Treatment of Labral Pathology: Reattachment and Replacement

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Introduction and Basic Science

Introduction

The acetabular labrum has an important role in the structure and function of the hip. In young, active patients, painful labral tears can limit activities or sports. These may be the result of an acute hip injury but can also be the first indicators of subtle acetabular dysplasia, femoroacetabular impingement, or joint laxity. The biomechanical function of the labrum is complex and continues to be debated. Furthermore, although it is an area of intense interest and current research, it is not yet known if current joint-preserving strategies will ultimately prevent hip arthritis. Nonetheless, addressing labral pathology and contributing bony anomalies can resolve hip pain and allow patients to return to their activities.

Embryology and Development of the Labrum

The cells of the acetabular labrum are first visible at 6 weeks gestation as the limb buds begin to differentiate. By 8 weeks gestation, the major structures in the hip, including the cartilage anlage for the acetabulum and femur as well as the joint capsule and synovium are microscopically identifiable. Correspondingly, the labrum begins to have a more triangular appearance at the acetabular rim [1]. It is important to note that the position of the femur relative to the acetabulum changes during the course of early development and may affect the structure of the developing labrum. During fetal development, the lower extremity internally rotates between weeks 8 and 11. At 11 weeks gestation the hip and knee are flexed and both lower extremities are adducted, with the left leg overlapping the right. The legs continue to flex until approximately 16 weeks gestation, when the full fetal position is attained. In the fetal position the hips are considered to be in a stable position [1, 3] with the inferior portion of the femoral head in contact with the anterior acetabulum [2].

Microscopically, the anterior labrum "caps" the anterior acetabulum during development, with a more tenuous attachment to the acetabular rim than the posterior labrum (Fig. 19.1) [2]. The transition between the acetabular cartilage and labrum anteriorly is somewhat abrupt and the collagen fibers are parallel to the chondrolabral junction (Fig. 19.1) [2, 4]. Posteriorly, the labrum has no intra-articular projections and is continuous with the acetabular cartilage with a gradual and interdigitated transition. Here, the collagen fibers are perpendicular to the chondrolabral junction (Fig. 19.1) [2, 4]. Subsequent changes to the labral structure that occur with more erect posture are not well-described. It is not known if the structure of labrum observed during development leads to the development of an area of weakness that predisposes later tears. In terms of vascularity the developing labrum's blood supply originates from the capsular side of the labrum and traverses to the articular aspect [4, 5].

Anatomy

Gross Appearance

The labrum is nearly circumferential around the acetabular fossa with anterior and posterior horns that are continuous and indistinguishable from the transverse acetabular ligament (Fig. 19.2a) [6, 7]. The labrum is widest anteriorly and thickest superiorly due to its triangular cross-section [7]. The joint capsule inserts on the bony acetabulum proximal to and distinct from the labrum, which creates a recess around the labrum (Fig. 19.2b) [7].

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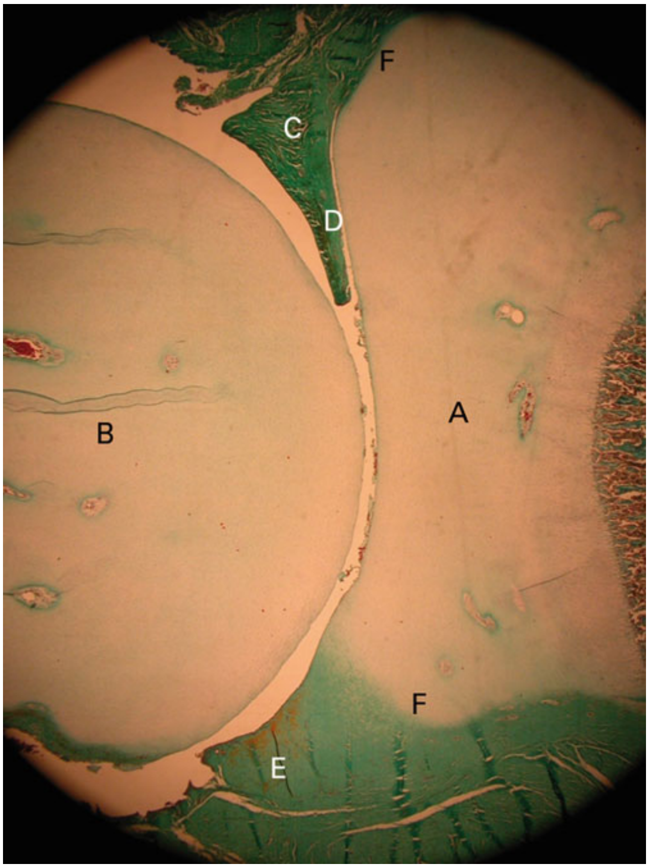

Fig. 19.1 The developing labrum. Photomicrograph of a fetal hip at term showing the attachments of the anterior and posterior labrum to the acetabular cartilage. The transition between the anterior acetabular cartilage and labrum is abrupt, with an intra-articular projection. The posterior labrum is directly attached to the acetabular cartilage with a gradual and interdigitated transition. There is no intra-articular projection of the posterior labrum. *A* acetabulum, *B* femoral head, *C* anterior labrum, *D* intra-articular projection of the anterior labrum, *E* posterior labrum, *F* posterior acetabulum-labrum transition zone (Reprinted with permission, Cashin [2])

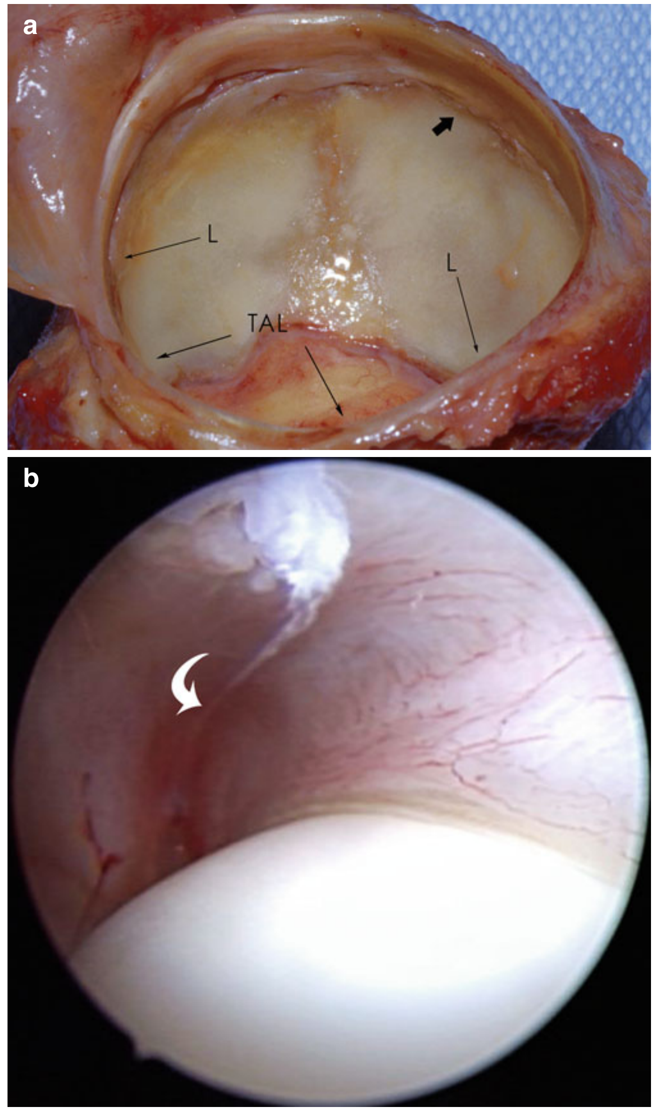

Fig. 19.2 Anatomy of the labrum. (**a**) Cadaveric labrum. The anterior and posterior horns of the labrum (*L*) are continuous and indistinguishable from the transverse acetabular ligament (*TAL*). Age-appropriate degenerative changes can be seen at the chondrolabral junction (*black arrow*). (**b**) Arthroscopic picture of the labrum from the peripheral compartment. The joint capsule attaches on the bony acetabulum above the labrum, creating the capsular recess (*curved arrow*). The most superficial layer of tissue on the capsular side of the labrum is well-vascularized, as can be seen here, and provides the majority of the blood supply to the labrum

Microscopic Anatomy and Histology

In the adult hip, there is a thin extension of bone into the substance of the labrum. In children, this extension remains cartilaginous as part of the acetabular epiphyseal cartilage (Fig. 19.3a, b) [1, 6, 7]. The articular and capsular sides of the labrum are structurally significantly different. The most superficial tissue layer on the capsular side is loose and well-vascularized (Fig. 19.2b). This then transitions to a layer of dense connective tissue, with a continuous transition between this dense connective tissue to a thin layer of fibrocartilage on the articular side of the labrum. This fibro cartilaginous layer consists of chondrocytes embedded between collagen fibrils [8]. The articular side of the labrum is in turn attached to the bony acetabulum via a tidemark zone of calcified cartilage [7]. A physiologic cleft between the labrum and cartilage has been observed under light microscopy at the chondrolabral junction [6, 8] and under scanning electron microscopy, a clear transition between the collagen structure of the cartilage and labrum can be seen. The difference in the collagen ultrastructure is indicative of the distinct functions of the cartilage and the labrum in the hip. The main portion of the labrum is made up of circumferentially oriented collagen fibers that are continuous with the transverse acetabular ligament [8]. These fibers consist of Type I collagen fibers that are divided into bundles by Type III collagen [8]. As collagen bundles are generally oriented in the direction of greatest tension, the circumferential orientation of the collagen

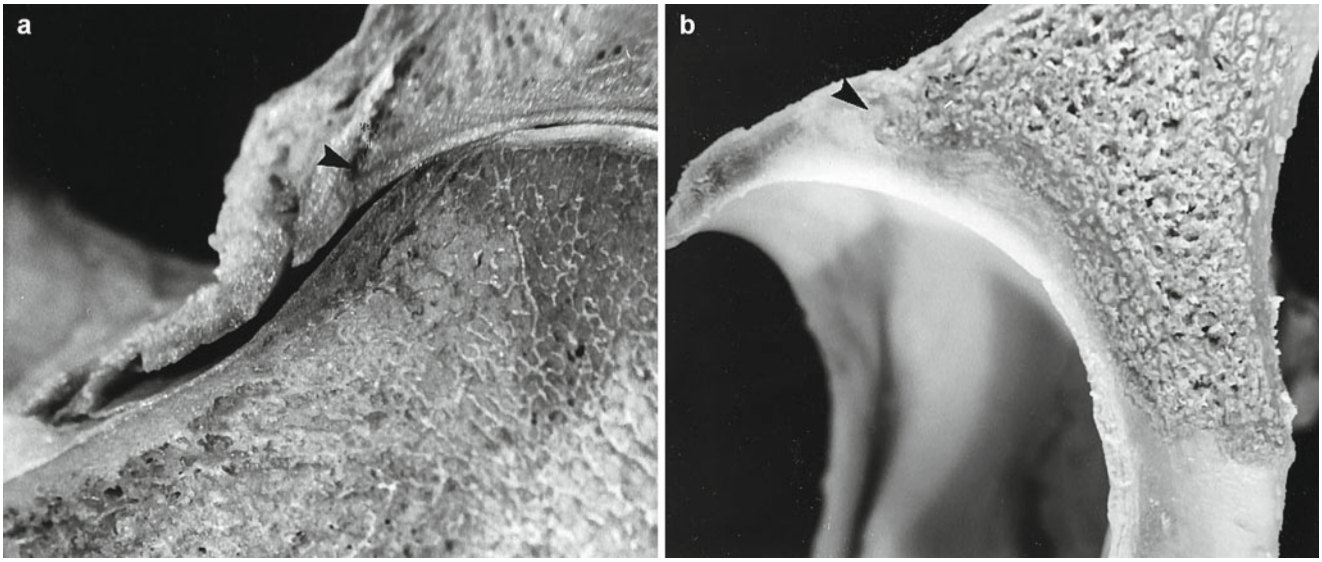

Fig. 19.3 Relationship of the labrum to the bony acetabulum. (**a**) Coronal cross section through an adult acetabulum and labrum. In the adult, the bony acetabulum (*arrowhead*) extends into the substance of the labrum. (**b**) Oblique cross section through the acetabulum and labrum of a child. In children, the acetabular epiphyseal cartilage extends into the labral substance; the ossified portion of the acetabulum (*arrowhead*) does not extend to the labrum (Reprinted with permission, Putz and Schrank [6])

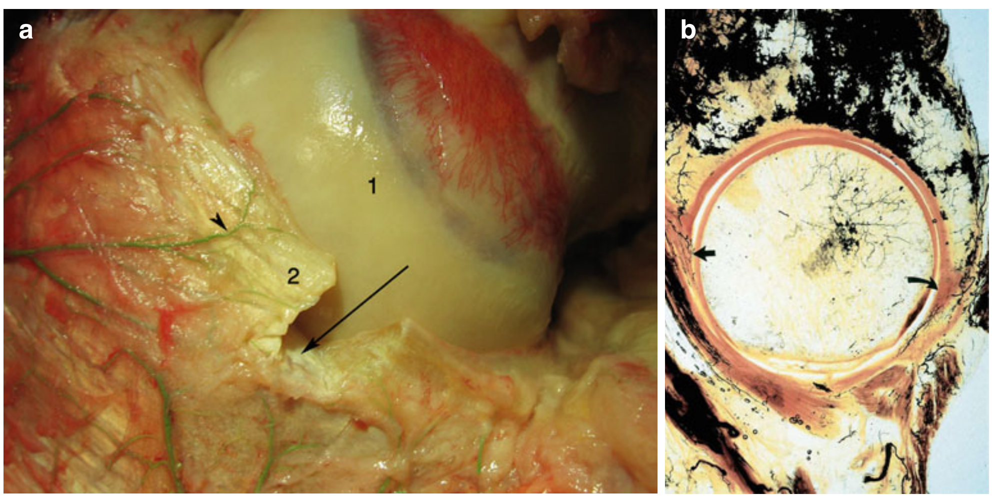

Fig. 19.4 Vascularity of the labrum. (**a**) Macroscopic perfusion of the labrum from radial branches of the periacetabular vascular ring (*arrowhead*). *1* Femoral head, *2* labrum. A section has been resected from the labrum to show the osseolabral junction (*arrow*). There are no grossly visible vessels at the junction (Reprinted with permission, Kalhor et al. [10]). (**b**) Sagittal section of the acetabulum and femoral head demonstrating microscopic vascularity of the labrum. The majority of the labral blood supply is from capsular perfusion, with a small contribution from the subchondral bone. Anterior labrum: *straight arrow*, posterior labrum: *curved arrow* (Reprinted with permission, Kelly et al. [11])

fibers in the labrum may be indicative of its biomechanical function [8].

The innervation of the labrum appears to be mostly on the capsular side. Free nerve endings—thought to primarily sense pain, as well as sensory nerve receptors for pressure, deep sensation, and temperature have been observed [9].

Vascularity

The sources of labral perfusion and the sites of labral vascularity have implications for healing after labral reattachment. Macroscopically, the labrum is perfused by radial branches of the periacetabular vascular ring (Fig. 19.4a). The majority of the blood supply to the ring comes from the superior and inferior gluteal arteries, with lesser contributions from the medial and lateral femoral circumflex arteries [10]. Microscopically, vascularity is greatest on the capsular side of the labrum and is about twice that of the articular aspect [8, 11]. No differences in vascularity have been observed between the anterior, posterior, or superior aspects of the labrum or between intact and degenerative specimens [11]. In addition, there is some perfusion from the bony acetabulum, although this is more variable than the capsular contribution (Fig. 19.4b) [11].

Biomechanics and Function

Biomechanics

The tensile and compressive properties of the labrum vary around its circumference. The Young's modulus (strength in tension) is significantly lower in the anterior-superior region of the labrum compared to the anterior-inferior region [12]. The compressive modulus (strength in compression) is lower in the anterior-superior region compared to the posterior labrum and there are no significant differences in the compressive modulus between other regions of the labrum [12]. Overall, the tensile and compressive properties of the labrum appear to be comparable to that of the meniscus in the knee suggesting a similar role [13]. It is worth noting that these biomechanical studies were undertaken in a cadaver model using older specimens. It is known that the biomechanical properties of connective tissue and cartilage in joints change with age, even if the structures are not obviously degenerative [14]. Labral strain in different positions has also been described [15]. In neutral flexion-extension and rotation, the labrum was found to be in a "pre-stretch" state with some load present already. Flexion and adduction created the highest strain in the anterior labrum; this increased slightly with external rotation as compared with neutral rotation. Hip flexion also caused increased strain in the lateral labrum; this was higher in the neutral position than in combination with abduction or adduction. When examined independently, abduction causes the highest amounts of strain in the lateral labrum, both in flexion to 90° and in full extension. Hip extension and neutral rotation created the highest strain in the anterolateral labrum; this increased with external rotation but decreased with adduction, abduction, and internal rotation. The posterior labrum has the highest overall magnitudes of strain [15].

Function

The labrum appears to have multiple roles in the hip. The relative contributions and exact mechanisms of these roles to overall hip function continue to be the subject of debate.

The most accepted of these roles is the labral contribution to hip joint sealing. The labral seal was first described in the nineteenth century [16] and appears to facilitate joint lubrication and cartilage nutrition. An intact labrum is less permeable than articular cartilage or meniscus [13] and is generally resistant to fluid extrusion from the joint [13]. This allows for maintenance of the labral seal, creating a pressurized fluid layer between the cartilage of the acetabulum and the femoral head. Load across the joint is carried by the fluid layer, shielding the articular cartilage from stress and increased friction, with a more even distribution of load (Fig. 19.5a) [16–19]. Loss of the labral seal results in increased load transfer by direct cartilage contact (Fig. 19.5b). This results in increased friction leading to degenerative changes in the cartilage, and ultimately results in arthritis. This has been

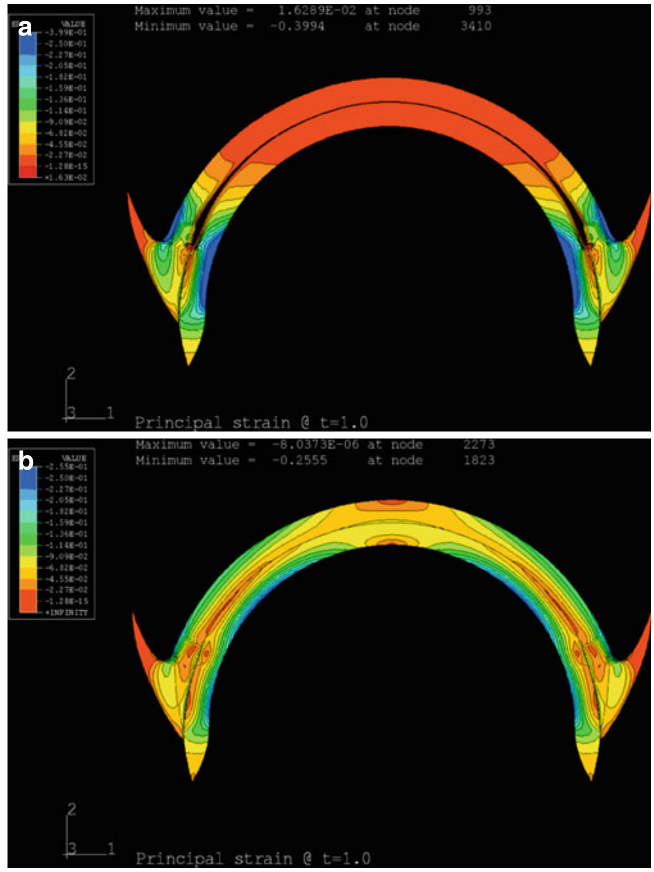

Fig. 19.5 Effect of the labral seal on cartilage stress. Finite element model of hip cartilage stress with (**a**) and without (**b**) the pressurized fluid layer created by the labral seal. With an intact labral seal, articular cartilage stress is evenly distributed and directed towards the periphery of the joint. When the labral seal is disrupted, the pressurized fluid layer is lost. There is direct cartilage contact, which increases friction and load across the cartilage surface (Reprinted with permission, Ferguson [16])

demonstrated in both finite element [18, 19] and cadaveric studies [17] and an MRI study has shown improvements in distribution of cartilage strain following labral reattachment when compared to labral resection [20]. A recent finite element model suggested that the labrum supports more load in the dysplastic hip than in the normal hip [21]. Interestingly, the model did not observe improvements in cartilage contact stress with preservation of the labrum as compared to labral resection. As a result, the authors argued that the labral seal has a larger contribution to hip stability rather than decreasing cartilage contact stresses [21].

The contribution of the labrum to hip stability is postulated to occur via both the labral seal as well as providing a mechanical block to motion. This is, however, the more debated role of the labrum. Grossly, the labral seal was noted to improve hip stability in the nineteenth century [16]. Multiple articles describing techniques in hip arthroscopy have noted that decreased force is required for traction during hip arthroscopy once the labral seal has been broken by introduction of a cannulated needle into the central compartment

[22]. Preservation of the labrum and capsule was also observed to improve the stability of hip hemiarthroplasty performed for femoral neck fracture [23]. The force required to distract the hip after both venting and incising the labrum was examined in a cadaveric study. The greatest proportional decrease in force occurred after incising the labrum, with 60 % less force required to distract the joint 3 mm [24]. Statistically significant increases in both external rotation and abduction were observed after incising the labrum, although clinically these were small, ranging from 1.5° to 7.5° as compared to the intact labrum [24].

A cadaveric model evaluating the relative contributions of the iliofemoral ligament and the labrum to hip stability found the iliofemoral ligament to be the primary stabilizer of the hip joint for external rotation and anterior translation and the labrum a secondary stabilizer. Based on these results, the authors concluded that when possible during hip surgery, both the labrum and iliofemoral ligament should be repaired [25]. In a joint compression model with the hip in a neutral position, removal of at least 2 cm of the labrum was necessary to destabilize the hip. Radial tears and smaller labrectomies did not destabilize the hip [26]. As a result, it is hypothesized that the labrum acts as a mechanical block contributing to hip stability. It is important to note however, that in this model the hip was only tested in neutral and as such the labrum may contribute more to hip stability at extremes of motion [26].

Labral Pathology

Classification

Beck and colleagues developed the most widely used classification of labral tears (Table 19.1) as part of their work describing femoroacetabular impingement [27]. Although labral tears had been described previously, their system is clear, reproducible, and can be used for labral tears that occur for reasons other than from impingement.

Trauma

Labral tears and occasionally small acetabular rim fractures are common in "simple" posterior hip dislocations i.e.—those that do not involve femoral head or acetabular fractures requiring open reduction. The location of the labral tear can be anterior, posterior, or both and is usually associated with a well-recognized subluxation or dislocation event [28–30]. Labral tears associated with acute trauma are often associated with significant chondral lesions and tears of the ligamentum teres. Bucket-handle and other substantial labral tears can also occur in the setting of acetabular fractures [31] and should be addressed at the time of surgical management of the fracture.

Table 19.1 Beck classification of labral tears

Description	Criteria
Normal	Macroscopically sound labrum
Degeneration	Thinning or localized hypertrophy, fraying, discoloration
Full-thickness tear	Complete avulsion from the acetabular rim
Detachment	Separation between acetabular and labral cartilage, preserved attachment to bone
Ossification	Osseous metaplasia, localized or circumferential

The Beck classification of labral tears is frequently used in studies reporting intra-operative findings and patient outcomes after labral tear or hip preservation surgery. It is a clear and reproducible system that can be used to describe labral tears occurring from any etiology or trauma

Dysplasia

Labral pathology was first recognized in dysplastic hips. In one series of patients undergoing hip arthroscopy for labral tears, nearly half of the patients had radiographic evidence of dysplasia [32]. The acetabular deficiency that occurs with dysplasia creates a static instability of the femoral head. As a result of chronic shear stress occurring at the acetabular rim, the labrum undergoes hypertrophy and helps to contain the femoral head [33, 34]. If the shear stress persists, the labrum becomes degenerative and ultimately fails. Myxoid degeneration and ganglia can be seen in the labrum on MRI (Fig. 19.6). These changes are generally rare in FAI patients [33]. The chondrolabral junction can also be avulsed from the acetabulum due to the shear stress of the femoral head. When this occurs, an avulsed piece of cartilage often remains attached to the torn labrum. This has been termed an "inside-out" lesion (Fig. 19.6) [34]. Radial labral tears occur more often in patients with dysplasia [31], which corresponds to the lateral force of the femoral head pushing on the labrum. Anterior and superolateral tears are most common [32, 34, 35]. There is also a high amount of associated acetabular rim degeneration in dysplasia [32, 34, 35]. A labral tear may hasten the progression of this degeneration as the load increases at the lateral edge of the joint [36]. It is important to distinguish between labral pathology due to dysplasia and that due to FAI, because it will influence surgical decision-making [37] patients with symptomatic hip dysplasia require a periacetabular osteotomy to reorient the acetabular socket and address the underlying bony insufficiency [34, 35, 37, 38].

Femoroacetabular Impingement

The concept of a "degenerative" labral tear is evolving. Many of the labral tears in patients who do not have dysplasia are due to subtle underlying bony anomalies that result in femoroacetabular impingement (FAI). In FAI, labral and cartilage injury results from hip motion in patients with abnormal femoral head and/or acetabular anatomy [39]. This

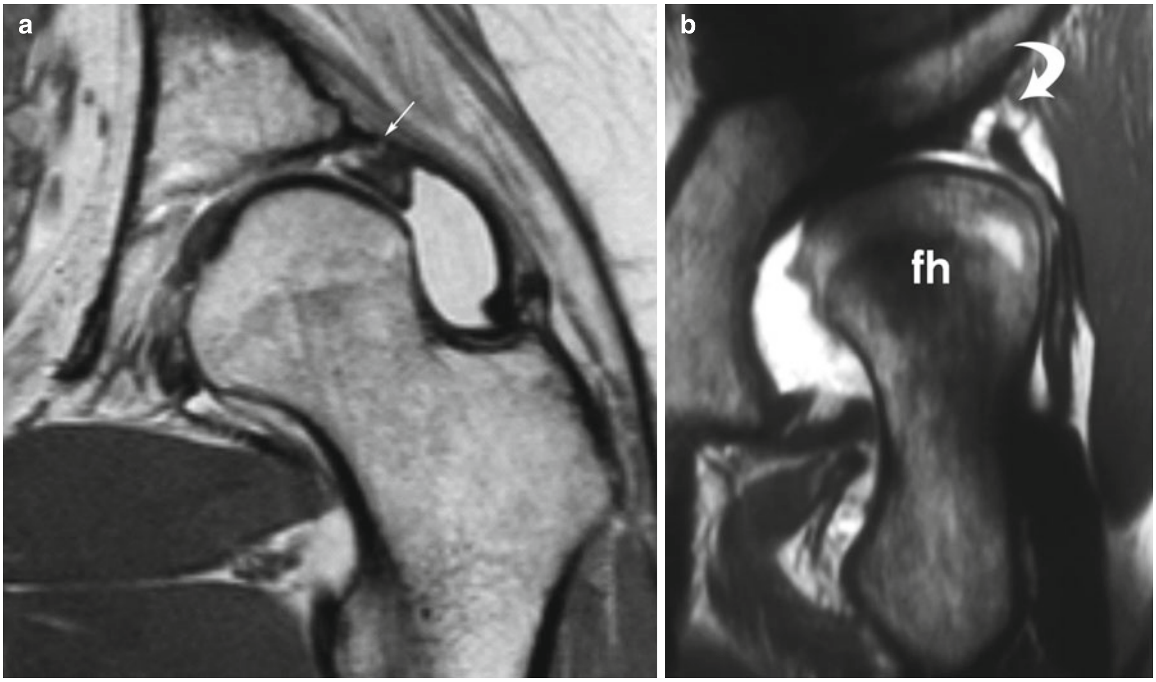

Fig. 19.6 The dysplastic labrum. (**a**) Coronal T1 MRI of a dysplastic labrum. Static overload results in myxoid degeneration and ganglia within the substance of the labrum. The shear stress of the femoral head causes an "inside-out" labral lesion (*thin arrow*): avulsion of the chondrolabral junction from the acetabulum. (**b**) MR arthrogram of a ruptured labrum (*curved arrow*). The femoral head (*fh*) has begun to migrate out of the acetabulum

is in contrast to dysplasia where static overload of the joint causes the associated labral and cartilage damage. Although FAI can result from various underlying bony anomalies, mechanically it can be grouped into cam impingement, pincer impingement, and mixed—both cam and pincer—impingement [27, 39]. The mechanical type of impingement correlates with the pattern of labral and cartilage damage that occurs (Fig. 19.7) [27].

In cam impingement, an aspherical portion of the femoral head (the "bony bump") jams into the acetabulum during flexion. The resultant shear force on the acetabulum leads to abrasion of the acetabular cartilage and labrum, creating an "outside-in" lesion (Fig. 19.7a, b) [27, 39]. About 2/3 of cam impingement patients have a focal labral tear. This usually occurs at the anterior or anterosuperior rim of the acetabulum. It is much less likely to involve the posterior acetabulum—18 % in one cohort [40–44].

In pincer impingement, global or focal overhang of the socket causes linear contact of the labrum and the femoral head-neck junction during flexion. This results in a crush injury to the labrum (Fig. 19.7c, d) [27, 39]. Patients with more predominant pincer pathology are less likely to have localized anterosuperior acetabular cartilage damage [40, 42], but may have a more circumferential labral lesion [27, 41]. Pincer impingement can also result in a secondary posterior impingement—a contrecoup injury to the posterior head and acetabulum when the femoral neck levers against the anterior rim as patients attempt to achieve a greater hip range of motion [27, 39]. This seems to be particularly common in patients with protrusio acetabuli [44].

Labral ossification may be visible on a plain radiograph or MRI as well. The labral crush injury from pincer impingement often results in labral ossification (Fig. 19.7d, e) [27, 39, 44, 45] which worsens the mechanics of pincer impingement. Histologically, the labral crush injury is associated with microfractures at the acetabular rim, which causes subsequent calcification and callus formation [43]. It appears that the bony callus formation and reparative tissue at the acetabular rim pushes the labrum away from the bone [43, 46].

Asymptomatic Labral Tears

Some labral tears may be asymptomatic. An MRI study of asymptomatic male Swiss army recruits observed abnormal labral morphology and labral lesions in 2/3 of the cohort. Labral pathology was observed more frequently in patients who also had bony cam lesions, occurring in 85 % of patients with a cam lesion. The adjusted odds ratios for this varied from 2.08 to 2.45, depending on the nature of the labral lesion [47]. In a series of elite and asymptomatic hockey players playing at the professional or collegiate level, 56 % had evidence of labral tears on 3 T MRI. All were actively playing without any limitations from their hips [48]. In addition, not all patients with radiographic evidence of labral tears obtain relief from intra-articular local anesthetic. This suggests that extra-articular sources may be the cause of pain, even in the presence of a labral tear [49, 50].

Laxity

The idea that capsular laxity may also be responsible for labral pathology is somewhat controversial. The proposed mechanism is one of secondary instability or micro instability. As a result of the instability, extra-physiologic motion results in increased pressure on the acetabular labrum and other structures [51–53]. A cadaveric study verified that there is increased anterior displacement of the femoral head with the hip in extension and external rotation. Although no labral tears were generated with the model in the study, this was associated with increased strain at the bone-labrum interface [52]. A motion capture study of professional ballet dancers with normal bony morphology observed superior and posterosuperior impingement in some dance positions at the extremes of motion. MRIs performed in these dancers confirmed the normal bony morphology but found degenerative changes superiorly and posterosuperiorly, corresponding to the observed areas of impingement [54]. Clinically, there are particular sports that involve repetitive hip rotation and axial loading. These include golf, figure skating, tennis, baseball, ballet, martial arts, and gymnastics. The repetitive

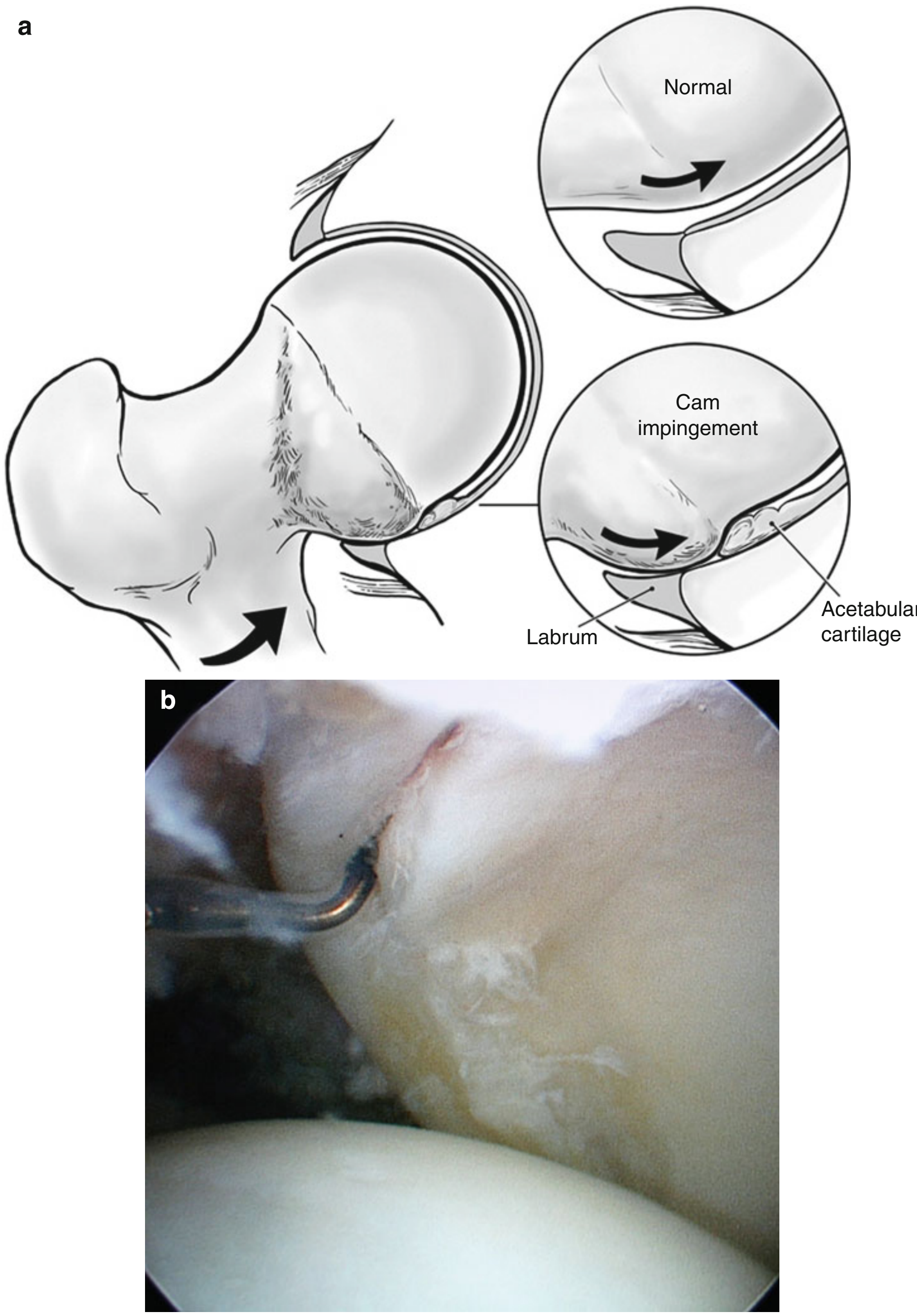

Fig. 19.7 The labrum in FAI. (**a**) Line drawing of outside-in cartilage delamination and labral tear caused by cam impingement. (**b**) Arthroscopic picture of a labral tear and cartilage delamination caused by a large cam deformity. (**c**) Line drawing of a labral crush injury caused by pincer impingement. (**d**) Picture of a completely ossified labrum due to pincer impingement seen during surgical hip dislocation. This patient also had a cartilage delamination injury (*probe*) from a cam deformity (Images **a** and **c** reprinted with permission, Byrd and Jones [45]). (**e**) Labral ossification (*arrow*) as seen on the radial T1 images of an MR arthrogram

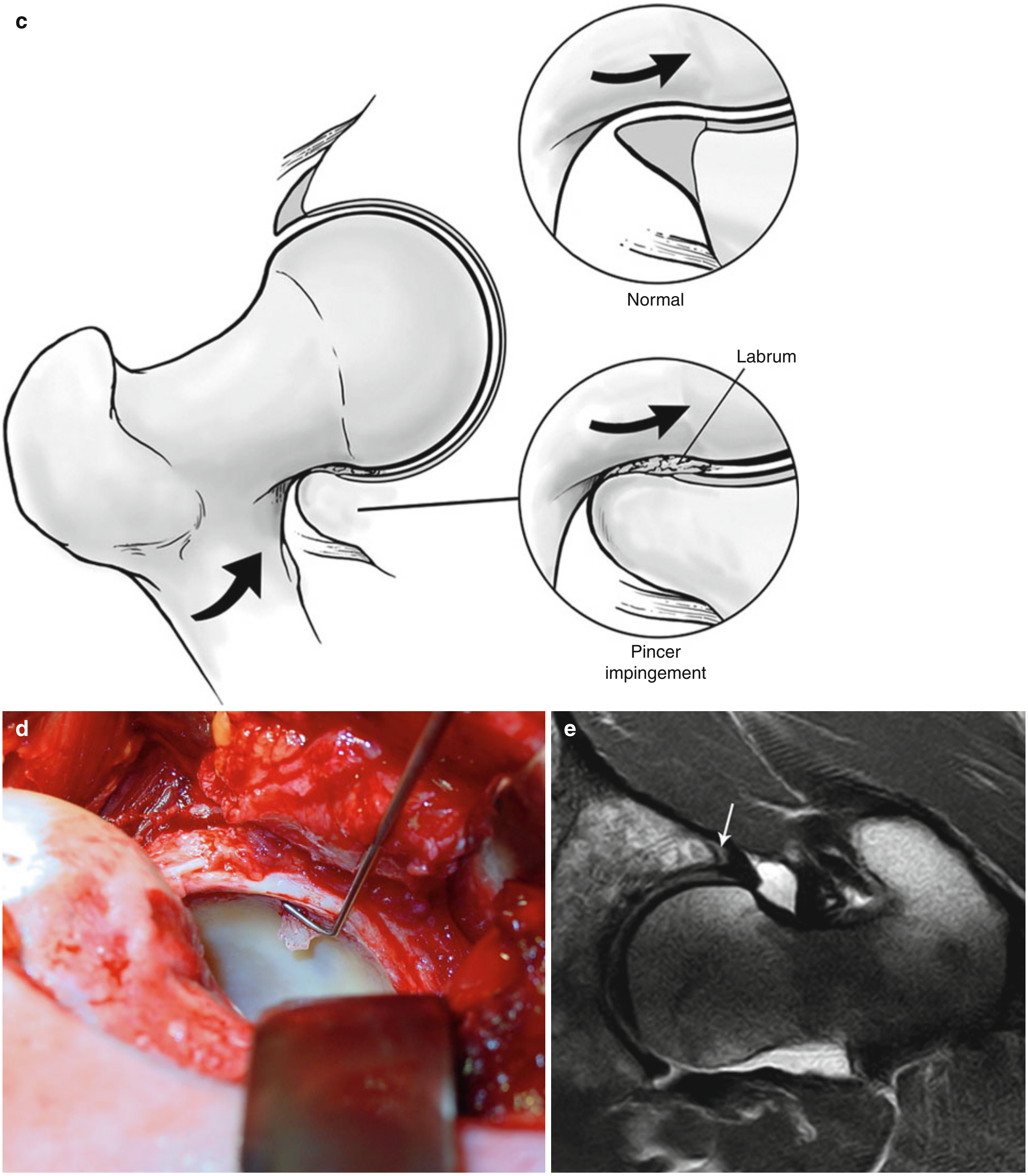

Fig. 19.7 (continued)

motion and subsequent laxity may be a predisposing factor for labral pathology in these athletes [53, 55]. Conversely, other authors have noted that patients with symptomatic labral tears generally have recognizable bony abnormalities. In some series, up to 90 % of patients with labral tears have associated bony pathology consistent with either FAI or dysplasia [56, 57].

Treatment and Surgical Techniques

Clinical and Radiographic Findings

The symptoms associated with labral pathology are variable and patients often have a combination of symptoms [58]. Patients with labral tears describe either an acute or an insidious onset of symptoms. Most often, the acute onset of symptoms is associated with a minor trauma or pivoting injury; the onset of symptoms is less often associated with a significant trauma. Generally there is some combination of groin pain with buttock, lateral leg, or thigh pain. The pain may be dull or intermittently sharp and is often worse with activity, walking, or prolonged sitting. Half of patients describe mechanical symptoms, which may consist of catching or clicking [58]. On gait exam, patients may have an antalgic limp or Trendelenburg lurch. A positive impingement test occurs when the patient has pain with the hip in 90° of flexion, adduction, and internal rotation.

All patients with suspected labral pathology should undergo a standard radiographic exam consisting of an AP pelvis x-ray and a cross-table lateral x-ray of the involved hip. These should be evaluated for signs of dysplasia or femoroacetabular impingement. The degree of existing degenerative change should also be noted. Patients with pre-existing degenerative changes have worse results after both arthroscopic and open labral procedures [58–61]. Patients should also undergo MRI with an intra-articular arthrogram, which is both sensitive and specific for labral tears. Meta-analysis of MRI and MR arthrogram indicates that MR arthrogram is a better diagnostic study for detecting labral tears than MRI without arthrogram [62]. A 1.5 T magnet is sufficient, although the series should include a fluid-sensitive sequence with a coil over the hip and a small field of view. The study should include radial slices through the femoral neck to evaluate for cam lesions not seen on standard x-ray views as the presence of a labral tear without an underlying bony deformity is rare [63]. Proper imaging may reveal up to 34.6 % unexpected asphericity of the head-neck junction [63]. The articular cartilage should also be examined for signs of degeneration not seen on the plain films. When it is difficult to determine if the cause of pain is coming from the hip or the back, we recommend a diagnostic intra-articular injection [58].

Surgical Treatment

Conservative management of a symptomatic labral tear may be considered in the presence of pure pincer FAI, because intra-articular cartilage damage usually is minimal and progression of degenerative changes is limited. In contrast, when patients with cam FAI become symptomatic, advanced articular cartilage damage is often already present. Thus, correction of the cam deformity is important for preserving the remaining cartilage. The same applies to labral pathology secondary to dysplasia, where restoration of hip biomechanics with acetabular reorientation is mandatory. Conservative management may include physical therapy for core and hip abductor strengthening, activity modification, non-steroidal anti-inflammatory medication, or cortisone injection. If conservative management does not improve symptoms within 3–4 months, surgical treatment is advocated.

In general, co-existing dysplasia, FAI, and chondral lesions should be addressed at the same time as the labral pathology. Often, the co-existing pathology will determine whether the labral tear will be treated as part of an open or arthroscopic procedure. Contraindications to hip joint preservation surgery, which encompasses most techniques for treating labral pathology, include Tönnis grade 2 or greater osteoarthritis and patients who are unwilling or unable to comply with the postoperative rehabilitation.

Labral Debridement and Refixation

A torn or degenerated labrum cannot be repaired back to its original shape and function. Surgical treatment of the labrum via *reattachment, refixation, or stabilization* results in healing and the formation of a more or less functional scar. If the labrum is not amenable to reattachment, debridement is reasonable. This generally is the case with fraying of the labral edge or extensive intrasubstance tearing. The idea behind debridement is that removal of a mechanical labral flap will improve symptoms. During arthroscopy, this can be accomplished with a shaver; in an open procedure we recommend sharp debridement. Because of the importance of the labrum to hip function, this should be performed in a conservative fashion, with debridement to healthy-appearing, stable tissue.

When technically feasible, labral reattachment is recommended (Fig. 19.8). There is reasonable evidence that the labrum heals following surgical reattachment. In a sheep model of arthroscopic labral reattachment the labrum healed via a fibrovascular scar and direct new bone formation [64]. The sheep were allowed immediate full weight-bearing and labral healing was assessed at 12 weeks. The reattached labrum did appear bunched and misshapen, unlike the smooth triangular appearance of the normal controls.

If indicated as part of the management for concomitant FAI and if one is comfortable with arthroscopic techniques, the labrum can be treated arthroscopically. Arthroscopic treatment is contraindicated in cases of clear acetabular dysplasia; the patient should undergo an acetabular reorientation procedure to address the dysplasia. General techniques for hip arthroscopy are described in detail in Chaps. 16 and 17. The senior author performs arthroscopy in the lateral position with the patient on a traction table and beginning in the peripheral compartment. From the peripheral compartment, the capsular side of the labrum can be assessed. FAI should be evaluated by flexing and extending the hip under direct arthroscopic visualization. The pattern of labral and cartilage damage is also evaluated and used to confirm the preoperative diagnosis of cam, pincer, or combined FAI. From the peripheral compartment, we address any cam deformity

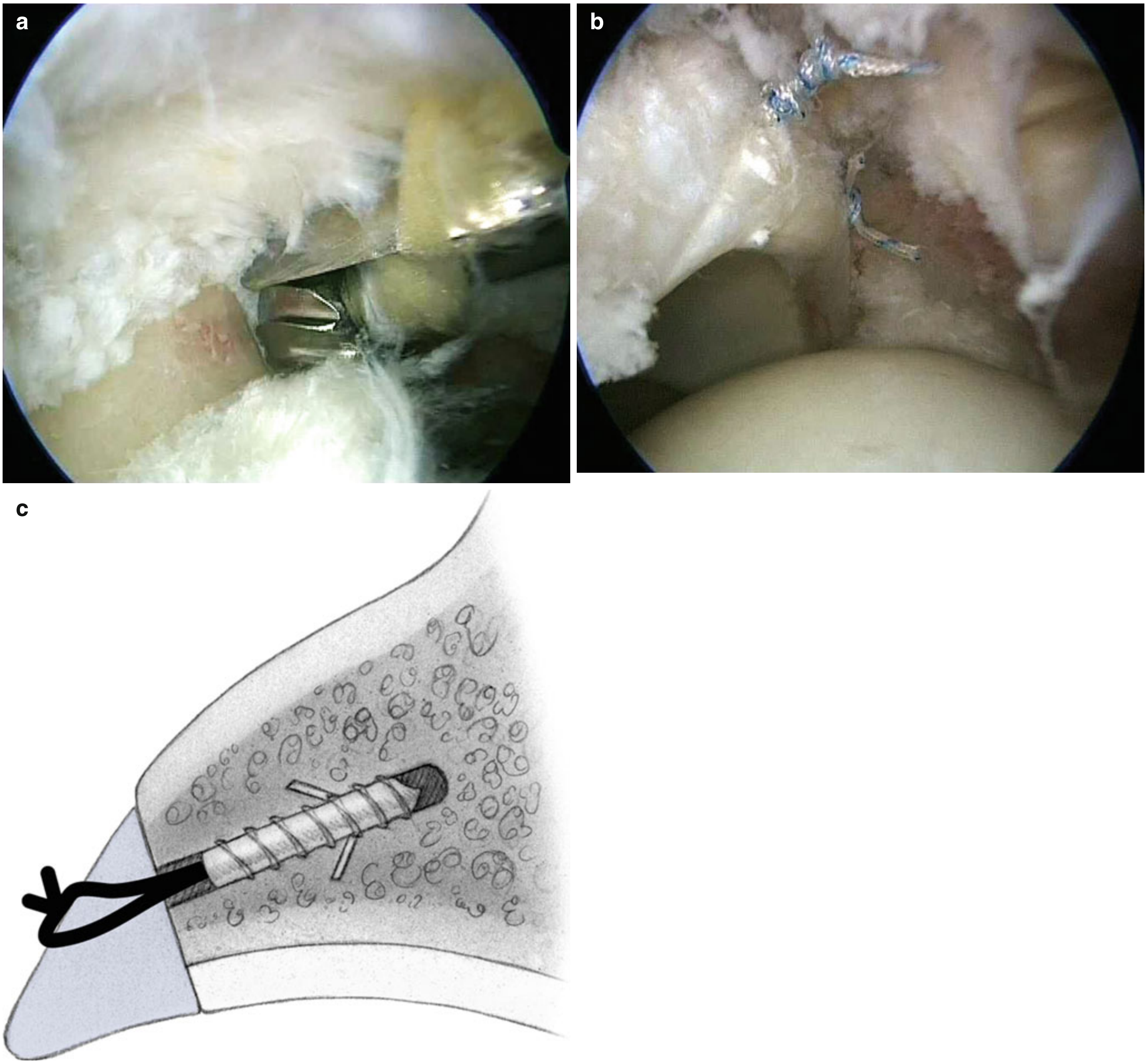

Fig. 19.8 Arthroscopic acetabular rim trimming and labral repair. (**a**) Acetabular rim trimming. (**b**) Appearance of the labrum following repair. (**c**) Anchor placement (**c** reprinted with permission, Espinosa et al. [81])

with a femoral neck osteoplasty. Traction is then placed and the central compartment accessed.

When pincer impingement is present, acetabular rim trimming should be performed. If the chondrolabral junction remains intact but the acetabular rim has clearly overgrown the labrum, the bony overgrowth can be resected with an arthroscopic burr without taking down the chondrolabral junction (Fig. 19.8a). When the labrum is torn at the chondrolabral junction or rim trimming cannot be performed without damaging the labrum, we use an arthroscopic knife or beaver blade to take down the labrum at the acetabular rim. Once the rim has been trimmed, we proceed with arthroscopic labral reattachment. Frayed portions of the labrum that would not be stable after labral reattachment are debrided. The overall length of the tear determines the number of suture anchors used for refixation. We use titanium, single-loaded suture anchors and place anchors through an accessory portal to achieve a better angle on the rim. The safe angle for suture anchor insertion varies with the position on the acetabular rim, the amount of rim trimming, and the depth of drilling [65]. When drilling, we use both intraoperative fluoroscopy and direct visualization of the central compartment cartilage to assess the angle and ensure that the anchor is not penetrating the acetabular cartilage.

To restore the labral anatomy, just the edge of the labrum is included in the refixation on the acetabular rim, leaving the point of the labrum intact (Fig. 19.8b, c). The labrum can be sutured with either simple or vertical mattress sutures. The reattachment is then secured with either sliding locking knots or multiple half hitches on alternating posts, taking care to ensure that the knots remain on the capsular side of the labrum (Fig. 19.8b). Once labral refixation is completed, traction is released. Traction time should be limited to less than 2 h to prevent iatrogenic nerve palsy.

If the patient is undergoing surgical dislocation for treatment of FAI or a periacetabular osteotomy to address acetabular dysplasia, the labrum should be addressed as part of the open procedure (Figs. 19.9 and 19.10). Mini-open approaches via a direct anterior approach to the labrum are also an option for addressing labral pathology when the surgeon is not comfortable performing arthroscopic labral refixation [66]. Regardless of the approach, any necessary rim trimming should be performed. Frayed labral tissue or delaminated cartilage should be sharply debrided. Similar to the arthroscopic technique, titanium, single-loaded suture anchors are used for open labral refixation. The anchor is placed on the rim under direct visualization, taking care not to penetrate the acetabular cartilage. The edge of the labrum is taken in the stitch and the labrum is reattached back to the acetabular rim. Again, the number of anchors used is variable and depends on the extent of the tear or the amount of rim trimming performed. The function of the labrum is assessed by dislocating the femoral head from the acetabulum with the reattached labrum. If a vacuum seal has to be broken with the typical suction sound, the suture or reconstruction is considered sufficient.

Labral Reconstruction

The goal of labral reconstruction is to restore labral function in a hip with a hypoplastic or deficient labrum that cannot be reattached, e.g. a labrum that is completely ossified or had previously been debrided. This is based on current ideas about the biomechanical function of the labrum, the importance of the labrum in preventing further degenerative changes in the hip, and clinical studies demonstrating better mid-term function for patients who underwent labral refixation as compared to patients who underwent labral debridement. The basic science behind this technique is limited to the aforementioned biomechanical models of the labrum. There are no published animal models of labral reconstruction and it is unknown if the reconstructed labrum functions similar to the native labrum. As a result, there are many clinical questions that remain to be answered regarding this technique; these include the time course for healing, whether it differs between graft types, and if the graft needs to undergo a “labralization” process to function like a labrum.

Two different techniques have been published for labral reconstruction [67, 68]. Philippon and colleagues published a technique and early results of arthroscopic labral reconstruction using an autologous IT band graft in 2010 [67]. Sierra and colleagues published a technique of open labral reconstruction with ligamentum teres autograft in 2009 in five patients with brief follow up [68]. A PubMed search for labral reconstruction also found techniques for arthroscopic labral reconstruction with both autograft and allograft hamstring tendon [69–72].

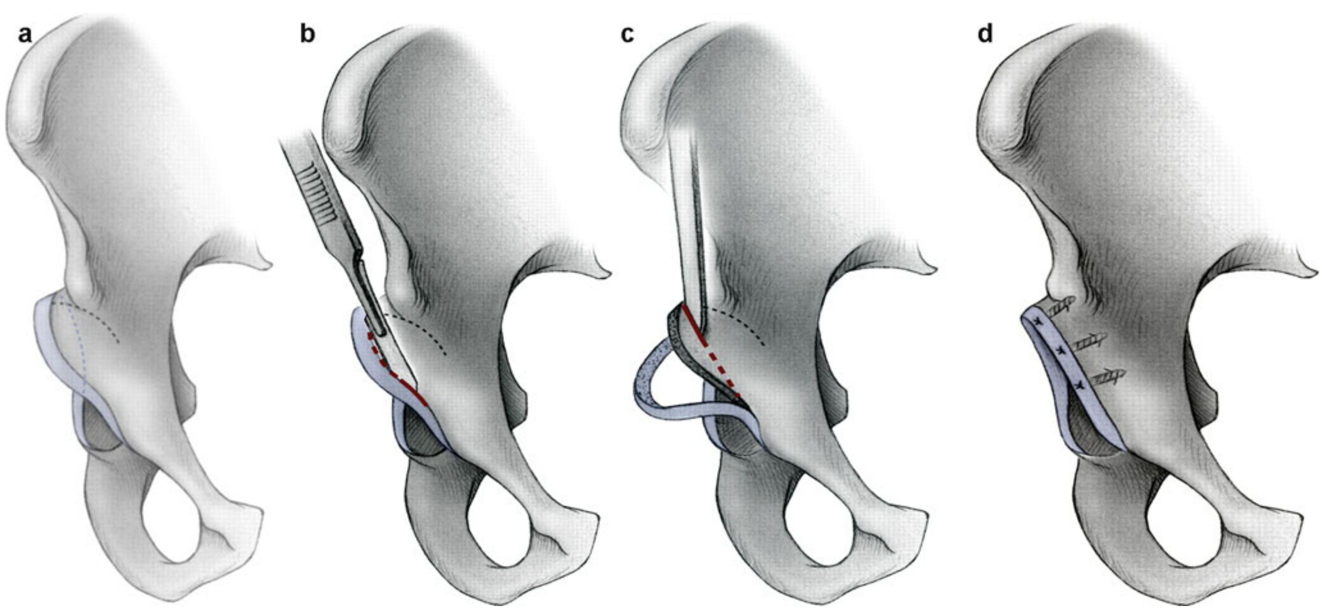

Fig. 19.9 Open acetabular rim trimming and labral repair. (**a**) Retroverted acetabulum. The *dashed line* indicates the bony rim. (**b**) Sharp takedown of the labrum from the acetabular rim. (**c**) Curved osteotome used to perform focal rim trimming. (**d**) Labrum repaired back to the acetabular rim (Reprinted with permission, Espinosa et al. [81])

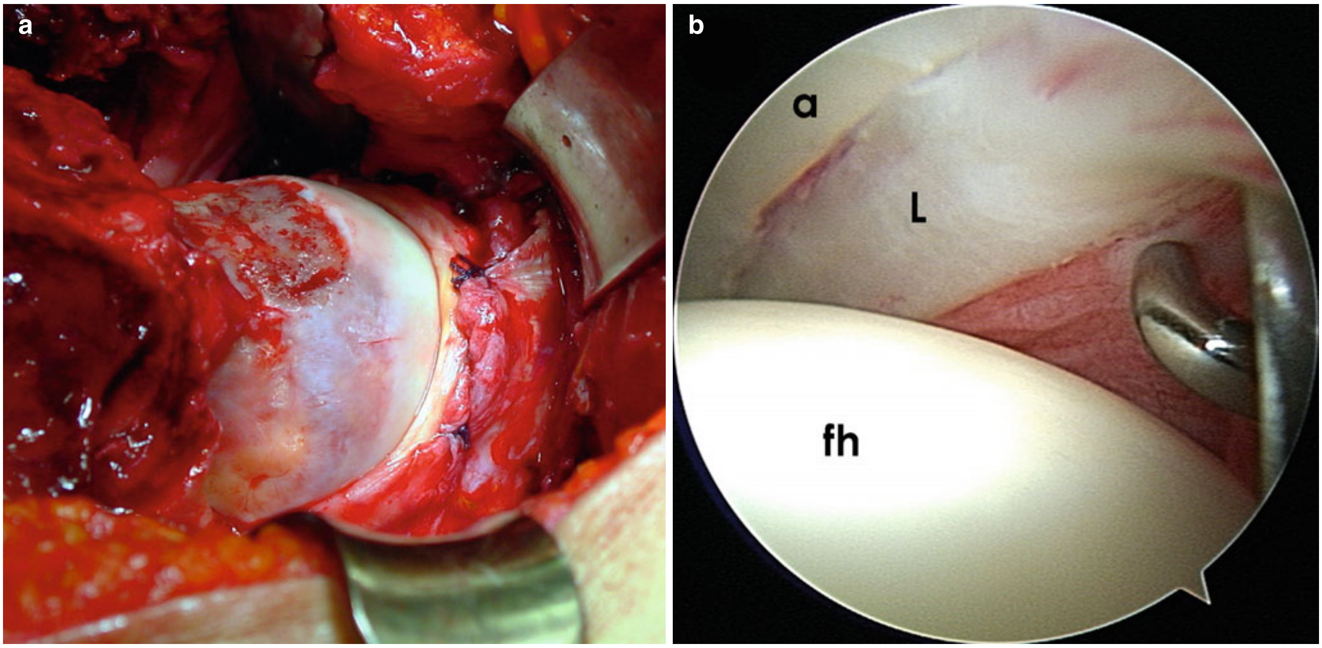

Fig. 19.10 (**a**) Labral repair after open acetabular rim trimming. (**b**) Arthroscopic image of a labrum that was repaired via a surgical dislocation. The labrum is well-healed and the labral seal has been re-created. *a* acetabulum, *L* labrum, *fh* femoral head

The senior author has reconstructed the labrum using the ligamentum teres in 14 patients as part of the treatment for FAI during surgical dislocation (Fig. 19.11). Indications for labral reconstruction using the ligamentum teres are symptomatic patients with a hypoplastic or deficient labrum that cannot be reattached. Contraindications to labral reconstruction are the same as those for FAI surgery and include Tönnis Grade 2 or greater arthritic changes on x-ray. The patient undergoes a surgical hip dislocation in the usual manner. As part of the approach to the hip, the ligamentum teres is divided to allow for full dislocation of the femoral head. The labrum and cartilage are examined and the bony FAI pathology should be addressed with acetabular rim trimming and femoral neck osteoplasty as appropriate. If the continuity and sealing function of the labrum are disrupted, labral reconstruction is performed to restore circumferential tension in the labrum and the labral seal. The remaining ligamentum is sharply debrided from the fovea and femoral head and kept in a saline soaked swab on the back table. The labral defect is assessed and scar tissue removed such that cancellous bone is visible at the acetabular rim (Fig. 19.11a). This restores the bony blood supply to the reconstructed labrum and enables labral healing. Once the size of the labral defect is known, fat and synovial tissue are carefully removed from the ligamentum and the graft is prepared to fit into the defect. Generally the ligamentum is much thicker than the native labral tissue; it should be trimmed as necessary so that the size and thickness are comparable to the remaining labrum. Suture anchors are placed along the acetabular rim and the ligamentum is sewn onto the rim, incorporating the ends of the graft into the original remaining labrum (Fig. 19.11b). Following labral reconstruction, the femoral head is gently reduced and the labral reconstruction is examined to ensure that the labral seal has been restored.

Rehabilitation and Postoperative Care

The postoperative protocols are similar for arthroscopic and open labral reattachments. For patients who have undergone surgical dislocation and open labral reattachment, the trochanteric osteotomy needs to be protected. Thus, patients are allowed 15 kg heel-toe weightbearing with crutches for 4 weeks. They may begin to advance their weightbearing at 4 weeks if the trochanter is not painful with weightbearing. For arthroscopic labral reattachment, patients may begin to advance their weightbearing after 2 weeks. On postoperative day 1; all patients start stationary biking with no resistance and CPM for 4–6 h daily with flexion as tolerated. Patients receive 3 days of non-steroidal anti-inflammatories postoperatively as part of our protocol for multi-modal pain control. This has the additional benefit of providing some heterotopic ossification prophylaxis. Patients receive crutch training in the hospital but formal physical therapy begins after 4–6 weeks, once weightbearing is advanced. Therapy can be advanced as tolerated, focusing on gentle range of motion, gait training, and strength initially, with progression to in-line jogging and sports as strength and proprioception return. Most patients are ready to begin jogging and returning to sports around 4½ months after surgery.

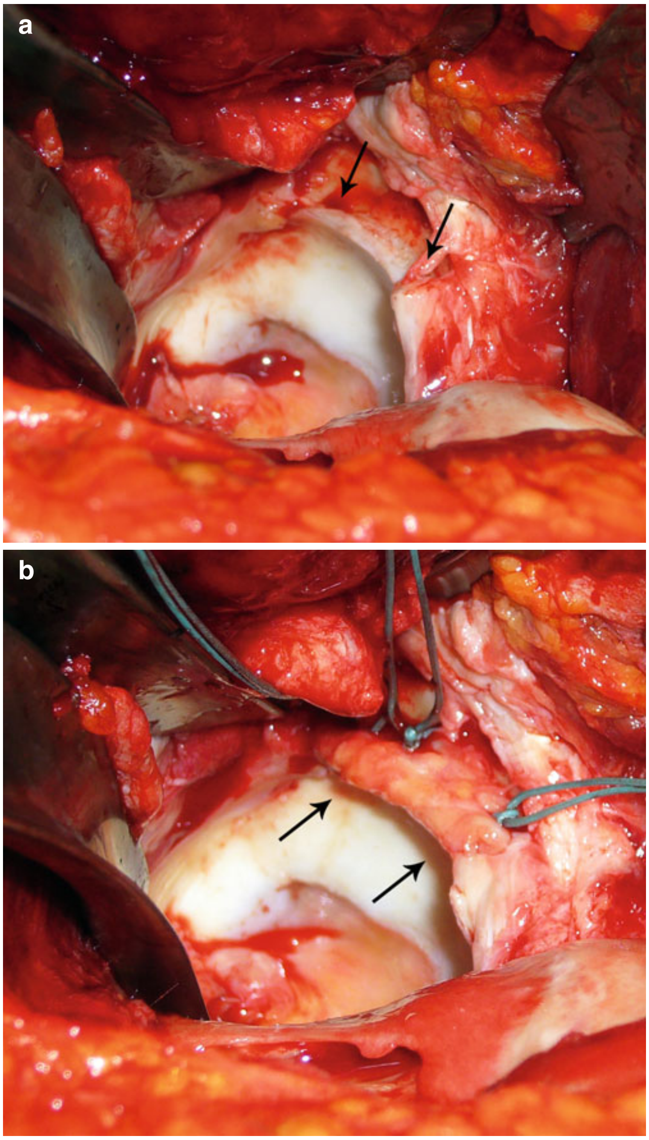

Fig. 19.11 Labral reconstruction. (a) The labral defect is visible between the *black arrows*. Cancellous bone is visible on the acetabular rim. (**b**) The labrum has been reconstructed with the ligamentum teres, held in place with suture anchors (*arrows*)

Results

The data on labral treatments continue to improve but is still limited. Level I or II prospective studies are particularly lacking [73]. Because FAI became more widely accepted only in the second half of the last decade, previously published results for labral debridement likely included patients with underlying FAI. Once the first results for open treatment of FAI were published [39, 74], addressing FAI was incorporated into the treatment of labral pathology [75]. Good results following both arthroscopic labral debridement and labral reattachment have been reported by several authors, with follow-up ranging from 1 to 10 years [59, 73, 75–77]. Arthroscopic and open treatment of FAI and labral pathology have also been compared. One systematic review suggests a lower complication rate for arthroscopy (0–5 %) compared to open management (0–20 %) and a lower conversion rate to total hip arthroplasty (0–9 % compared to 0–20 %) [78]. One caveat to this analysis is that the review included early experience with open FAI management. Since then indications for open management have become narrower and complication rates similar to those published for arthroscopy [79].

Labral debridement and labral reattachment have been compared directly for both arthroscopy and surgical hip dislocation. Clinically, the results are better for patients undergoing reattachment [75, 77, 80, 81]. A clear but mild progression of arthritis, from an average Tönnis grade of 0.6–1.2, was observed radiographically during the first year after dislocation and labral debridement [80]. This was not observed for patients who underwent labral reattachment.

The results of labral reconstruction have only recently been published. In the previously mentioned case series of patients undergoing labral reconstruction with the ligamentum teres, 4 out of 5 were happy with the result after short term follow up (5–20 months). One patient progressed to total hip arthroplasty but had extensive cartilage damage at the time of the labral reconstruction [68]. One-year follow-up was obtained for 41 out of 95 patients who underwent arthroscopic labral reconstruction with IT band autograft over a 3 year period. Of the 41, 4 (9 %) underwent conversion to total hip arthroplasty. These patients were significantly older than the patients who did not subsequently require hip arthroplasty, with average age of 49 as compared to 36 at the time of reconstruction. There was significant improvement in the mean Harris Hip Score, from 62 to 83, and the median patient satisfaction postoperatively was 8/10, ranging from 1 to 10 [67]. In the senior author's experience, 1-year postoperative Oxford Hip scores following labral reconstruction ranged from 30 to 47, out of a possible maximum of 48. Out of the six patients with 1-year follow up, patient satisfaction was generally high (80–100 out of 100), with all patients stating that the operation helped and that they would undergo the surgery again. One patient reported a satisfaction score of 40 and most patients had some residual pain at rest which increased with activity. Thus, although labral reconstruction as a complementary technique to FAI surgery does help to decrease symptomatic hip pain, mild residual symptoms after labral reconstruction surgery may persist.

Although the results are generally reported to be good or excellent after treatment of labral pathology, up to 35 % of patients may not be entirely satisfied. A high number of patients who have a poor result ultimately progress to total hip arthroplasty [73]. In the arthroscopic series, a 7–11 % failure rate has been reported [75, 82]. One study stratified patients by the presence or absence of cartilage lesions. After labral debridement, patients with coexisting cartilage lesions tend to have similar or worse pain. Comparatively, if the cartilage was intact, patients demonstrated improvement after treatment of the labrum [61]. For long-term follow up (10–20 years), survival is defined as progression to total hip arthroplasty. In these series, the biggest predictor of long-term survival was the presence or absence of cartilage damage at the time of the initial arthroscopy [59, 60]. In a pre-FAI cohort who underwent labral debridement, 10 % of patients who had no cartilage damage underwent hip arthroplasty on long-term follow-up (90 % survival). Conversely, for patients with Outerbridge grade III or IV cartilage damage at the time of arthroscopy, 80–90 % had undergone conversion to total hip arthroplasty [59, 60].

Aside from conversion to arthroplasty, the most common reasons for subsequent surgery after both open and arthroscopic surgery include inadequate decompression of FAI [83, 84], lysis of adhesions [82, 84, 85], unrecognized dysplasia [37, 38], failure of labral healing, and loosening of a suture anchor [75, 83]. In addition, after surgical hip dislocation, the greater trochanter screws often need to be removed [79, 86, 87].

The results vary for returning to sports following treatment of the labrum and results have been published for both arthroscopic and open management. In arthroscopic series of athletes undergoing arthroscopic treatment of FAI and labral tears, 73–96 % were able to return to sport at their previous level 1–2 years after surgery [45, 88–90]. Similar results have been reported after surgical hip dislocation for FAI and labral tears [86]. These results should be viewed with some caution as professional athletes in particular have a financial incentive to return to play, regardless of a suboptimal result [73, 86, 88]. Nonetheless, similar to other measures of survival, patients with diffuse cartilage damage at the time of arthroscopy did not return to play [90].

Complications

In general, complications after labral refixation or debridement are related to the specific approach used for surgery. Heterotopic ossification is a recognized complication after both hip arthroscopy [91] and surgical dislocation [79]. Postoperative prophylaxis for 1–2 weeks with non-steroidal anti-inflammatory medication may help to decrease the incidence of this [92]. Other complications occurring after surgical dislocation include mild residual pain over the greater trochanter [87], mild heterotopic ossification [79], non-union of the greater trochanter requiring revision (1.8 %) and post-operative deep vein thrombosis (2/334 patients) [79]. Complications after hip arthroscopy include traction-related transient nerve palsies of the pudendal nerve with associated erectile dysfunction [59, 61, 93–95], lateral femoral cutaneous nerve [59, 61, 93, 94], and sciatic nerve [96]. Other groin injuries including labial hematoma [93], vaginal tearing [96], and scrotal necrosis [95] have also been reported after traction for hip arthroscopy. These are best minimized by attention to the position and padding of the peroneal post preoperatively as well as limiting total traction time to less than 2 hours. Scope-related complications can include instrument breakage [94–96], cartilage damage—which is likely under-recognized and underreported [97, 98], and fluid extravasation into the thigh, abdominal compartment [99], or intrathoracic compartment [100].

Summary and Conclusions

Although the exact biomechanical function and properties of the labrum are still being defined, it is clear that the labrum is important for normal hip function. Labral degeneration and labral tears can be asymptomatic and apparently a part of the “normal” degenerative process. Nonetheless, labral tears are often a source of hip pain. Labral pathology is generally observed in conjunction with an underlying bony abnormality—either FAI or dysplasia—and particularly in gradual onset of hip pain or in association with minor trauma. Positive results have been reported for both open and arthroscopic treatment. This includes both labral debridement and labral refixation. Currently, appropriate treatment of labral pathology includes either open or arthroscopic management of any underlying FAI or dysplasia, and, when feasible, labral refixation. When the labrum is degenerative and unable to be reattached, it should be debrided back to a stable base. Once the labrum is addressed appropriately, good to excellent results can be expected, including the return to professional-level sports. However, patients with associated chondral damage at the time of surgery are more likely to have a poor result and progress to arthroplasty.

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