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Research article

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Labral cuff refixation in the hip: rationale and operative technique for preserving the chondrolabral interface for labral repair: a case series

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ABSTRACT

Arthroscopic labral 'takedown' and refixation is utilized to permit adequate visualization and resection of the acetabular rim deformity, in patients with pincer or mixed femoroacetabular impingement. Deficiencies exist in present techniques, which include disruption of vital anatomical support and vascular structures to the labrum and chondrolabral junction, drill or anchor articular penetration risk, bunching, elevation and instability of the labrum. A new operative technique is described which preserves the important chondrolabral interface, accurately restoring the 'flap seal' of the acetabular labrum while minimizing vascular disruption and reducing the risk of drill and anchor penetration. A prospective series of 123 consecutive cases of pincer or mixed femoroacetabular impingement, treated with arthroscopic labral cuff refixation and preservation of the chondrolabral interface, is reported; operative technique and 2-year outcomes are presented.

INTRODUCTION

Labral tears are commonly associated with symptomatic femoroacetabular impingement (FAI) and surgical treatment of these tears with resection or repair has been shown to be successful [1–10] There is increasing opinion that preservation of the labrum is beneficial to the patient and improved clinical outcome has been reported with repair over debridement or resection [1, 2, 11–14].

The primary function of the labrum is to maximize the stability of the femoral head during weight bearing, impact loading and resisting femoral head translation with hip movements; the labrum also acts in a sealing capacity maintaining lubrication and lowering joint contact stresses [15, 16].

Labral resection may reduce the thickness of the labrum, disrupting the physiological seal between the free edge of the labrum and the femoral head [17–19]. Resection may also reduce the surface area and depth of the acetabular rim, further affecting the role of the labrum in stability of the hip joint [20–23]; increasing cartilage consolidation (strain) under load, which may eventually lead to joint degeneration [24–27].

The importance of treating the underlying bony deformities, which have resulted in the labral pathology, and restoring normal anatomy is also now widely recognized [10, 28–30].

Arthroscopic acetabuloplasty is performed for the treatment of pincer and mixed impingement of the hip. This may be achieved without the need for labral detachment[29, 31–34]; however, for many cases, especially in the presence of larger pincer deformities, a surgical detachment with retraction of the labrum is undertaken to expose the rim of the acetabulum, permitting good visualization and enabling adequate recession of the rim and associated pincer deformity [1, 7, 11, 29]; this subsequently requires the refixation of the labrum to the acetabular rim.

Although a number of techniques have been described to perform refixation, two methods are most commonly utilized arthroscopically: the simple loop technique developed by Philippon [12] and the labral base repair described by Fry and Domb [29].

A number of biomechanical studies have demonstrated improved stability and restoration of the suction seal with repair over resection [19]. A through-labrum repair technique may have potential biomechanical advantages over a looped technique [35, 36] but no significant differences in clinical outcome have been demonstrated between repair types [37, 38].

Given the avascular nature of the articular labrum, consideration should be given to preserving the vascularity on the capsular side where a rich, anastomosis of arterioles provide much of the healing potential to any repair [39, 40].

Refixation techniques should therefore optimize the restoration of the labral anatomy to preserve important biomechanical functions of the labrum including stability and suction seal, and provide an environment for healing by protecting the vascularity.

The purpose of this report is to discuss the important principles associated with arthroscopic acetabuloplasty and labral refixation for the treatment of pincer and mixed FAI, and to describe the rationale and the surgical technique for an improved method of labral 'takedown' and refixation [41], with 2-year clinical outcome measures.

PATIENTS AND METHODS

The study design is a prospective clinical review with institutional board approval of a consecutive series of patients treated with a newly established arthroscopic technique. All patients with a clinical diagnosis of mixed or pincer FAI who required arthroscopic acetabuloplasty and in whom the chondrolabral junction was preserved were included.

All patients underwent a full clinical assessment using standardized patient questionnaires, a clinical examination (FADIR and FABER test) and measurement of the range of motion (flexion, adduction, abduction, internal and external rotation) of the hip joints. All patients provided written consent for inclusion of their data in the study

Plain radiography (including a standardized AP pelvis, 90° Dunn and False profile view) and MR Arthrography were utilized to establish the nature and extent of bony impingement and confirm the presence of labral and chondral pathology. A CAM deformity was present if the Alpha angle measured > 65° (AP) or > 55° (Dunn). A lateral centre-edge angle (CEA) was considered normal between 25 and 35°; over-coverage > 35°; mild dysplasia between 22 and 25° and dysplasia < 22°. A pincer deformity was considered present when a crossover sign was evident on the AP pelvis or a clear bony prominence or rim fracture was observed on the acetabular rim, on the false profile view.

Over a 10-month period (November 2013–August 2014) 310 consecutive arthroscopic FAI procedures were performed; in 123 of these cases (104 patients), acetabuloplasty utilizing a chondrolabral preserving technique was undertaken and the labrum was repaired using a labral 'cuff' refixation.

Clinical progress was measured at 1 and 2 years post-surgery, utilizing the modified Harris Hip Score, SF36, UCLA activity rating, WOMAC Osteoarthritic index and assessment of the range of hip motion.

Statistical analysis

Non-parametric data analysis (median and interquartile range, Wilcoxon signed-rank and Mann–Whitney U test) was utilized to examine the significance of the clinical results using SPSS v23 (SPSS Inc., Chicago, IL). A P values of <0.05 was considered significant.

Operative technique

The patient is administered with a general anaesthetic and a standard supine hip arthroscopy set up with limb distraction is utilized, using anterolateral and modified mid-anterior portals. A high anterolateral camera position is developed to permit an 'anterior profile view' of the anterolateral rim and labrum from 11 to 5 o'clock position (Fig. 1). The mid-anterior portal remains the primary working portal for labral 'takedown', rim recession and labral refixation (Table I).

Using a 50-degree angled, flat-surfaced, radiofrequency probe, a plane between the capsule and the anterolateral rim of the acetabulum is developed preserving the highly vascular connective tissue overlying the acetabular periosteum. This periosteal connective tissue layer is elevated like a 'cuff' of tissue from the bony rim using a hooked radiofrequency probe, protecting as much of the cuff as possible. The surgical elevation of the cuff continues caudally and around the end of the acetabular rim, the labrum being progressively 'reflected' from its fibrocartilage bony

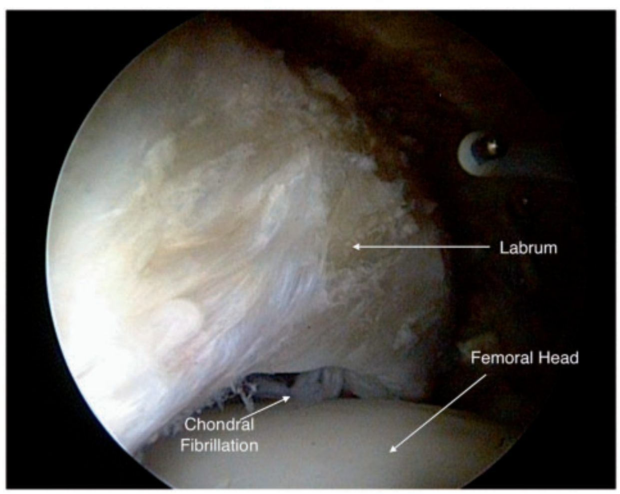

Fig. 1.'Anterior Profile View' of the labrum (as seen from the anterolateral portal) in a distracted right hip joint.

Table I. Labral reflection and cuff refixation

Principles:		
1	Tissue preservation	• Fibrovascular connective tissue 'cuff'
		• Chondrolabral interface
		• Labrum
2	Labral base stability	• Tensioned cuff repair
		• Chondrolabral continuity
3	Optimal flap seal	• No labral elevation or bunching
		• No suture passage through body of labrum
		• Mobile labral body and triangular free edge
4	Safe suture anchor placement (Zone 12–2 o'clock)	• 'Safe Zone' > 4 mm away from articular edge avoiding joint penetration
Pitfalls	Cuff refixation	• Ensure adequate cuff to permit stable repair
		• Unsuitable for unstable, detached or bulky labra

The important principles behind the evolution of labral reflection and labral cuff refixation techniques and potential pitfalls.

attachment, while preserving the chondrolabral junction completely (Fig. 2a and b). This reflection is advanced further elevating articular cartilage from its bony attachment en-masse with the labrum and continued to the required depth for adequate planned acetabular recession.

The reflected labrum hangs inferiorly clearly exposing the bony rim of the acetabulum but remains suspended by its strong and preserved attachment to the articular cartilage; localized and global pincer deformities, and rim fractures if present, are clearly identified at this stage following labral reflection. An acetabular recession is then performed using a 4 mm mechanical burr (Fig. 3a and b). A drill hole is created for the insertion of a suture anchor anteriorly (at the 2 o'clock position in a right hip); in this position the suture anchor can be placed safely well away from the articular edge (>4 mm) to avoid possible penetration of the joint. A 17-gauge arthroscopy needle is passed through the labral cuff-body junction; a suture loop is shuttled down the cannulated centre and is utilized to pull the lower limb of the fixation suture through the labral cuff junction (Fig. 4). The labrum is then refixed to the acetabular bone using an arthroscopic sliding knot, tensioned appropriately so that the cuff is stretched gently to remove any laxity. This step is repeated until the labrum is adequately secured using either portal to optimize drill angle; for most cases because of the increased stability afforded by preserving the chondrolabral junction, two anchors will generally suffice. In zones outside of 12–2 o'clock, the suture anchor may require closer placement to the joint surface, as the width of the rim decreases.

The labrum is then assessed with a probe for the stability of fixation, the traction is released and the suction seal is dynamically assessed (Fig. 5a and b). Depending on whether a CAM deformity co-exists or not, femoro-osteoplasty may be subsequently undertaken as required.

Post-operatively, patients are mobilized four hours following surgery and permitted to fully weight bear as comfortable with the aid of crutches for 5 days. Early movement is encouraged with the use of a static bicycle from Day 1 and hydrotherapy is commenced once incisions have healed usually at Day 10 post-operatively. Return to running is permitted from 6 weeks and a return to sport specific training at 10 weeks.

RESULTS

Of the 123 cases included in the study, 106 (86.2%) were male (88 patients) and 17 (13.8%) female (16 patients): (M:F ratio (6.2:1)), with an average age of 26 (15–45) and 31 (19–49) years, respectively.

A pincer deformity was present in all cases. Lateral acetabular coverage (CEA) was considered normal in 51.2% of cases, over-coverage was present 55 cases (44.7%), mild

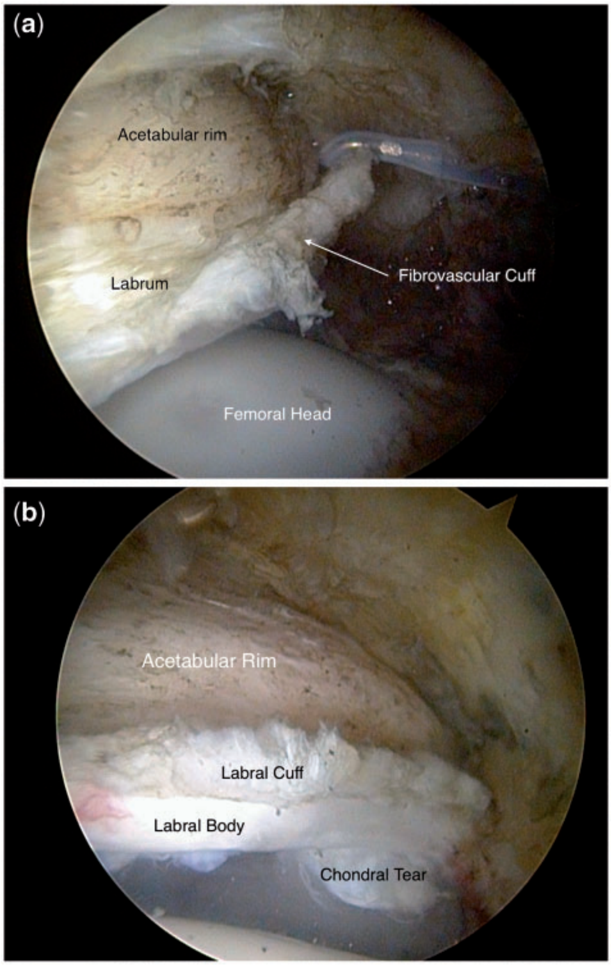

Fig. 2. (**a**) Labral reflection using a hooked radiofrequency probe. (**b**) Labral Cuff preserved for 'suspension' refixation.

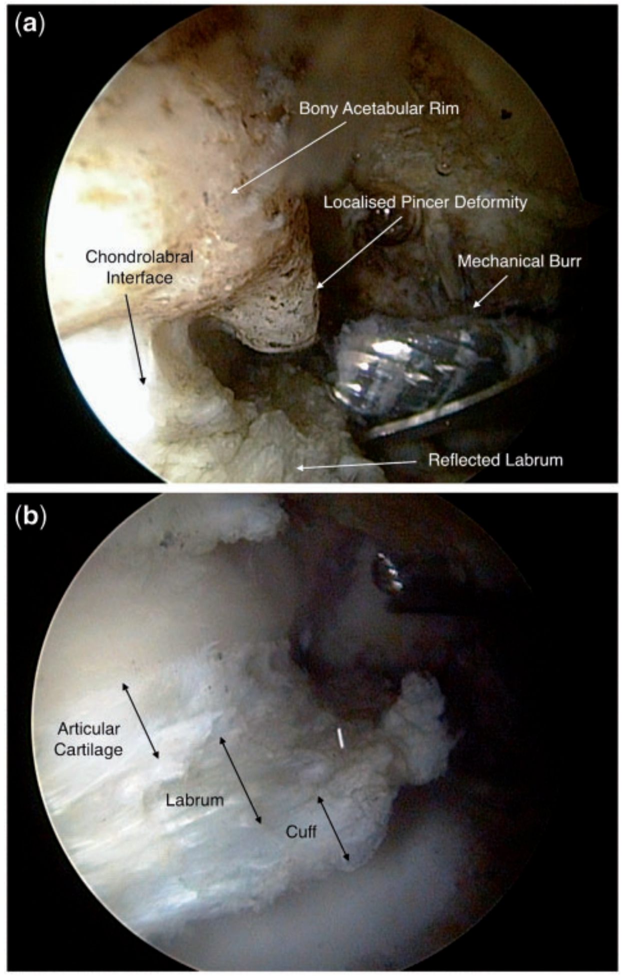

Fig. 3. (**a**) Fully exposed acetabular rim and pincer deformity following chondrolabral reflection. (**b**) Completed acetabular recession with removal of pincer deformity. Note the preservation of the important intact chondrolabral junction. The 'cuff' is clearly identified in preparation for refixation of labrum.

dysplasia in 3 cases (2.4%) and there were 2 cases of dysplasia (1.6%). The mean Alpha angle was 64.6° (range 41–107°) on the AP view and 60.0° (range: 35–129°) on the Dunn view. A CAM deformity was present in 66.7% of cases.

At arthroscopy, pathology at the chondrolabral junction was identified in all cases, including fibrillation (97.5%), partial thickness tearing (83%) and/or delamination (wave sign, 28%), however the chondrolabral junction in every case remained in continuity. Total traction time for the surgery averaged 60 min (range: 37–84 min).

In total, all 123 cases have reached 2 year post-operation; no patient has undergone hip replacement and in five cases a repeat hip arthroscopy was required for adhesions/capsular repair (4.1%). Of the 118 cases remaining, 94 (80%) have re-attended for full clinical assessment at a mean of 1.6 (0.6–2.5) years and 107 (91.5%) cases have completed outcome evaluation at a mean of 2.4 (1.7–3.2) years. In 11 cases (9 patients), no objective review data was collected (1 emigrated; 7 cases unable to further contact; in 3 cases, next-of-kin advised surgery was successful).

All outcomes scores demonstrated a highly significant improvement at 1 and 2 years ($P < 0.001$) (Table II), with improved range of hip movement (Table III). Mean post-operative Alpha angle improved from 64.6 to 60.5° on AP view and from 60 to 51.2° on Dunn view; the mean CEA improved from 33.7 to 31.0° (Table IV).

97.1% of patients stated the surgery met their expectations and would repeat if required; surgery resulted in relief of their pain in 97.1% and enabled a return to their sport in 94.2%.

There were 20 incidences (16.3%) of mild, transient neuropraxia: 4 involving the pudendal nerve (1–4 weeks) and 16 involving the anterolateral thigh (2 days to 12 weeks).

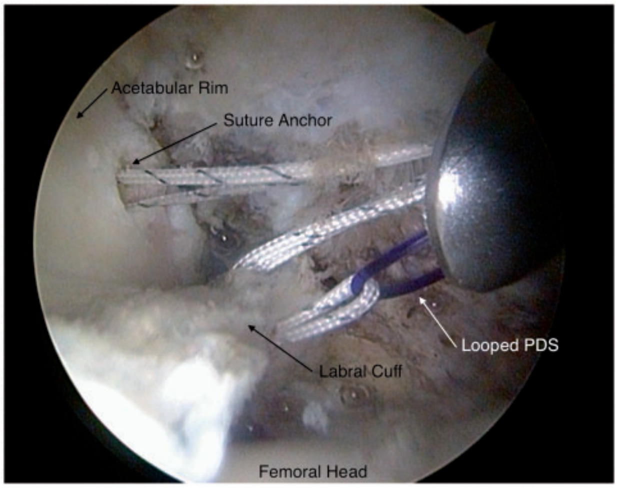

Fig. 4. Looped PDS suture (Ethicon, Somerville, NJ) is used to pull the distal limb of fixation suture through the 'cuff' of the labrum during labral refixation to acetabular bony rim (as seen from the anterolateral portal).

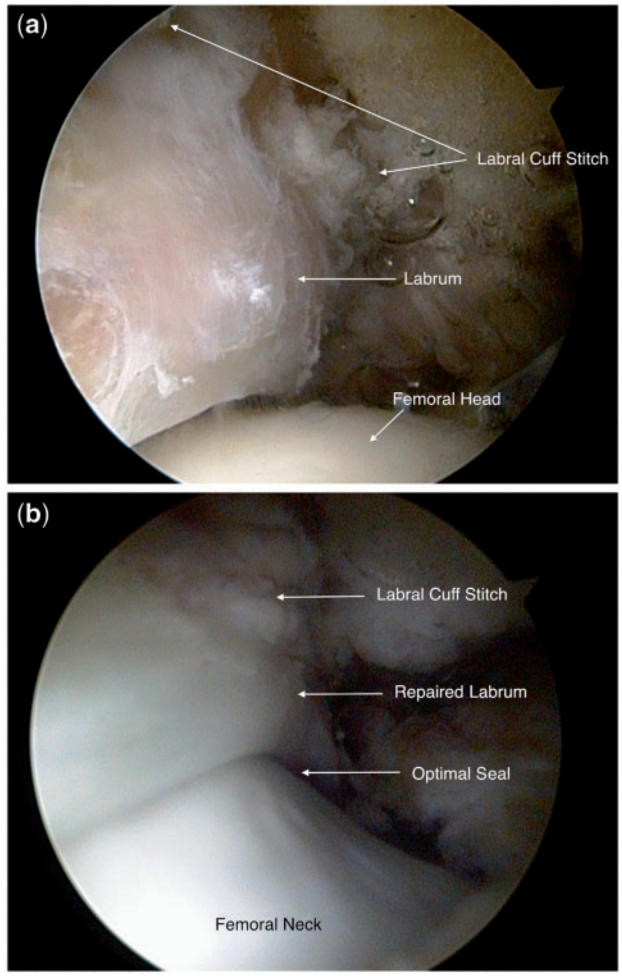

Fig. 5. Labral cuff refixation with traction on (**a**) and traction off (**b**). The labrum has been repaired back to the recessed acetabular rim; the body of the labrum remains completely free from suture fixation and mobile to optimize function as a 'flap-seal'.

DISCUSSION

The simple looped and labral base repair techniques have been well described in conjunction with bony deformity correction; good clinical outcome has been reported in patients with and without chondrolabral preservation, with these techniques [1, 2, 11, 33, 34, 37, 38].

The results of this study, at 1 and 2 years post-surgery, indicate that excellent clinical outcome and a very high patient satisfaction can be achieved by preserving an intact chondrolabral interface and utilizing a suspension-type labral repair, following acetabuloplasty; although statistically, hip movements improved, such may not be clinically significant (Table III).

The chondrolabral junction is a transition zone from articular cartilage to fibrocartilage of the labrum [22, 42] and forms a very important and strong attachment for the labrum. In the vast majority of younger patients with pincer and mixed FAI, even in the presence partial thickness labral tearing, this physiological transition zone, clearly observed at arthroscopy, is well preserved and stable. The body of the labrum is suspended freely and mobile, with a solid basal attachment, enabling it to act like a 'flap seal' optimizing the sealing of the hip joint during loading and motion [19, 24].

The non-articular base of the labrum has a transitional attachment to the bony rim of the acetabulum, with a thin fibrous 'cuff' extending proximally over the edge of the rim attaching onto the periosteum of the acetabulum [22, 42]. Surgical labral detachment disrupts all of the anatomical attachments of the labrum including the fibrous cuff, the basal attachment to the acetabular rim and the interface at the chondrolabral transition zone [7].

Given the avascular nature of this transition zone, the potential for surgical chondrolabral disruption to heal is questionable. Similar avascular zones in the knee meniscus have been shown to have poor healing capacity and tears in this region are generally excised [39, 43, 44]. Labral tears in this transition zone have poor healing potential [45] and as such to effectively create a 'surgical tear' is therefore not ideal.

Maximal strain has been demonstrated in the anterolateral labrum during full extension and with flexion, adduction and internal rotation (impingement position). Weight bearing and impact loading create additional shear forces on the labrum which may eventually lead to tearing and instability [15]. Anterior translation of the femoral head may increase following anterior capsulotomy and is resisted by a stable anterior labrum [16]. Stability of the repaired

Table II. Clinical outcome following labral cuff repair

	Pre-op	*Min 1 year post-op* (P < *0.001*)	*2 year post-op* (P < *0.001*)
n	123	112	107
Mod Harris Hip	76 (70–88)	100 (96–100)	100 (96–100)
UCLA	6 (5–9)	10 (9–10)	10 (9–10)
WOMAC	18 (31–8)	1 (4–0)	1 (6–0)*
SF36	74 (62–85)	92 (86–96)	92(87–95)*

Demonstrates the clinical outcome scores pre-operatively and at minimum 1 year (average 2.3 years) and 2 years post surgery for patients treated with chondrolabral preservation and labral cuff refixation; median values and (interquartile range) are displayed.
Improvements in all scores at 1 and 2 years are highly significant (P < 0.001); *n = 77.

Table III. Range of hip movements

	Pre-op	*Post-op*	*P *value*
n	94	94	
Flexion	118.5 (8.5)	119.5 (5.8)	0.297
Abduction	50.4 (9.1)	53.7 (7.3)	0.008
Adduction	25.2 (4.9)	27.9 (3.8)	0.000
Internal rotation	29.9 (9.2)	32.8 (6.9)	0.003
External rotation	38.7 (7.7)	43.2 (5.6)	0.000
Total mean ROM	262.7	277.1	0.000

Demonstrates the range of hip movements pre-operatively and at mean 1.6 (0.6 – 2.5) years post labral cuff fixation in 94 cases (80%). Mean values with standard deviation are displayed. Paired samples T test, *P < 0.05 statistically significant.

Table IV. Radiological deformity correction

	Pre-op	*Post-op*	*P *value*
n	123	123	
Alpha angle (AP)	64.0 (15.8)	60.5 (14.1)	<0.001
Alpha angle (Dunn)	60.1 (12.7)	51.2 (8.1)	<0.001
CEA	33.7 (5.5)	31.0 (5.0)	<0.001

Demonstrates the range of X-ray deformity angles measured pre-operatively and post deformity correction in all 123 cases (100%). Mean values with standard deviation are displayed. Paired samples T test, *P < 0.05 statistically significant.

labrum is therefore paramount to withstanding such forces during normal daily and sporting activities.

In an attempt to protect these important anatomical considerations and optimize the stability of the labral repair, a 'labral reflection' technique was developed. The elevated and preserved fibrous 'cuff' is utilized in refixation; the outer (capsular) zone of the labrum, which has a high concentration of dense connective tissue, and the loose connective tissue cuff offer excellent strength for refixation.

The evolution of this technique has resulted in the preservation of the chondrolabral junction becoming the priority, and for all cases requiring acetabuloplasty, the labrum is routinely reflected from the acetabular rim, constituting more of a 'peel-back' rather than a 'takedown' manouevre.

Anatomical repair is important and labral refixation must be secure and stablize chondrolabral dysfunction [26]. With the simple loop stitch technique, bunching of the labrum may result in loss of the free edge of the labrum at refixation points, and elevation of the labrum above the chondral verge; this can disrupt the labral seal and expose the now free chondral verge leaving it unprotected against recurrent loading and abrasion (Fig. 6). Cadaveric studies have shown repair using a simple looped technique does not restore normal sealing properties to the labrum although is however superior to labral resection or the presence of a tear [19].

The labral base repair technique [29] was developed to improve on some of the perceived deficiencies of the simple loop stitch technique. However, surgical labral detachment is recommended for pincer deformity >3 mm disrupting the important chondrolabral transition zone. The base repair requires close approximation of the suture anchor to the articular cartilage or elevation of the labrum may result, increasing the risk of joint penetration with the drill or anchor. With labral detachment, the articular side of the labral base will either remain unattached and unstable (with a partial base stitch) or will be fully incorporated into the suture loop and as such may be elevated away from the chondrolabral junction, increasing an already undesirable separation of the transition zone; this in turn may leave the chondral verge unprotected and at risk (Fig. 7).

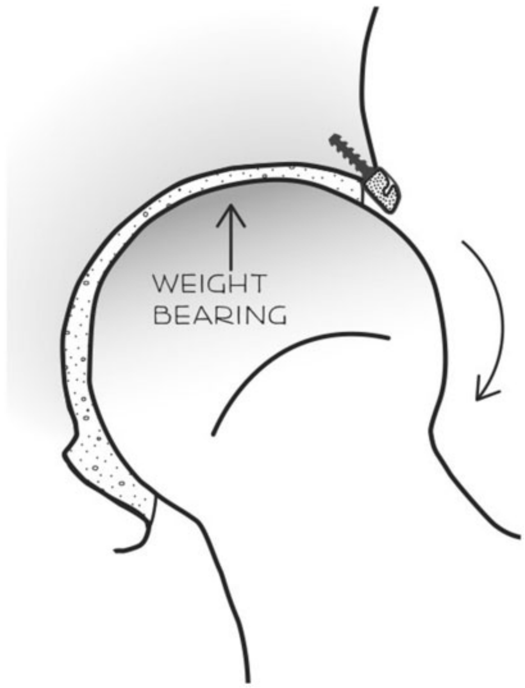

Fig. 6. Simple loop stitch repair: low screw insertion close to articular edge. Bunching and elevation, with instability and separation of chondrolabral junction, may result in increased contact stress on chondral verge.

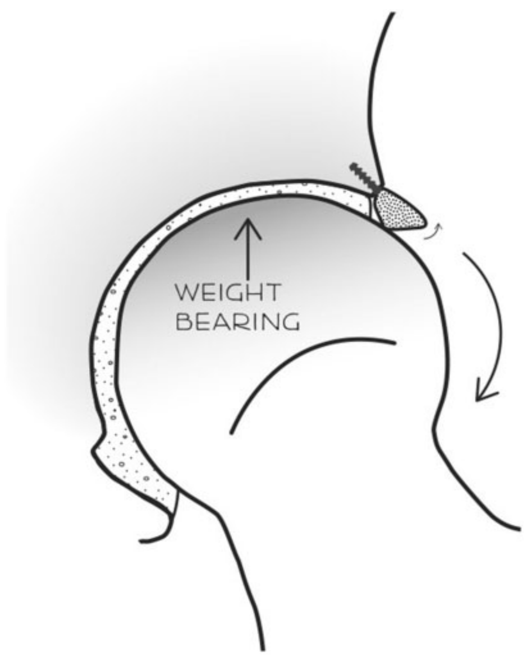

Fig. 7. Labral base fixation: low screw insertion is required to prevent elevation of labrum and poor sealing. Chondrolabral instability and separation may be increased with weight-bearing and extension moment.

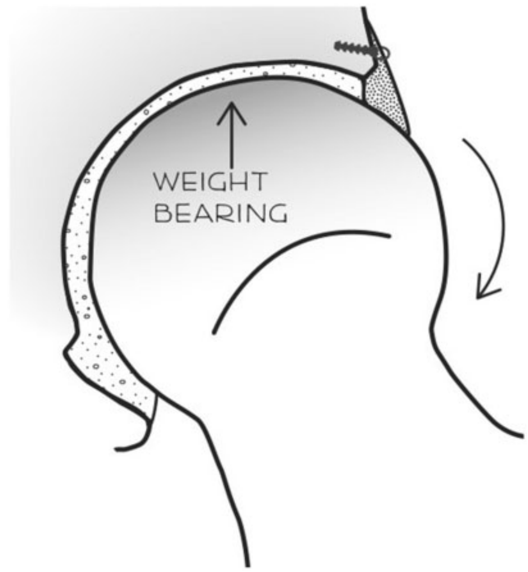

Fig. 8. Labral cuff repair: high screw insertion in safe zone away from articular edge; intact chondrolabral junction and tensioned cuff fixation provides stability with weight bearing and during motion.

The labral base repair may be utilized in cases where the chondrolabral junction remains intact; however, the suture still must be passed through the body of the labrum resulting in bunching, elevation and potential loss of suction seal and labral mobility; Other suture techniques that incorporate the body of the labrum into the repair such as vertical mattress sutures also present with similar problems.

By avoiding suture passing around or penetration of the labrum, the cuff repair protects the free edge and body of the labrum from incorporation into the repair, this 'suspension-like' refixation optimizes the flap-seal over the femoral head (Fig. 8).

When contemplating surgical labral detachment ('take-down'), consideration should always be given to the vascular supply and healing potential of the labrum. The blood supply to the labrum is primarily located on its capsular surface and extends radially from a peri-acetabular vascular ring supplied mainly by the superior and inferior gluteal arteries [39, 40] Arterioles penetrate the capsular third of the substance of the labrum and end near its free edge [23]. There is no clear evidence that the labrum receives a blood supply from the subchondral bone or it's articular connections [39, 40]. As such a labral tear does not therefore significantly interfere with its vascular supply but paradoxically the tear has poor healing potential.

The loose connective tissue on the capsular side of the labrum extends proximally along the periosteal surface of the acetabulum and contains the radial blood vessels, which supply the labrum; these are destroyed with removal

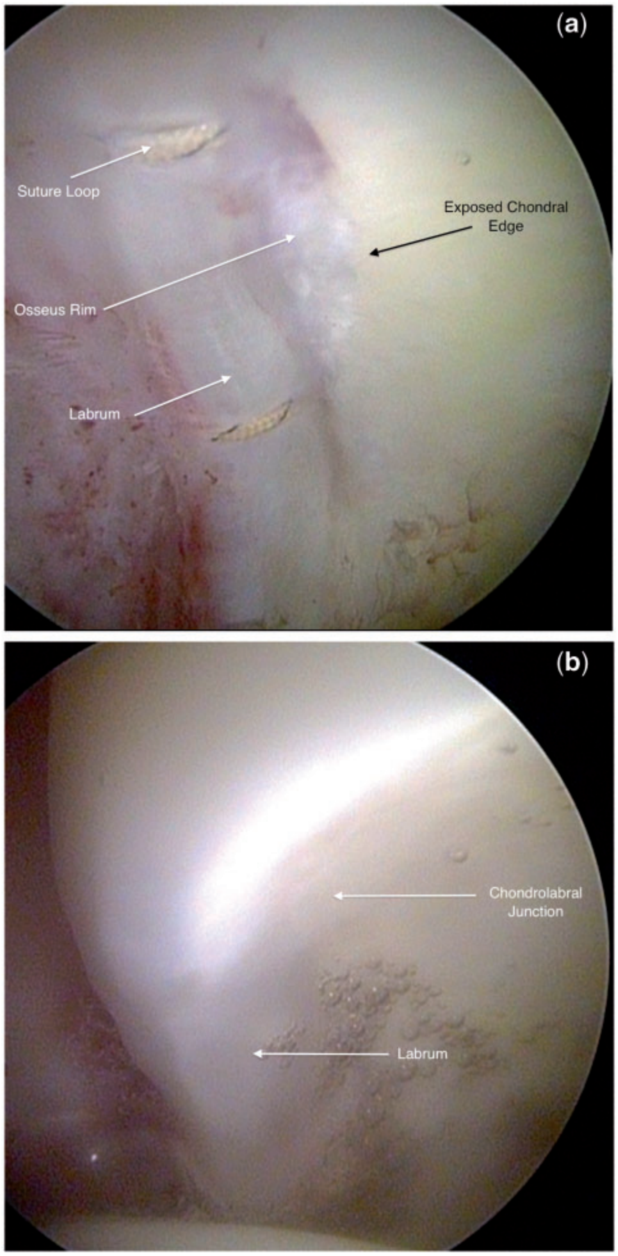

Fig. 9. (**a**) Repeat hip arthroscopy at 1 year following a simple looped labral repair demonstrates poor chondrolabral healing with separation, exposed sub-chondral bone and elevation of a bunched labrum restricting function as a mobile seal. (**b**) Repeat hip arthroscopy at 1 year following a labral cuff repair demonstrates a preserved and anatomical chondrolabral junction with the body of the labrum free from suture, permitting optimal function as a 'flap seal'.

of the connective tissue with a synovator or with radiofrequency, and during surgical detachment, further increasing the avascular void [40].

The labral cuff reflection technique may preserve much of the radial vascular network as they enter the substance of the labrum, with surgical disruption occurring only at the level between the radial vessels and the peri-acetabular vascular ring. Protection and refixation of the cuff to the periosteal surface could promote earlier re-vascularization of these radial vessels and the labrum, encouraging earlier healing.

The labral cuff technique optimizes post-fixation stability by preserving the chondrolabral interface and preventing elevation and bunching of the labrum.

On repeat hip arthroscopy, at 1 year following a loop repair procedure, bunching and elevation of the labrum remain and poor chondrolabral healing and separation is evident (Fig. 9a); on repeat arthroscopy following a labral cuff repair technique, the body of the labrum and the chondrolabral interface remain completely intact, preserving natural and functional anatomy (Fig. 9b).

The limitations of the technique include patients who have very large pincer deformity and in whom the labrum has been significantly reduced in size or calcified, making repair with any technique difficult; in patients with large full thickness, chondrolabral tearing and for those with a hypertrophic labrum secondary to instability, although still amenable to cuff refixation, loop or base refixation may provide better stability.

CONCLUSION

Chondrolabral preservation, labral reflection ('peel-back') and labral cuff refixation offers an alternative to existing takedown, detachment and refixation techniques previously described. Further studies may help clarify the perceived benefits of this technique on improved chondrolabral stability, optimal fluid-seal lubrication and vascular preservation.

Clinical outcome however at 1 and 2 years post-surgery has demonstrated a highly significant improvement in validated outcome measures, an increase in the functional range of hip motion and high patient satisfaction; longer-term follow-up will help determine whether this technique will continue to offer patients prolonged success.

CONFLICT OF INTEREST STATEMENT

None declared.

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