CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 382, pp. 232–240

Anatomy, Histologic Features, and Vascularity of the Adult Acetabular Labrum

Richard M. Seldes, MD; Virak Tan, MD*; Jennifer Hunt, MD**; Mark Katz, MD*; Raz Winiarsky, MD*; and Robert H. Fitzgerald, Jr., MD**

Acetabular labrum tears have been implicated as a cause of hip pain in adult patients. Few studies describe the anatomy, histologic features, and microvasculature of the acetabular labrum and labral tears. Fifty-five embalmed and 12 fresh-frozen adult hips with a mean age of 78 years (range, 61–98 years) were studied. Of these, 96% (53 of 55) of the hips had labral tears, with 74% of the tears located in the anterosuperior quadrant. Histologically, the fibrocartilaginous labrum was contiguous with the acetabular articular cartilage through a 1- to 2-mm zone of transition. A consistent projection of bone extends from the bony acetabulum into the substance of the labrum that is attached via a zone of calcified cartilage with a well-defined tidemark. Two distinct types of tears of the labrum were identified histologically. The first consisted of a detachment of the fibrocartilaginous labrum from the articular hyaline cartilage at the transition zone. The second consisted of one or more cleavage planes of variable depth within the substance of the labrum. Both types of labral tears were associated with increased microvessel formation seen within the tear. The acetabular labrum tear appears to be an acquired condition that is highly prevalent in aging adult hips. Labral tears occur early in the arthritic process of the hip and may be one of the causes of degenerative hip disease.

The acetabular labrum is a fibrocartilaginous structure attached to the acetabular rim. It has been studied in children in association with developmental dysplasia of the hip.[12,15,16,19–21,24,26,28] The acetabular labrum also has been implicated in various pathologic conditions of the adult hip.

Acetabular labral tears have been described as a biomechanical cause of hip pain in active adult patients.[1,6,7,9,11] Degeneration and alteration of the acetabular labrum in adult patients have been suggested as causes of hip pain and precursors to osteoarthritis of the hip.[1,2,8,25] Damage to the acetabular labrum has been reported as a cause of irreducible dislocation[5,17] or recurrent dislocation[14,22] after traumatic dislocation of the hip. Posterior hip dislocations produce posterior labrum tears. Surgical

From the Departments of *Orthopaedic Surgery and **Pathology, The University of Pennsylvania School of Medicine, Philadelphia, PA.

Reprint requests to Richard M. Seldes, MD, The Hospital for Special Surgery, Department of Medical Education, 535 East 70th Street, New York, NY 10021.

Received: September 7, 1999.

Revised: January 21, 2000; April 6, 2000.

Accepted: May 2, 2000.

TABLE 1. Acetabular Labrum Measurements

Measurements	Anterosuperior	Anteroinferior	Posteroinferior	Posterosuperior
Width (mm ± SD)	5.4 (± 2.3)	6.3 (± 2.4)	6.4 (± 1.7)	3.8 (± 1.8)
Thickness (mm ± SD)	5.5 (± 1.5)	4.0 (± 1.4)	4.2 (± 1.3)	4.9 (± 1.2)
Capsular recess (mm ± SD)	7.6 (± 2.6)	6.6 (± 2.7)	7.9 (± 3.2)	7.6 (± 2.5)

SD = standard deviation.

and the transverse acetabular ligament. The labrum appeared to be a continuous structure around the acetabulum as it formed the transverse acetabular ligament over the cotyloid notch. The hip capsule consistently inserted on the bony acetabulum proximal to and distinct from the labrum, forming a recess that ranged between 6.6 mm and 7.9 mm from the anteroinferior and posteroinferior quadrants, respectively.

Of hips, 96% (53 of 55) had gross labral tears. Of the tears, 74% were located in the anterosuperior acetabular quadrant, and 32% them extended into two or three quadrants. The average size of the tears was 2.7 cm (0.5–8.0 cm). Seven hips had two labral tears. Two morphologic types of labrum tears were seen. Of labrum tears, 89% were detachments of the labrum from the bony acetabulum, 11% of which were within the substance of the labrum. No difference was found between the size or distribution when comparing the two types of tears.

Stage 2 or less osteoarthritis was seen in 68% and 59% of the femoral heads and acetabula, respectively (Table 2). Of hips, 18 (33%) had focal arthritic lesions on the femoral head corresponding to the location of the labral tear. Further, 5% (three hips) of the acetabula had peripheral osteophyte formation that was formed within the labrum tear between the articular margin and the detached labrum. Two of three of these hips had only mild acetabular cartilage damage (Stage 2 arthritis).

The specimens studied histologically also had minimal to mild osteoarthritic changes. The articular cartilage was well-preserved with absent or rare evidence of flaking and fibrillation. The tidemark showed normal morphologic features without significant reduplication or thickening.

Histologically, the acetabular labrum merged with the articular hyaline cartilage of the joint surface of the acetabulum through a transition zone of 1 to 2 mm (Fig 2). A consistent thin tongue of bone extended from the edge of the bony acetabulum into the substance of the labrum (Figs 1,3). The labrum attached firmly to the articular side of this bony extension via a zone of calcified cartilage with a well-defined tidemark. The labrum attached directly to the outer surface of this bony extension of the acetabulum without a zone of calcified cartilage or a tidemark (Fig 3). A group of three to four small blood vessels was located in the substance of the labrum, traveling circumferen-

TABLE 2. Arthritis of the Femoral Head and Acetabulum

Site of Arthritis	None N (%)	1 N (%)	2 N (%)	3 N (%)	4 N (%)
Femoral Head	8 (15%)	11 (20%)	18 (33%)	15 (27%)	3 (5%)
Acetabulum	5 (9%)	14 (25%)	14 (25%)	19 (36%)	3 (5%)

Classification of hip arthritis of Byers et al.[2]

repair or excision of the acetabular labrum by arthroscopic or open means have been described as treatment options for acetabular labrum tears.[1,3,6,7,9,11,14,17,22]

Although a growing literature describes pathologic clinical conditions of the adult acetabular labrum[1,6,7,9,11] and surgical treatments,[1,3,6,7,9,11,14,17,22] few studies describe the anatomy of this structure in the adult.[2] The current study was done to describe the gross, histologic, and microvascular anatomy of the adult acetabular labrum and tears of the labrum.

MATERIALS AND METHODS

For the current study, 55 embalmed and 12 fresh-frozen cadaveric hips were used. The donors were 50% female, with a mean age of 78 years (range, 61–98 years). A history of hip function or symptoms before death was not available.

The gross anatomy was studied systematically in each embalmed hip. All soft tissues surrounding the hip capsule were dissected free. A capsulotomy then was performed circumferentially at the midportion of the femoral neck, taking care to preserve the labrum and the articular surfaces. The hips were disarticulated after cutting the ligamentum teres at its femoral insertion. Arthritic changes of the acetabulum and femoral head were recorded using the staging system described by Byers et al.[2] The appearance of Stage 1 arthritis consisted of cartilage with a fine granularity. In Stage 2 arthritis, coarse granularity and superficial fraying were present. Stage 3 arthritis consisted of deep fissuring and loss of cartilage substance leaving a depressed area with a rough base of soft tissue. In Stage 4 arthritis was seen ossification in the base of a lesion with a Stage 3 appearance.

All labral tears were documented, noting size and location around the acetabulum. The tears were localized to one or more acetabular quadrants. A labral tear was defined as a detachment of the labrum from the bony acetabulum where a 3-mm probe could be inserted. Standardized measurements were made of each labrum as shown in Figure 1. Measurements of the labrum were recorded corresponding to each acetabular quadrant.[27] The relationship of the hip capsule, ligamentum teres, and cotyloid notch to the labrum was documented.

The fresh-frozen hips were dissected as described above. During each dissection, the appearance of the acetabulum, femoral head, labrum, and labral tears were recorded. Each bony acetabulum was removed from the pelvis by osteotomizing the ilium, ischium, and pubic bones. The capsular attachments to the bony acetabulum were left intact. Each specimen was preserved in 10% buffered formalin and decalcified in 10% formic acid. Radial sections were cut from the center of the acetabulum to the labrum, perpendicular to its surface, at 45° increments. Each section was labeled according to the acetabular quadrant from which it originated. The specimens then were embedded in paraffin, cut into 5 μm sections, stained with hematoxylin and eosin, and examined with light and polarized light microscopy. Microvascular staining was performed using immunohistochemical stains for Factor VII antigen[23] (Dako, Carpenteria, CA; dilution 1:3000).

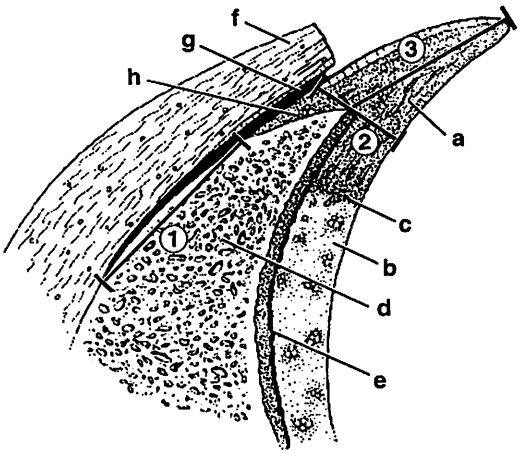

Fig 1. Illustration of histologic appearance of labrum attachment site. (A) labrum; (B) articular hyaline cartilage; (C) articular cartilage–labrum transition zone; (D) bony acetabulum; (E) tidemark; (F) hip capsule (cut); (G) capsular recess; (H) group of vessels. 1. capsular recess; 2. thickness of labrum; 3. width of labrum.

RESULTS

All hips had labra present and had well-formed acetabula. Overall, the labrum was widest in its anterior half and thickest in its superior half (Table 1). Inferiorly, no distinction was seen between the substance of the labrum

Fig 4. Photomicrograph showing a group of vessels (h, arrows) within the labrum (A) and hypervascular synovium within the capsular recess (G); capsule (F); The bony acetabulum also is seen (D) (Stain, factor VIII immunohistochemical stain; magnification, ×10).

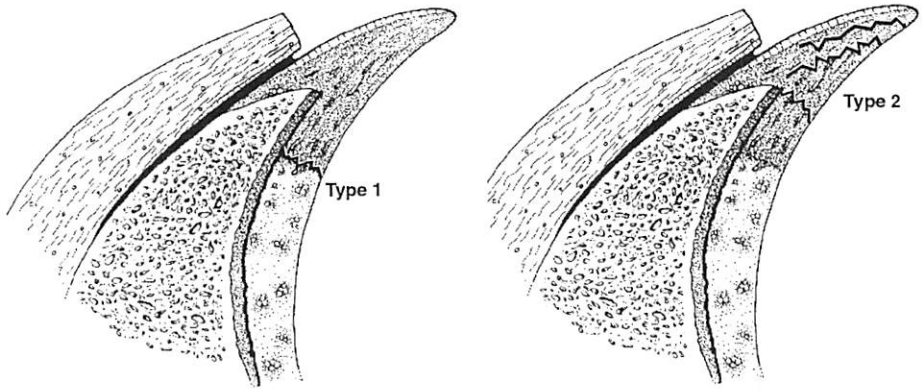

Fig 5. Illustration of Type 1 and Type 2 labral tears.

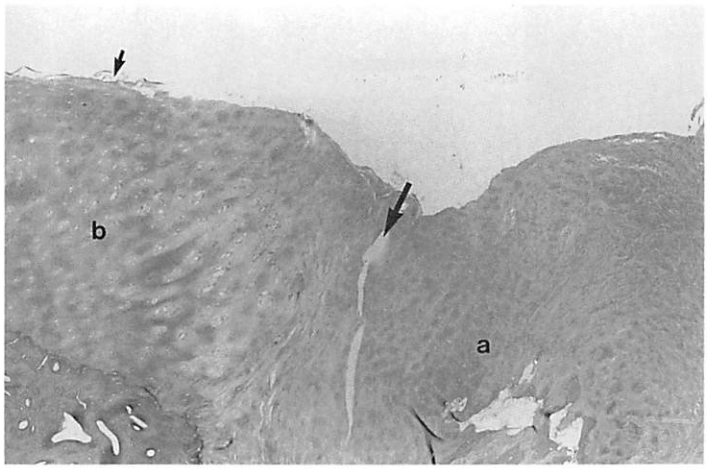

Fig 6. Photomicrograph of Type 1 labral tear (large arrow) at the transition zone between the labrum (A) and the articular cartilage (B). Only mild arthritic changes on articular cartilage (small arrow) are present (Stain, hematoxylin and eosin; magnification, ×10).

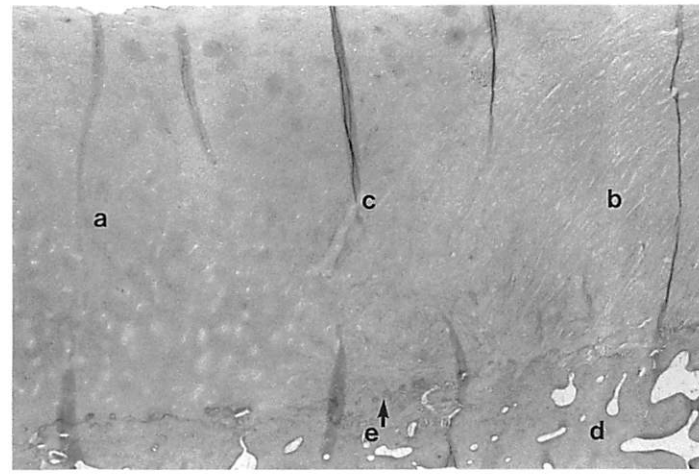

Fig 2. Photomicrograph of labrum attachment (B) to bony acetabulum (D) and transition zone (C) between labrum and articular cartilage (A). Tidemark zone is visible (E) (Stain, hematoxylin and eosin; magnification, ×10).

tially around the labrum at its attachment site on the outer surface of the bony acetabular extension. A narrow synovial-lined recess separated the labrum from the capsule. The lining of the cleft consisted of highly vascularized, loose connective tissue and fat (Fig 4).

Two distinct types of tears of the labrum were identified histologically (Fig 5). The first type of tear consisted of a detachment of the labrum from the articular cartilage surface. These tears occurred at the transition zone between the fibrocartilaginous labrum and the articular hyaline cartilage (Fig 6). This type of tear was perpendicular to the articular surface and, in some cases, extended down to the subchondral bone.

The second tear consisted of one or more cleavage planes of variable depth within the substance of the labrum. This type of tear extended perpendicular to the surface of the labrum. The tears of this type that extended to the subchondral bone were associated with tidemark reduplication and endochondral ossification in the labrum.

Various histologic degenerative changes were seen in conjunction with the labral tears. More advanced labral tears frequently were associated with adjacent articular cartilage

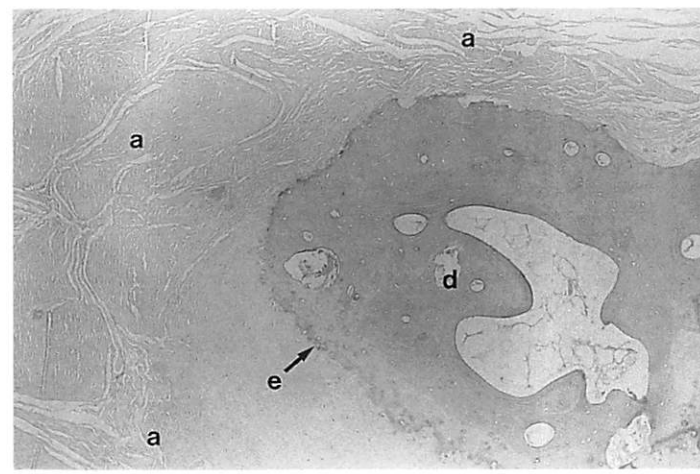

Fig 3. Photomicrograph of bony acetabular tongue (D) within the labrum (A). Tidemark zone (E) is visible at the attachment site on the articular side of the labrum (Stain, hematoxylin and eosin; magnification, ×10).

in 1977 by Altenberg,[1] who reported two patients successfully treated with partial labral excision through an arthrotomy. Since then, several studies have been published regarding the diagnosis, imaging,[3,4,13,18] and treatment[1,3,5–7,9,11,14,22] of acetabular labrum tears. Few studies, however, have described the anatomy of the adult acetabular labrum[2,10] and no studies have investigated the histologic features and microvasculature of this structure and associated tears. The current study provides a detailed description of the gross, histologic, and microvascular anatomy of the adult acetabular labrum and labrum tears.

Significant findings from this investigation include the high prevalence (95%) of labrum tears in the cadaveric hips studied and the confirmation that most of these tears occur in the anterosuperior acetabular quadrant. In addition, a detailed histologic description of the labral attachment to the bony acetabulum and two distinct types of tears were described. The microvascular anatomy of the labrum and labrum tears also was documented.

The high prevalence of labral tears seen in the cadaveric specimens in the current study indicates that the acetabular labrum tear is a common finding in the aging adult hip. It is impossible to predict the clinical significance of this finding in an anatomic study such as the current one, although this finding is consistent with the gross anatomic study of cadaveric hips by Byers et al.[2] In the Byers et al study of 365 cadaveric hips from patients ranging in ages from 9 to 89 years, 88% of hips from patients older than 30 years of age had detachments of the labrum from the articular cartilage. The prevalence of detachments increased with increasing age. Of detachments, 64% were located anteriorly. The presence of a tear in hips from patients younger than 30 years of age was extremely rare.

Several clinical studies[3,7,13,18] have implicated the anterior and superior quadrants as the regions where acetabular labral tears most commonly occur. Walker[26] in an anatomic study of 74 normal fetal acetabula found that 14% of the labra had a cleft present in the anterosuperior acetabular quadrant between the labrum and the cartilaginous socket that was observed only microscopically. This region, therefore, may be a weak area in the labrum that predisposes it to detachments at a later age. These detachments may be potentiated by acetabular dysplasia where abnormal forces act on the labrum-cartilage junction, which may explain the high association of labral tears seen in patients with hip dysplasia. In addition, a weak region in the labrum may explain why patients with a history of only minor trauma have labral tears develop. The repeated stresses on the hip from everyday life over several decades also may be enough to cause a labral tear in a potentially weak region as evidenced in the current study and in the work of Byers et al.[2]

As a result of the current study, two distinct types of labral tears have been identified. One occurring at the articular cartilage and labrum transition zone and one within the substance of the labrum. From the current findings, the authors think that the labral tear is a factor in peripheral acetabular osteophyte formation. In 5% of the hips studied, osteophytes were interposed within a labrum tear between the articular cartilage and the labrum. This phenomenon also was confirmed histologically as cystic destruction of bone with prominent remodeling and osteophyte formation were seen within labrum tears that extended to the subchondral bone. Osteophytes within labral tears were present in some hips without advanced arthritis. This phenomenon may be one of the early stages (or a causative factor) of degenerative joint disease of the hip. Based on the measurements of the labrum in the current study, the labrum appears to contribute significantly to the morphologic features of the hip. Therefore, a tear of the labrum might lead to minor abnormal migration of the femoral head, causing traction at the labral-bony acetabulum junction and resulting in osteophyte formation within the labral tear.

The attachment site of the labrum to the bony acetabulum is an interesting construct. A projection of bone from the bony acetabulum

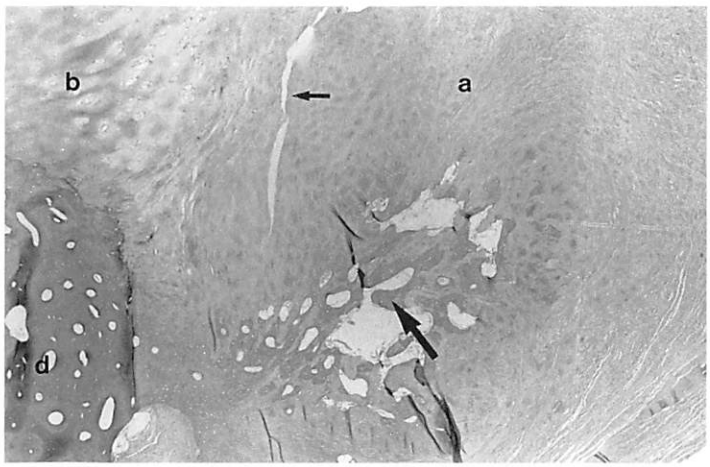

Fig 7. Photomicrograph of osteophyte formation (large arrow) in the presence of a Type 1 labral tear (arrow) between the labrum (A) and the articular cartilage (B); bony acetabulum (D) (Stain, hematoxylin and eosin; magnification, ×10).

lesions. This adjacent articular cartilage became detached from the subchondral bone, which formed a flap of articular cartilage just above the tidemark. The most striking degenerative changes were seen when a labral tear progressed to a detachment of labrum from the underlying bony projection of the acetabulum. The degenerative changes that resulted included tidemark reduplication and cystic destruction of the subchondral bone with prominent remodeling. In some cases, osteophyte formation resulting from a tear was seen (Fig 7).

Both types of tears were associated with chondrocyte proliferation and hyalinization of the labral fibrocartilage along the edges of the defects. Evidence also was seen of myxoid changes and cystic spaces in the fibrocartilaginous substance of the labrum in some cases. All labral tears were associated with increased microvascularity within the substance of the labrum at the base of the tear adjacent to the labrum's attachment to bone (Fig 8).

DISCUSSION

An acetabular labrum tear in a young adult patient not associated with major trauma is a recently recognized entity. It first was described

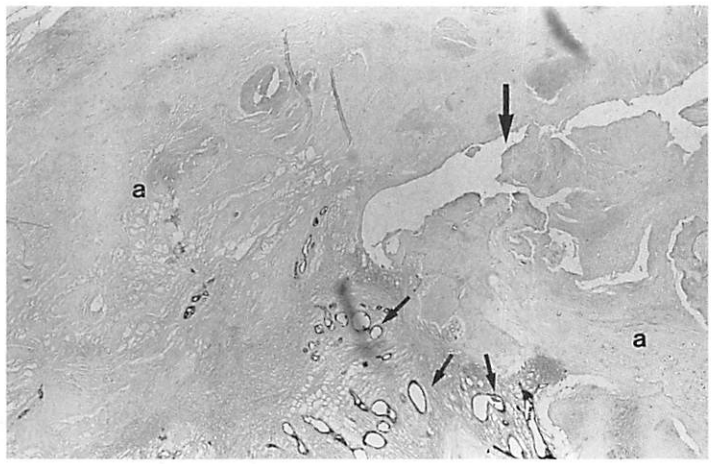

Fig 8. Photomicrograph showing hypervasculatrity (small arrows) within a Type 2 labral tear (large arrow); labrum (A) (Stain, factor VIII immunohistochemical stain; magnification ×10).

13. Leuning M, Werlen S, Ungersbock A, et al: Evaluation of the acetabular labrum by MR arthrography. J Bone Joint Surg 79B:230–234, 1997.
14. Lieberman JR, Altchek DW, Salvati EA: Recurrent dislocation of a hip with a labral lesion: Treatment with a modified Bankart-type repair. J Bone Joint Surg 75A:1524–1527, 1993.
15. Matles AL: A microscopic study of the newborn fibrocartilaginous acetabular labrum. Clin Orthop 54:197–206, 1967.
16. Milgram JW, Tachdjian MO: Pathology of the limbus in untreated teratologic congenital dislocation of the hip. A case report of a ten-month-old infant. Clin Orthop 119:107–111, 1976.
17. Patterson I: The torn acetabular labrum. J Bone Joint Surg 39B:306–309, 1957.
18. Petersilge CA, Haque MA, Petersilge WJ, et al: Acetabular labral tears: Evaluation with MR arthrography. Radiology 200:231–235, 1996.
19. Ponseti IV: Growth and development of the acetabulum in the normal child. J Bone Joint Surg 60A:575–585, 1978.
20. Ponseti IV: Morphology of the acetabulum in congenital dislocation of the hip. J Bone Joint Surg 60A:586–599, 1978.
21. Ralis Z, McKibbin B: Changes in shape of the human hip joint during its development and their relation to its stability. J Bone Joint Surg 55B:780–785, 1973.
22. Rashleigh-Belcher HJC, Cannon SR: Recurrent dislocation of the hip with a "Bankart-type" lesion. J Bone Joint Surg 68B:398–399, 1986.
23. Sehested M, Hou-Jensen K: Factor VIII related antigen as an endothelial cell marker in benign and malignant diseases. Virchows Arch 391:217–225, 1981.
24. Strayer LM: Embryology of the human hip joint. Clin Orthop 74:221–240, 1971.
25. Ueo T, Hamabuchi M: Hip pain caused by cystic deformation of the labrum acetabulare. Arthritis Rheum 27:947–950, 1984.
26. Walker JM: Histologic study of the fetal development of the human acetabulum and labrum: Significance in congenital hip disease. Yale J Biol Med 54:255–263, 1981.
27. Wasielewski RC, Cooperstein LA, Kruger MP, et al: Acetabular anatomy and the transacetabular fixtion of screws in total hip arthroplasty. J Bone Joint Surg 72A:501–508, 1990.
28. Watanabe RS: Embryology of the human hip. Clin Orthop 98:8–26, 1974.

extends into the substance of the labrum. The labrum attaches to this bony extension by a tidemark and a zone of calcified cartilage. This is an interesting observation because a tidemark and zone of calcified cartilage typically are seen with hyaline or articular cartilage. This bony extension of the acetabulum with the fibrocartilaginous labrum firmly attached by a tidemark effectively increases the articular weightbearing surface of the acetabulum.

The normal microvasculature of the acetabular labrum consists of a group of small vessels located in the substance of the labrum traveling circumferentially around the labrum at its attachment site on the outer surface of the bony acetabular extension. In addition, the labrum is surrounded by highly vascularized synovium that is present in the capsular recess. In all of the labral tears studied histologically, neovascularization had occurred within the tear and the substance of the labrum. This new vessel formation may be the result of migration of the surrounding synovium into the tear or a result of bleeding from the underlying subchondral bone. A potential appears to exist for healing of labral tears, which may have an impact on treatment protocols for acute labral tears. From the current anatomic study, it is impossible to determine which labrum tears were symptomatic and, therefore, complete clinical correlation is still in question. However, based on the presence of neovascularization seen within labral tears, it may be possible to heal a clinically symptomatic acute tear with protected weightbearing for a period of time or through surgical fixation of the torn labrum to the bony acetabulum.

To understand the consequences of acetabular labral tears and partial excision of the acetabular labrum, the function of the acetabular labrum needs to be better understood. As a part of the current study, based on the measurements made of the acetabulum and the labrum, it was determined that the labrum contributed an average of 22% to the articulating surface of the hip and increased the volume of the acetabulum by 33%. The acetabular labrum does appear to contribute significantly to the morphologic features of the hip. Acetabular labrum tears and partial labrum excisions may accelerate degenerative articular changes attributable to altered hip biomechanics. Additional study is needed to better understand the biomechanical implications attributable to a tear or a partial excision of the acetabular labrum.

The acetabular labrum tear appears to be an acquired condition that is highly prevalent in aging adult hips. A labral tear appears to occur early in the arthritic process of the hip and may be one of the causes of degenerative hip arthritis. Two distinct types of labral tears occur, which may be related to the histologic anatomy of the attachment site of the labrum to the bony acetabulum. A microvascular response consistently occurs within labral tears. Protected weightbearing or surgical fixation of labral tears may be options for treatment of labral tears but additional clinical studies are needed.

References

1. Altenberg AR: Acetabulur labrum tears: A cause of hip pain and degenerative arthritis. South Med J 70:174–175, 1977.
2. Byers PD, Contepomi CA, Farkas TA: A post mortem study of the hip joint. Ann Rheum Dis 29:15–31, 1970.
3. Byrd JW: Labral lesions: An elusive source of hip pain. Arthoscopy 12:603–612, 1996.
4. Czerny C, Hofmann S, Neuhold A, et al: Lesions of the acetabular labrum: Accuracy of MR imaging and MR arthrography in detection and staging. Radiology 200:225–230, 1996.
5. Dameron TB: Bucket handle tear of acetabular labrum accompanying posterior dislocation of the hip. J Bone Joint Surg 41A:131–134, 1959.
6. Dorrell JH, Catterall A: The torn acetabular labrum. J Bone Joint Surg 68B:400–403, 1986.
7. Fitzgerald RH: Acetabular labrum tears. Clin Orthop 311:60–68, 1995.
8. Harris WH, Bourne RB, Oh I: Intra-articular acetabular labrum: A possible etiological factor in certain cases of osteoarthritis of the hip. J Bone Joint Surg 61A:510–514, 1979.
9. Ikeda T, Awaya G, Suzuki S, et al: Torn acetabular labrum in young patients. J Bone Joint Surg 70B:13–16, 1988.
10. Keene GS, Villar RN: Arthroscopic anatomy of the hip: An in vivo study. Arthroscopy 10:392–399, 1994.
11. Klaue K, Durnin CW, Ganz R: The acetabular rim syndrome. J Bone Joint Surg 73B:423–429, 1991.
12. Laurenson RD: Development of the acetabular roof in the fetal hip. J Bone Joint Surg 47A:975–983, 1965.