance imaging (MRI) studies were unavailable or if labral maceration or ossification precluded accurate measurements of labral length at any location. Demographic variables including age, clinical diagnosis, sex, height, weight, and body mass index (BMI) were recorded for all patients.

Imaging Protocol and Measurements

After comprehensive evaluation by the orthopaedic surgeon, patients underwent a standardized series of plain radiography (including supine anteroposterior [AP], cross-table lateral, and AP pelvic views) as well as preoperative MRI and whole-pelvis computed tomography (CT). Standard AP pelvic views were obtained with the patient positioned supine with the lower extremities internally rotated 15° to maximize femoral neck length. The x-ray beam was directed midway between the anterior superior iliac spine and the pubic symphysis, with a focus film distance of 100 cm. Radiographs were determined to be adequate with symmetric obturator foramina and a distance of 1 to 3 cm between the coccyx and pubic symphysis.[3,7] The lateral center-edge angle (LCEA) was determined on AP pelvic radiographs, in accordance with the technique described by Ogata et al,[21] as the angle subtended by (1) a line through the center of the femoral head and orthogonal to the transverse line passing through the teardrops of both hips and (2) an oblique line drawn from the center of the femoral head to the lateral weightbearing sclerotic zone (sourcil) of the acetabular rim.

Patients were grouped according to the degree of acetabular coverage, as determined by LCEA measurements: normal acetabular coverage (25°-39.9°), acetabular overcoverage (≥40°), borderline dysplasia (20°-24.9°), and frank dysplasia (<20°).

In addition to suggestive physical examination findings, the clinical diagnoses of bony impingement and/or acetabular dysplasia were determined according to accepted pathomorphological measurements on radiography and MRI.[15,25] Confirmative findings of FAI included features corresponding to focal acetabular overcoverage (crossover sign or ischial spine sign), an LCEA ≥40°, and/or an acetabular inclination (AI) less than 0° for pincer FAI; an alpha angle exceeding 50° on radial sequences of the head-neck junction and a femoral head-neck offset ratio less than 0.18 for cam FAI; and for acetabular dysplasia, an LCEA less than 20°. Hips with an LCEA ranging from 25° to 39.9° were considered to have normal acetabular coverage.

Patients were evaluated using a standard orthopaedic MRI hip protocol on 1.5-T or 3-T magnets with a phased array torso coil. The MRI hip protocol consisted of an axial proton density (PD) sequence, an axial oblique fat-saturated PD (FSPD) sequence, coronal T1-weighted and FSPD sequences, and a sagittal FSPD sequence. A slice thickness of 3 mm and a gap of 0.5 mm were used. The field of view was 18 cm with a matrix size of 320 × 192. Magnetic resonance arthrography or delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) studies were aligned with the above protocol for measurements of labral length. Patients who had undergone advanced imaging elsewhere before consultation were evaluated for imaging adequacy, and repeat MRI scans were obtained if deemed necessary.

The length of the acetabular hip labrum was measured at 3 separate anatomic sites along the acetabular rim: lateral, anterior, and anteroinferior (Figure 1). The labral length was measured from the acetabular rim to the free edge of the labrum (in mm) on a PACS workstation (Enterprise; McKesson).

Examiners

Clinical examinations and radiographic assessments were performed by a senior orthopaedic surgeon specializing in hip preservation. MRI measurements were evaluated by our institution's dedicated musculoskeletal radiology team, composed of 4 fellowship-trained musculoskeletal radiologists with 5 to 7 years of experience. In complex cases, measurements were verified by 2 senior authors (M.K.J. and B.P.).

TABLE 1
Patient Demographics (N = 236)[a]

	Values
Age, y	33.5 ± 11.2
Male sex, n (%)	58 (24.6)
Height, cm	168.7 ± 9.7
Weight, kg	69.1 ± 15.2
Body mass index, kg/m^2	24.1 ± 4.4
Lateral acetabular coverage of hips, n (%)	
Frank dysplasia (LCEA <20.0°)	28 (11.9)
Borderline dysplasia (LCEA 20.0°-24.9°)	34 (14.4)
Normal (LCEA 25.0°-39.9°)	139 (58.9)
Overcoverage (LCEA ≥40.0°)	35 (14.8)

[a]Data are reported as mean ± SD unless otherwise indicated. LCEA, lateral center-edge angle.

Interobserver reproducibility of radiographic measurements of the LCEA and MRI measurements of labral length (at 3 locations: lateral, anterior, and anteroinferior) was evaluated by 2 authors (M.K.J. and B.P.) in a blinded random subset of 25 hips using a 2-way, mixed, absolute-agreement single-measure intraclass correlation coefficient (ICC). ICC values >0.80 indicate excellent reliability; 0.61-0.80, substantial reliability; 0.41-0.60, moderate reliability; 0.21-0.40, fair reliability; and ≤0.20, poor reliability.[19] Accordingly, the ICC demonstrated excellent reliability for measurements of the LCEA performed on plain radiography (ICC, 0.934; 95% CI, 0.850-0.971), measurements of lateral labral length on MRI (ICC, 0.993; 95% CI, 0.972-0.998), measurements of anterior labral length on MRI (ICC, 0.985; 95% CI, 0.961-0.994), and measurements of anteroinferior labral length on MRI (ICC, 0.970; 95% CI, 0.932-0.987).

Statistical Analysis

All variables were evaluated for the distribution of normality using a combination of histograms, quantile-quantile plots, and Shapiro-Wilk tests. Baseline demographic characteristics of independent groups were compared using a 1-way analysis of variance (ANOVA) with the post hoc Tukey honest significant difference (HSD) test for quantitative variables and cross-tabulation with χ^2 analysis for nominal variables. Bivariate correlations between quantitative variables were analyzed using the Pearson correlation coefficient. The significance of mean differences in labral length between independent groups and measurement locations was determined using a 3 (measurement location) × 4 (LCEA group) mixed-model ANOVA. Degrees of freedom of the F distribution were adjusted using the Greenhouse-Geisser correction for violations of sphericity. Significant main effects and interactions were analyzed using post hoc Tukey HSD tests and repeated-measures 1-way ANOVAs with post hoc Bonferroni-corrected paired *t* tests. Separate stepwise multiple linear regression procedures were performed to evaluate

TABLE 2
Comparison of Demographic Variables Across Clinical Subgroups[a]

	LCEA Subgroup				
	<20.0° (n = 28)	20.0°-24.9° (n = 34)	25.0°-39.9° (n = 139)	≥40.0° (n = 35)	*P* Value[b]
Age, y	29.9 ± 7.0	33.1 ± 11.0	33.7 ± 11.5	35.9 ± 12.3	.062
Male sex, n (%)	6 (21.4)	5 (14.7)	35 (25.2)	12 (34.3)	.298
Height, cm	169.0 ± 7.4	165.4 ± 7.4	168.9 ± 10.4	170.6 ± 9.7	.146
Weight, kg	69.6 ± 14.6	67.8 ± 14.9	68.8 ± 15.5	70.6 ± 15.1	.885
Body mass index, kg/m^2	24.3 ± 5.0	24.7 ± 4.9	23.9 ± 4.3	24.0 ± 3.9	.264

[a]Data are reported as mean ± SD unless otherwise indicated. LCEA, lateral center-edge angle.
[b]One-way analysis of variance was used to compare quantitative variables, and χ^2 cross-tabulation was used to compare frequencies between independent groups. There were no significant differences ($P < .05$) in baseline demographic variables between groups.

whether any significant ($P < .05$) or near-significant factors ($P < .10$) from univariate analyses served as independent predictors of labral length at each of the 3 measurement locations. Statistical significance for all comparisons was set at $P < .05$ (2-tailed). All analyses were conducted using SPSS Statistics (version 22.0; IBM Corp). Post hoc power analysis indicated that a sample size of 124 hips would be required to achieve statistical significance given a 3 × 4 mixed-model ANOVA with an effect size of the primary outcome measure of 0.25, an α of .05, and a required power $(1 - \beta)$ of 0.80.[9]

RESULTS

Participants and Descriptive Data

The study cohort comprised 236 patients (58 male, 178 female). The mean (±SD) patient age was 33.5 ± 11.2 years, patient height was 168.7 ± 9.7 cm, patient weight was 69.1 ± 15.2 kg, and patient BMI was 24.1 ± 4.4 kg/m^2. Among the 236 patients evaluated, 139 (58.9%) had normal acetabular coverage, 35 (14.8%) had acetabular overcoverage, 34 (14.4%) had borderline dysplasia, and 28 (11.9%) had frank dysplasia (Table 1). Demographic variables did not vary significantly between these clinical subgroups (Table 2).

Hip Morphological Characteristics Influencing Labral Length

Lateral acetabular coverage demonstrated a strong negative correlation to length of the lateral labrum (r = –0.706, $P < .001$), anterior labrum (r = –0.596, $P < .001$), and anteroinferior labrum (r = –0.504, $P < .001$) (Table 3 and Figure 2). The size of the pincer or cam lesion, degree of femoral torsion, degree of acetabular version, and BMI did not bear significant correlations to labral length (Table 3).

Enlarged Labral Length Correlated With Reduced Lateral Acetabular Coverage

The degree of lateral acetabular coverage and the location of measurement (lateral, anterior, anteroinferior) each independently exhibited a statistically significant correlation with the labral length (F(6,462) = 4.453; $P < .001$; partial η^2 = .058). Post hoc Tukey HSD tests indicated that patients with frank dysplasia and borderline dysplasia demonstrated statistically equivalent measurements of lateral, anterior, and anteroinferior labral length. Labral length (at all locations) was significantly increased in these 2 clinical subgroups relative to those with normal acetabular coverage ($P < .001$) or acetabular overcoverage ($P < .001$) (Table 4). Measurements of labral length at all locations were significantly increased in hips with normal acetabular coverage relative to those with acetabular overcoverage ($P < .001$) (Table 4).

When analyzing across measurement locations, labral length was maximized at its lateral aspect and minimized at its anteroinferior aspect in patients with frank dysplasia (F(2,54) = 16.918; $P < .001$; partial η^2 = .385), borderline dysplasia (F(2,66) = 21.001; $P < .001$; partial η^2 = .389), and normal acetabular coverage (F(2,274) = 17.012; $P < .001$; partial η^2 = .110). In contrast, labral length did not vary significantly according to the measurement location in patients with acetabular overcoverage (F(2,68) = 1.536; P = .223; partial η^2 = .043) (Table 4).

TABLE 3
Pearson Correlation Coefficients Determining the Relationship Between Various Hip Morphological Characteristics and Labral Length[a]

	Labral Length		
	Lateral	Anterior	Anteroinferior
Lateral acetabular coverage (LCEA)	**–0.706**	**–0.596**	**–0.504**
Size of pincer lesion	–0.052	–0.177	–0.082
Size of cam lesion	–0.074	0.007	0.068
Femoral torsion	0.115	–0.090	–0.044
Central acetabular version	0.025	–0.097	0.005
Body mass index	0.028	–0.019	0.042

[a]Correlation coefficients (r) were interpreted as weak (0.10-0.29), moderate (0.30-0.49), and strong (0.50-1.00). Bolded values indicate statistical significance ($P \leq .05$). LCEA, lateral center-edge angle.

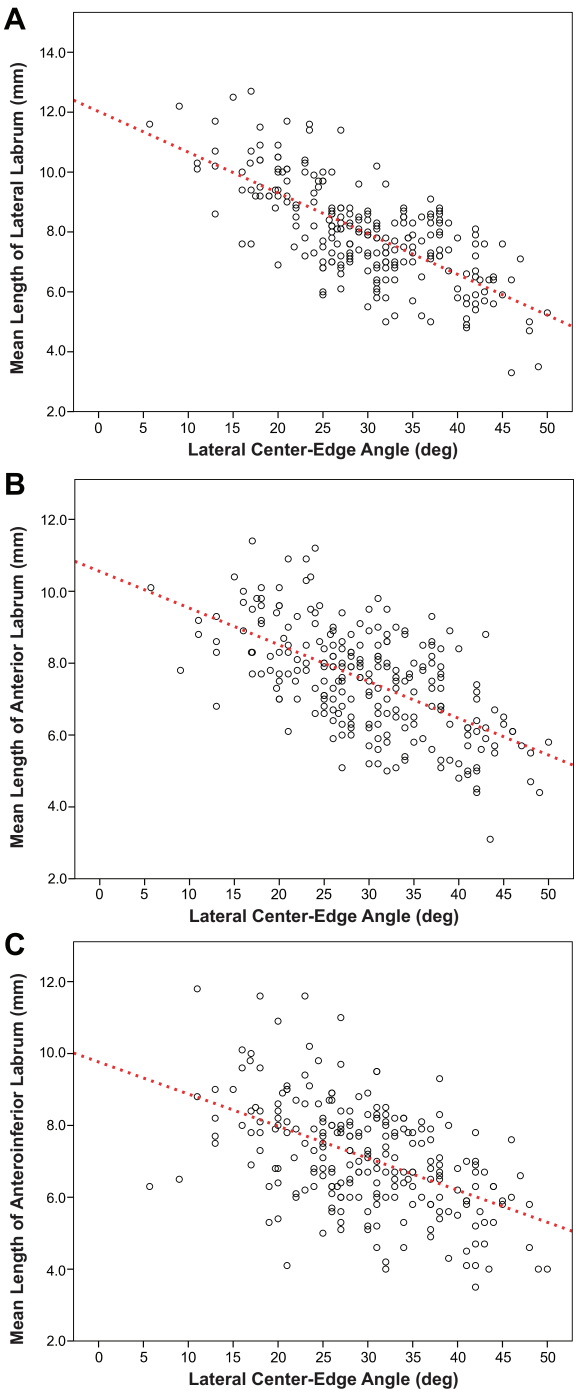

Figure 2. The mean length of the (A) lateral, (B) anterior, and (C) anteroinferior labrum is negatively correlated to measurements of the lateral center-edge angle.

Independent Predictors of Hip Labral Length

Stepwise multiple linear regression analysis was used to identify independent determinants of labral length at each measurement location on MRI. The length of the lateral labrum was predicted to increase by 0.14 mm per degree reduction in the LCEA (F(1,234) = 232.53; adjusted R^2 = 0.496; P < .001). Similarly, the length of the anterior labrum was predicted to increase by 0.11 mm per degree reduction in the LCEA but intrinsically decreased by 0.44 mm given the female sex (F(2,232) = 68.39; adjusted R^2 = 0.365; P < .001). Finally, anteroinferior labral length was predicted to increase by 0.09 mm per degree reduction in the LCEA (F(1,234) = 79.74; adjusted R^2 = 0.251; P < .001). The effects of these predictor variables outweighed those of all others, including age and BMI.

DISCUSSION

The results of this study demonstrate a significant relationship between acetabular coverage and labral size, providing evidence for our hypothesis that the labrum undergoes adaptive changes. Specifically, the mean labral length at the lateral location was 32% larger in frankly dysplastic hips and 21% smaller in hips with acetabular overcoverage relative to hips with normal coverage. This supports the notion that hips with deficient and excessive lateral acetabular coverage undergo unique patterns of pathomechanical loading, with compensatory hypertrophy in the former and osseous metaplasia in the latter.

This investigation revealed a reproducible trend of increasing labral size from the overcoverage group to the frankly dysplastic group at each location of measurement. In fact, the labrum at the lateral margin of dysplastic acetabula was almost twice the size of the corresponding labrum in acetabula with overcoverage. We were able to show that when standardizing the labral size by acetabular morphological type, both frank and borderline dysplasia exhibited similar (statistically equivalent) values that were significantly greater than those of the normal acetabular coverage group.

It is not surprising that lateral acetabular coverage was most strongly correlated with the length of the lateral labrum (Table 3). Interestingly, however, the LCEA also showed a statistically significant correlation with the size of both the anterior and anteroinferior labrum. One implication of this finding is that although we measured labral length at 3 discrete locations, it is important to realize that the labrum is a single continuous viscoelastic structure. As such, loads experienced by one anatomic region will be transmitted to the entire labrum via longitudinal collagen fibers. Additionally, lateral acetabular deficiency may be associated with a lack of coverage anteriorly and posteriorly as well, thereby exhibiting globally increased shear forces within the hip. With improved techniques for mapping acetabular volume, future studies may be able to resolve how different patterns of dysplasia geographically influence the adaptive changes seen in the labrum.

Acetabular version did not show a significant correlation to labral length. Given that version is a measure of anterior coverage relative to posterior coverage, it is possible that some hips with excessive acetabular anteversion had posterior overcoverage and that other hips with excessive acetabular retroversion had posterior undercoverage, thereby eliminating any correlation that would otherwise be seen as a result of excessive anteversion in the setting

TABLE 4
Hip Labral Length According to Lateral Acetabular Coverage[a]

LCEA	Sample Size, n	Labral Length, Mean ± SD, mm		
		Lateral	Anterior	Anteroinferior
<20.0°	28	10.12 ± 1.32	8.97 ± 1.06	8.32 ± 1.53
20.0°-24.9°	34	9.44 ± 1.23	8.61 ± 1.31	7.96 ± 1.58
25.0°-39.9°	139	7.68 ± 1.08	7.38 ± 1.13	7.03 ± 1.25
≥40.0°	35	6.08 ± 1.15	5.83 ± 1.12	5.67 ± 1.12

[a]Hips with frank and borderline acetabular dysplasia demonstrated statistically equivalent measurements of lateral, anterior, and anteroinferior labral length. These measurements were significantly increased relative to those of subgroups with normal acetabular coverage ($P < .001$) or acetabular overcoverage ($P < .001$). The mean labral length at all locations of measurement was in turn significantly increased for normal acetabular coverage relative to acetabular overcoverage ($P < .001$). There was a statistically significant increase in measurements of labral length when moving from anteroinferior to anterior to lateral aspects of the labrum across all groups ($P < .05$ for all comparisons), except in those with acetabular overcoverage. In hips with acetabular overcoverage, measurements of labral length did not differ significantly according to location. LCEA, lateral center-edge angle.

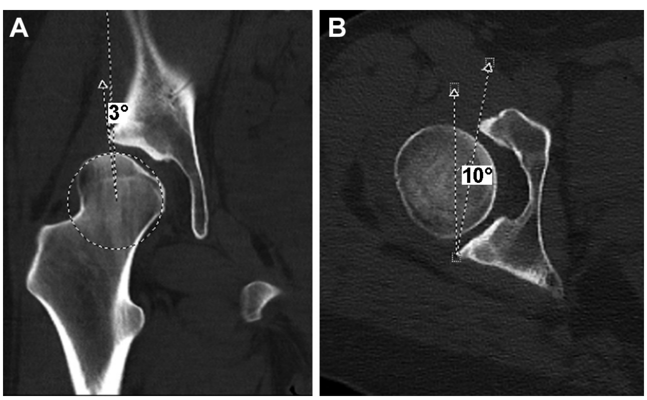

Figure 3. (A) Coronal and (B) axial computed tomography (CT) scans of a patient with frank dysplasia (CT-based lateral center-edge angle of 3°) and normal acetabular version of 10°. This figure illustrates the concept that acetabular version is a measure of anterior coverage relative to posterior coverage. In the setting of global dysplasia (lack of coverage anteriorly, laterally, and posteriorly), the net effect on acetabular version may be zero or even negative with apparent retroversion. A crossover sign in such cases should be interpreted with caution as errant anterior rim trimming would exacerbate the acetabular volume deficiency as well as the underlying hip instability.

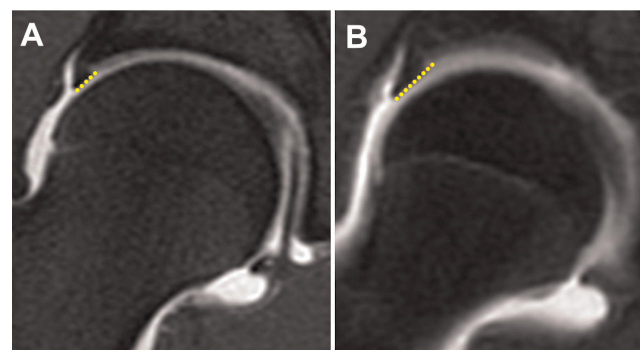

Figure 4. Coronal MRIs utilizing a fat-saturated proton density sequence comparing (A) acetabular overcoverage with (B) borderline dysplasia. The lateral labral length (dotted line) in borderline dysplasia was, on average, 55% larger than that in acetabular overcoverage.

of isolated anterolateral dysplasia. Furthermore, many borderline and frankly dysplastic hips exhibit global acetabular deficiency (laterally, anteriorly, and posteriorly), with a net zero effect on acetabular version (Figure 3). It is apparent, then, that acetabular version is a useful measure when considered in conjunction with other established parameters for coverage; however, it may be unreliable when used alone.

Our study revealed that borderline dysplastic hips (LCEA 20°-24.9°) demonstrated a similarly increased labral size when compared with frankly dysplastic hips (LCEA <20°). More importantly, both borderline and frankly dysplastic hips exhibited a significant increase in labral size when compared with hips with normal coverage or acetabular overcoverage (Figure 4). Currently, the majority of patients with borderline dysplasia are treated with hip arthroscopic surgery and/or capsular plication, attempting to restore stability through a "soft tissue only" approach.[8] Given the degree of similarity in adaptive changes between borderline and frank dysplasia, our study raises concerns for the adequacy of this approach in restoring hip stability. Further work is necessary to determine the extent to which borderline dysplastic hips behave like frankly dysplastic hips, thereby warranting consideration for both soft tissue and bony approaches to restoring stability via realignment osteotomy.

By developing improved methods to assess the labral contribution to hip stability, we can begin to integrate labral size characteristics into our decision-making algorithm to address hip pathological conditions. In our experience, many active patients with symptomatic cam-type FAI and borderline acetabular coverage exhibit a recurrence of symptoms approximately 6 to 12 months after arthroscopic treatment alone (cam osteoplasty, labral repair, and capsular plication) on resuming high-demand activities. These patients almost uniformly have enlarged labra, and it is our suspicion that they suffer from residual instability as all improve after subsequent periacetabular osteotomy. The clinical implication of correlating labral size characteristics to hip stability is profound as it may enable a more holistic treatment of borderline dysplastic patients with impingement characteristics.

Our study confirms prior qualitative observations of increasing labral size in patients with developmental dysplasia of the hip.[10,12,14,16,17,20] The majority of existing quantitative studies investigating labral size have focused on labral volume.[1,5,17,18] Similar to Cotten et al,[5] we observed that the thickness of the labrum (measured from the articular surface to the capsular surface) showed little variability, while the length (measured from the rim of the acetabulum to the free edge) showed significant variability. With this in mind, our findings are in keeping with those of Kubo et al,[18] who demonstrated significant increases in labral volume in patients with dysplasia compared with normal controls at all measured labral positions.

In a recent multicenter study investigating labral morphological types in dysplastic hips, Sankar et al[22] observed labral hypertrophy in only 40% of mildly dysplastic hips (LCEA $>20^\circ$ or AI $<20^\circ$) and 60% of severely dysplastic hips (LCEA $<20^\circ$ or AI $>20^\circ$). The authors concluded that labral enlargement is not a universal finding in hip dysplasia and is therefore not a reliable diagnostic criterion for instability. They further proposed that labral enlargement may be merely the end result of the failure of ossification of the cartilaginous acetabulum during development and that this condition is not unique to dysplasia. Although this hypothesis is intriguing and warrants further consideration, their investigation was limited by selection bias and qualitative/subjective determination of labral hypertrophy. Our study provides rigorous quantitative data for every subset of lateral acetabular coverage. These normative data may be used in future studies investigating the adaptive capacity of the skeletally mature labrum.

This study has several limitations that warrant discussion. First, the study was limited by the lack of a control group without pain for comparison. As a result, we have refrained from drawing any conclusions regarding the pain-generating capacity of an enlarged labrum. A second limitation involves the variability between imaging protocols performed on patients. Despite this heterogeneity, we maintained a low threshold to obtain repeat MRI scans if previously performed studies were deemed inadequate. Third, while the radiographic LCEA value was not available to the radiologists at the time of MRI measurements of labral size, they could not be blinded to a general assessment of the LCEA by visual inspection of the hip joint. The close approximations in the measured labral size between the 2 authors (M.K.J. and B.P.) as determined by the ICC results support the notion that the measurements were ultimately unbiased. Lastly, in this study, we categorized our patients according to the degree of lateral acetabular coverage. Given that hip dysplasia is a 3-dimensional problem involving varying degrees of anterior, lateral, and posterior acetabular deficiency, our borderline and frank dysplasia groups likely exhibit some heterogeneity with respect to the actual degree of global acetabular dysplasia.

CONCLUSION

We have shown a direct correlation between the severity of dysplasia and labral length, demonstrating that even patients with borderline dysplasia have significantly increased values when compared with hips with normal coverage or overcoverage. Borderline dysplasia poses a unique treatment dilemma, with options ranging from an arthroscopic-only approach to combined treatment with realignment osteotomy. Labral length may represent one of many adaptive changes serving as a marker of instability to guide decision making in patients with borderline dysplasia. Further studies are warranted to prospectively validate the use of labral length as a guide to treatment.

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