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Original Article

Arthroscopic acetabular labrum reconstruction with capsular autograft: clinical outcome and preliminary results

Zhenhan Deng[1,2], Jiaji Yue[1], Yizi Zheng[2,3], Ronak Naveenchandra Kotian[4], Wei Lu[1], Daping Wang[1], Kan Ouyang[1]

[1]Department of Sports Medicine, The First Affiliated Hospital of Shenzhen University, Shenzhen Second People's Hospital, Shenzhen 518035, Guangdong, China; [2]Guangxi University of Chinese Medicine, Nanning 530200, Guangxi, China; [3]Department of Thyroid and Breast Surgery, Shenzhen Breast Tumor Research Center for Diagnosis and Treatment, National Standardization Center for Breast Cancer Diagnosis and Treatment, Shenzhen Second People's Hospital/The First Affiliated Hospital of Shenzhen University Health Science Center, Shenzhen 518035, Guangdong, China; [4]Department of Orthopaedics, Victoria Hospital, Bangalore Medical College and Research Institute, Bangalore 560002, India

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Abstract: To introduce a novel technique to reconstruct the acetabular labrum using capsular autograft, and to evaluate the preliminary clinical outcome, a retrospective review of a prospectively collected registry was undertaken that identified 21 patients (21 hips) who underwent arthroscopic reconstruction of the labrum by capsular autograft from January 2016 to January 2018. Modified Harris Hip Score (mHHS), Hip Outcome Score (HOS), and Hip Outcome Score-Activities of Daily Living (HOS-ADL) were recorded preoperatively and postoperatively. Clinical outcome was analyzed to evaluate the effectiveness of this technique. Twenty-one patients, with an average follow-up time of 25.4 ± 1.6 months, were included in this study: 7 patients were diagnosed with hypoplastic labrum (width <5 mm), 9 patients with complex tear of labrum, and 5 patients with degenerative labrum. The mHHS (61.3 ± 5.5 vs. 87.5 ± 4.2, P<0.001), HOS (52.5 ± 5.1 vs. 87.3 ± 3.8, P<0.001) and HOS-ADL (48.5 ± 5.8% vs. 75.2 ± 3.5%, P<0.001) between preoperative and the 6-month follow-up were significantly different. Gender exerts no influence on the outcome of mHHS, HOS and HOS-ADL. Therefore, local capsular autograft is readily available during arthroscopy with no donor-site morbidity. The reconstruction of the hip labrum may be valuable for patients with hypoplastic or dysplastic labrum, complex tear of labrum and severe degeneration. With appropriate patient selection, this technique is promising in preliminary clinical outcome.

Keywords: Acetabular labrum, reconstruction, capsular autograft, arthroscopy

Introduction

Soft tissue injury around the hip joint is frequently found in young patients, and the injury exerts great adverse influence on the lower limb function and jeopardizes the patients' quality of life [1]. Due to the advancement in understanding the anatomical, biomechanical and pathological abnormalities of hip joint diseases coupled with clinical and arthroscopic technology, the treatment of soft tissue injury around hip joint has become one of the greatest advances in sports medicine in the past decade. With the help of appropriate traction technique, femoroacetabular impingement (FAI), gluteus contracture and labrum injury can be treated through arthroscopic techniques. The labrum can increase the stability of the hip joint and retain synovial fluid in the acetabular compartment, which is critical for the articular compartment. The cause of labral injury includes FAI, dysplasia, acute or chronic trauma and so on [2-4].

The importance of acetabular labrum has been studied extensively in various anatomic and biomechanical studies [5, 6]. The primary function of labrum is to stabilize the hip joint and to

retain the dynamics of articular synovial fluid. A labral lesion or loss of labral tissue has been shown to be associated with early progression of hip joint arthrosis [7]. The importance of labrum in maintaining the stability of hip joint and protecting the articular cartilage has drawn great attention from clinicians. Some scholars even believe that the curative effect of hip arthroscopic surgery is directly related to whether or not the labrum is retained during the operation [8]. A cadaveric study showed that the labrum had a "synovial sealing effect", which prevents the loss of synovial fluid in the acetabular compartment, thereby protecting the articular cartilage and reducing the risk of osteoarthritis (OA) in the hip joint [9]. Because of its biochemical properties, repair of the labrum is recommended rather than partial excision. When the labrum is severely dysplastic or the labrum is injured with complicated laceration and obvious degeneration, it is recommended to reconstruct the labrum with appropriate tissue as graft [10]. Ideally, the labrum should be preserved when treating patients with labral tears because of the association of labrum injury with degenerative changes in hip joint [7].

At the time of surgery, labrum may be nonsalvageable or nonexistent because of significant tearing, degenerative tissue or hypoplasia in some patients, so that labral reconstruction is an option. The autologous iliotibial band is the most commonly used grafts in labrum reconstruction with satisfactory clinical outcome postoperatively [11-13]. Besides, arthroscopic gracilis autograft and the open technique using the ligamentum teres were also reported before [14, 15]. However, during the surgery, a central rectangle of the iliotibial band is dissected and prepared on a back table by tubularizing the tissue with a braided, absorbable suture, and then passed through the mid-anterior portal and secured to the acetabular rim with a series of suture anchors [1]. The preparation of the graft might prolong the operation time and increase the risk of infection. Additionally, the non-vascularized graft might increase the risk of tissue necrosis after the operation leading to failure of reconstruction.

In this study, a novel technique of arthroscopic reconstruction of acetabular labrum with local articular capsule transplantation was introduced, and the preliminary clinical outcome and effectiveness were analyzed. It is believed that this new method of labral reconstruction has the advantage of avoiding donor-site morbidity, and prevented the possibility of disease transmission.

Methods and materials

Subjects

This retrospective study was approved by the Ethical Committee of Shenzhen Second People's Hospital (KS2015036), and all patients gave informed consent for the operation before surgeries. From January 2016 to January 2018, clinical data of patients who underwent arthroscopic capsule autograft to reconstruct labrum in our department were collected. All surgeries were performed by the same senior surgeon.

Inclusion criteria

All patients suffered from pain in the inguinal region due to various reasons, with failure of conservative treatments (exercise habit changes, oral administration of non-steroidal anti-inflammatory drugs (NSAIDS), and physiotherapy) over 6 months. All patients suffered from painful activity limitation, and anterior impact test (flexion, adduction, rotation-induced pain) was positive. Preoperative examinations included X-ray (pelvic anteroposterior and frog's lateral view), Computer Tomography (CT) scanning with digital three-dimensional reconstruction of hip joint, and unilateral Magnetic Resonance Imaging (MRI) scan of hip joint. Diagnostic criteria for pincer impingement include positive crossover sign, positive ischial spine sign, and CE angle (CEA) >40°. Cam type of impingement is defined as angle of alpha >55° in the preoperative X-ray.

Patients with the following labrum conditions were eligible in this study if they underwent arthroscopic reconstruction and had minimum 24 months follow-up data available: (1) Labral dysplasia (width <5 mm); (2) Complex tear that could not be repaired by suture intra-operatively; (3) Obvious degeneration of labrum was found during the operation, including but not limited to calcification or defect of labrum.

CEA was calculated on pre-operative CT. Patients with CEA less than 25°, preoperative

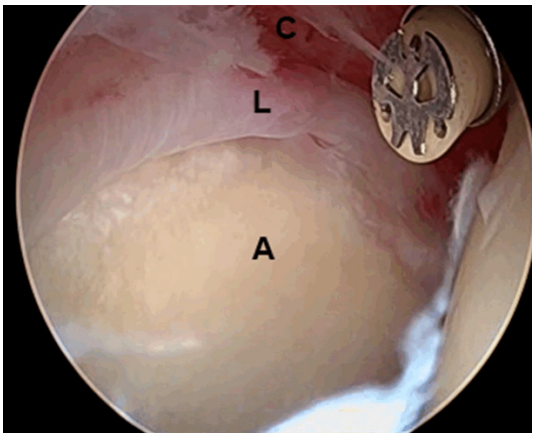

Figure 1. Acetabular labrum dysplasia. The width of labrum is less than that of the radiofrequency tip (4 mm). A, acetabulum; C, capsule; L, labrum.

subluxation, and affected limb turned inwards or outward, which require strengthening capsular suture during operation were excluded.

Surgical techniques

Proper general anesthesia with paralysis is necessary for hip arthroscopy. All patients lied in supine position on an orthopedic traction bed with a padded perineal post, and the surgical side extremity was positioned in adduction, with 10° flexion in the hip joint and femur internally rotated. With the help of X-ray fluoroscopic guidance, anterolateral (AL) portal was created into the central compartment, and then under direct visualization, the medial-anterolateral (MAL) portal was created [16], and articular capsulotomy was performed between the two portals. Comprehensive diagnostic arthroscopic exploration was performed using a 70° lens to determine the pathological state of labrum, and to evaluate the extent of cartilage injury, especially the acetabulum-labrum junction. If the labrum suffered from an obvious dysplasia (width <5 mm, **Figure 1**), complex tear or severe degeneration, regional autogenous articular capsule transplantation was used to reconstruct the anatomical structure of labrum.

Before the capsular autograft reconstruction, the labral tissue was evaluated and the nonsalvage tissue were ought to be debrided to the stable extent, observation was made through the AL approach and the bipolar radiofrequency energy (bRFE) was applied to cut the joint capsule at about 5-10 mm above the labrum edge, from 10 to 12 o'clock, via MAL approach. The size of the joint capsule tissue needed was determined based on the size of defective area in the labrum. The purpose was to suture the original labrum with the extracted articular capsule tissue and to ensure that diameter of the reconstructed labrum was about 5-7 mm. 3.0 mm single-loaded suture anchors (Arthrex, USA) and the mattress suture technique were used for reconstruction. Generally, the incision width of the capsule is around 10 mm so that the reconstructed labrum is 5 mm in diameter after suturing. Care should be taken to ensure that when the suture is tied, the capsular tissue lies on the acetabular rim in a manner similar to the adjacent labral tissue. It should be noted that excess capsular tissue can be trimmed back with a suction shaver after reconstruction; however, if the suture is passed too close to the free edge of the capsular tissue, then the capsule will bunch and the tissue will not protrude beyond the rim when the knots are tied. This is critical if the capsular tissue is to restore labral function (**Figure 2**).

If there was pincer impingement, the excessive acetabular rim was trimmed. If there was no bone impingement, the acetabular rim was properly debrided for refreshment. After the acetabular rim was appropriately prepared, several 2.3 mm bio-absorbable anchors (Smith & Nephew, USA) were inserted from the MAL approach to suture the articular capsule tissue and residual acetabular labrum on the acetabular rim intermittently. Generally, each anchor was placed about 1 cm apart from another to ensure the labrum was properly fixed. This technique also avoided the ligation of vessels in the articular capsule (**Figure 3A**, **3B**).

We released the traction and observed the peripheral compartment under direct vision. The reconstructed labrum was in close association with the femoral head when the hip joint moved in order to ensure the acetabular labrum reconstruction was sufficient for synovial sealing (**Figure 3C**). We then moved the hip joint to check if there was cam impingement between the femoral neck and the labrum, and trimmed the osteophyte at the head-neck junction if needed. In cam impingement cases, the osteophyte at the head-neck junction was trimmed. In the non-impingement cases, the labrum was sutured after freshening the acetabulum.

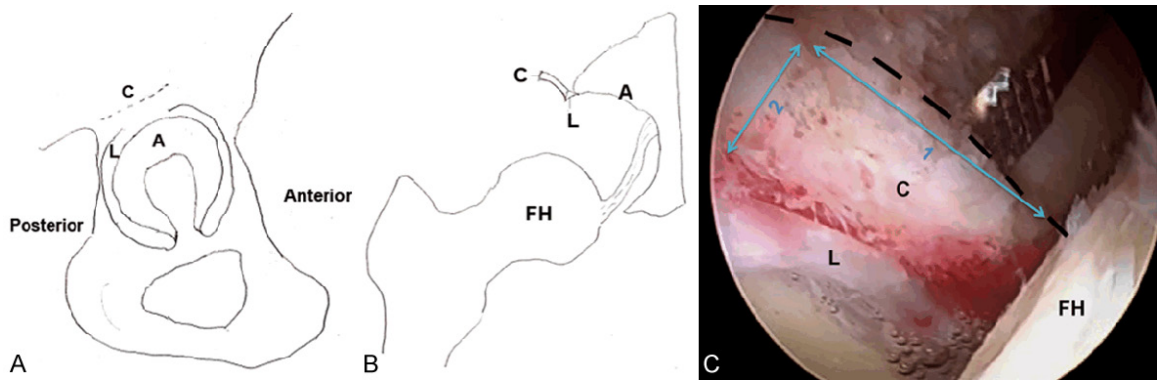

Figure 2. Determination of area of partial incision of capsule. A. The dotted line indicates the incision of the joint capsule, indicating the border between the joint capsule and the defect of the labrum. B. The proper length of capsule is detached from acetabulum edge to joint surface side, and retains the connection between capsule and acetabulum joint surface to preserve the blood supply of the incised capsule. C. The arthroscopic view of the detachment of capsule during the operation. Line 1 indicates the length of the incision of the joint capsule, which is about 130% that of the labral defect. Line 2 indicates the incision width of the joint capsule, which depends on the width of the defect in the labrum. A, acetabulum; C, capsule; FH, femoral head; L, labrum.

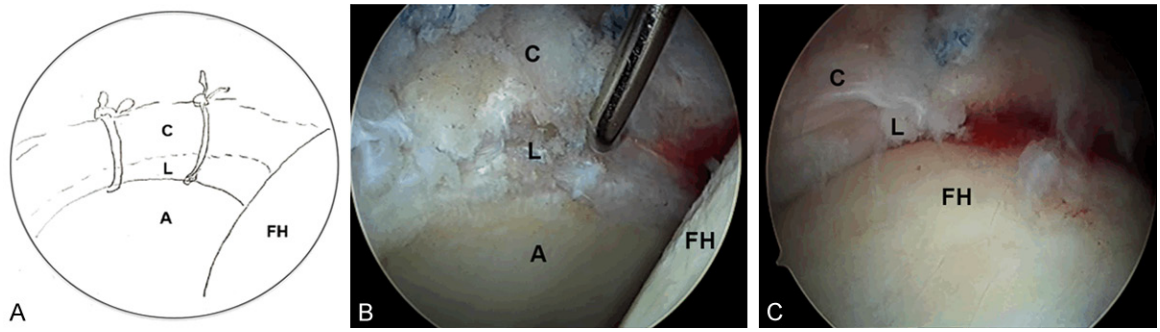

Figure 3. Reconstruction of labrum with capsule autograft. A. The sketch of the reconstruction of labrum with capsule autograft. B. The arthroscopic view of the reconstruction of labrum with capsule autograft during the operation. C. After release of traction, the labrum encysts the femoral head and restrains the synovial fluid. A, acetabulum; C, capsule; FH, femoral head; L, labrum.

Postoperative rehabilitation

Postoperative rehabilitation was patient specific and depended on concomitant procedures that performed in addition to capsular autograft reconstruction. Patients were advised to maintain less than 10 kg weight bearing as tolerated using a flat-foot gait with crutches. This gait is beneficial for maintaining pelvic level, preventing pelvic tilt caused by pain and increasing the pressure of reconstructed labrum. Range of motion in hip joint was limited to 90° of flexion in the first postoperative 6 weeks. Passive hip joint mobility and muscle strength exercises were conducted gradually for preventing joint stiffness.

At 6 months postoperatively (POM), the crutches were no longer needed and the patients started to exercise on a fixed bicycle or elliptical machine with light resistance. They were allowed swimming with heavy kicking at POM 3, golf was allowed at POM 4, and antagonistic training was resumed within the possible tolerance range at POM 6.

Follow-up

All patients were followed-up at least 24 months after surgery. The follow-up included outpatients visiting at 6 weeks, 3, 6, 12 and 24 months postoperatively. All patients underwent standard clinical assessment including radiographic examinations and detailed physical examinations by one senior doctor. MRI was performed to evaluate the healing of the reconstructed labrum at POM 6. The incidence of hip OA was assessed by X-ray and clinical physical

Table 1. The clinical assessment of labrum reconstruction preoperatively and at the last follow-up

	Preoperative	Last follow-up
mHHS	61.3 ± 5.5	87.5 ± 4.2#
Male	63.0 ± 6.0	87.1 ± 5.5*
Female	60.0 ± 4.9	87.8 ± 3.2
HOS	52.5 ± 5.1	87.3 ± 3.8#
Male	53.0 ± 6.2	85.1 ± 3.3*
Female	52.1 ± 4.4	88.9 ± 3.4
HOS-ADL	48.5% ± 5.8%	75.2% ± 3.5%#
Male	48.4% ± 7.1%	75.0% ± 3.2%*
Female	48.5% ± 5.0%	75.3% ± 3.8%

Note: #, Compare with the preoperative assessment, $P<0.05$. *, Compare with female patients assessment, $P<0.05$.

examination at POM 24. The hip function was assessed by modified Harris Hip Score (mHHS), hip outcome score (HOS) and hip outcome scoring of daily living (HOS-ADL) scores preoperatively and at the last follow-up. Any postoperative complications or reoperations were noted as well.

Statistics analysis

SPSS 19.0 software was used for statistical analysis. Data were expressed as mean ± standard deviations. Functional scores before and after surgery were assessed by paired sample t test, and functional scores of patients of different genders were assessed by independent sample t test. The difference was statistically significant when $P<0.05$.

Results

Demographic characteristics and follow-up

A total of 21 patients including 9 males and 12 females with an average age of 46.7 ± 5.7 years who underwent arthroscopic labrum reconstruction with capsular autograft were included in this study. The average follow-up time was 25.4 ± 1.6 months (24-30 months).

Among them, 7 cases were diagnosed with labral dysplasia (width <5 mm); 9 cases were diagnosed with complicated laceration of labrum; severe degeneration was found in 5 cases, with all lesion located in the anterolateral side. The labrum injury with cam impingement was diagnosed in 5 cases, labrum injury with pincer impingement in 3 cases, labrum injury with mixed impingement in 11 cases, and simple labrum injury in 2 cases. Cartilage lesion was found in 14 patients (66.67%), including 9 females and 5 males. Softening and swelling of cartilage were found in 5 cases and classified as Outerbridge type I. 9 cases were classified as Outerbridge type II, and fragmentation and fissuring were observed within soft areas of articular cartilage arthroscopically. All cartilage lesions were located at the acetabular margin and the contact region of labrum and articular cartilage. No special treatment was performed after the removal of the exfoliated cartilage.

Clinical outcomes

The mHHS, HOS and HOS-ADL scores at the last follow-up were significantly higher than those preoperatively ($P<0.001$, **Table 1**). However, no statistic difference was found in these scores between male and female subgroups ($P>0.05$, **Table 1**).

Complications

No serious complications such as nerve injury, infection or pressure ulcer occurred during the follow-up. No patients needed revision or further operation at the last follow-up. At POM 6, MRI showed that all patients achieved healing of the reconstructed labrum, and no anchor peeling and reconstructed labral avulsion occurred (**Figure 4**).

Discussion

Labral reconstruction has become an important tool in the armamentarium of hip surgeons. Cases of satisfactory outcomes after labral debridement, labral refixation, and labral repair are well documented [17]. In this study, it is promising that the restoration of labrum improves the preliminary clinical results, and we believe that reconstruction using capsular autograft is another option for the treatment of labral deficiency.

The intact of acetabular labrum is critical for the function of hip joint, as well as preventing the progression of osteoarthritis. Anatomic and biomechanical studies have revealed the two critical biological functions of the soft tissues surrounding the hip joint. The hip labrum can significantly increase the contact surface of femoral head and acetabulum with increase in

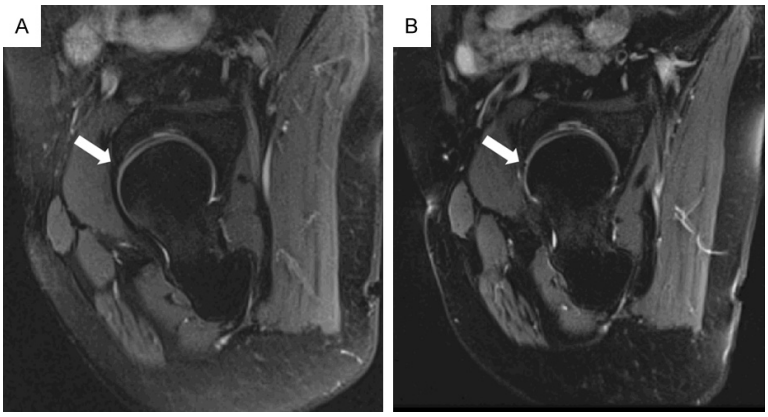

Figure 4. The preoperative and POM 6 MRI of a 56-year old female patient, who was diagnosed with labral dysplasia. A. Hypoplasia of the labium can be observed on the sagittal view (white arrow). B. Reconstruction of the labrum and good healing can be observed on the sagittal view (white arrow).

average area of 28.8 cm^2 to 36.8 cm^2 [18]. Therefore, the acetabular coverage will enhance the stability of hip joint, and increase the volume of acetabular joint as well anatomically. From the biomechanical perspective, the femoral head is surrounded by the labrum with compactness to limit distraction, rotation, and translation. The femoral head sealing ability of labrum ensure the daily and athletic functions of the hip joint. From the biomechanical perspective, acetabular volume increases from 31.5 cm^3 without the labrum to 41.1 cm^3 with the labrum. Crawford et al. [19] have demonstrated the importance of intact labrum in the stability of the hip joint. Sixty percent less force was required to distract the hip about 3 mm after creation of the labral tear. In addition, the specimen with a labral tear externally rotated 7.1° more and displaced 0.67 mm more than the intact specimen, indicating micro-instability in the hip. Myers et al. [19] believed that the labrum had the same ability as the iliofemoral ligament to function as the primary stabilizer of the hip joint. Besides, the labrum traps the synovial fluid and lubricates the central compartment leading to pressurization of the cartilage interstitial fluid in a more uniform manner. With the appropriate volume of synovial fluid, the loading between the acetabulum and femoral head prevents the direct cartilage-to-cartilage contact thus balancing the distribution of stress, which can protect the cartilage and postpone the degeneration of joint.

Additionally, labral tears lead to fluid efflux [9] and deteriorate the fluid dynamics. It causes synovial fluid leak through an unintended vent in the central compartment resulting in higher stress to the solid components of the articular cartilage. Labrum plays an important role in maintaining the normal structure and function of the hip joint. With the loss of the labral functions, the articular cartilage will wear more rapidly and accelerate the hip joint arthrosis.

Labral tear can lead to hip pain, which is the most common surgical indication of hip arthroscopy. Currently, clinical research on labrum injury is very extensive. McCarthy et al. believed that the removal of labrum will significantly increase acetabular pressure and articular stress, thus leading to early onset of OA in the hip joint [7]. Presently, preliminary treatment includes NSAIDS medications or injections, modification of activities or total hip arthroplasty (THA) for the patient debilitated by hip pain. Unfortunately, THA and modifications of activities are not clinically acceptable for young patients. Arthroscopic reconstruction of labrum not only provides symptomatic relief but also prevents the onset of hip arthrosis. At present, the “gold standard” for the treatment of labrum injury is to repair the tear or reconstruct it with grafts [20]. Especially for irreparable labral injuries, the primary intention is to reconstruct the defect, which can effectively restore the stability of hip joint. It also reestablishes the synovia due to its sealing effect to obtain excellent clinical outcome [14].

In this study, all patients presented positive feedback with satisfaction in their functional recovery. The mHHS, HOS and HOS-ADL scores at the last follow-up were significantly improved compared with those preoperatively, which finding was similar to the results reported in other studies [11, 21, 22]. At the last follow-up, no clinical and X-ray evidences of hip OA were found, and no reoperation was required. This novel technique had good clinical results, which were similar to a previous study [23]. Labrum reconstruction by invasive operation was first reported by Sierra et al. [15], and then Philippon et al. [11] reported that labrum reconstruction

can be performed arthroscopically with autologous or allogenic tissue. Studies [24-26] have reported that the labral reconstruction grafts include semitendinosus tendon, iliotibial bundle, hamstring tendon and allogenic labrum. Although the operation time is relatively short utilizing allografts with an easier prediction of the transplant size, less complications and faster recovery, the economic burden of autologous transplantation is relatively high, and the patients will also take the risk of infection. Although the current improvement of inspection, processing and sterilization technology reduces the risk of diseases transmitted in allograft transplantation, the risk cannot be completely avoided [26]. Autologous iliotibial bundle transplantation has some shortcomings as well, such as the possibility of complications in the donor site, the difficulty of obtaining appropriate graft length and the difficulty of locating.

Currently, graft choices for reconstruction include ipsilateral gracilis tendon harvested from the knee, a semitendinosis allograft [5] and other autografts. Philippon et al. [11] reported one of the first studies of arthroscopic acetabular labral reconstruction with an iliotibial band autograft. After a minimum 1-year follow-up, mHHS significantly improved and younger patients presented more satisfying feedback. Weidner et al. [27] reported the study of labral reconstruction with ligamentum capitis femoris. This novel technique adequately restored the labrum and its sealing function, and obtained good clinical results at 1 year follow-up. It has been reported that autologous or allogeneic tissue reconstruction of labrum is effective in the early stage. However, arthroscopic transplantation and fixation of grafts has a high technical requirement, and the transplanted tissue undergoes vascularization and remodeling. A significant advantage of this local capsular autograft technique had several advantages. Autograft is harvested from the nearby capsular tissue with rich blood supply that promotes the healing of the labrum. This technique avoids donor-site morbidity and may decrease postoperative pain, scarring, and blood loss. Capsular tissue is also well suited for filling small or segmental labral defects of 10 to 20 mm. The main shortcoming of this technique is the inability to close or plicate the capsule after reconstruction. We suggest that this precludes the use of this technique in patients with a lateral CEA less than 25°. It is unclear at this point how capsular tissue will compare with other graft choices such as hamstring tendon or iliotibial band. However, the utilization of local vascularized tissue presents the advantages of a faster graft remodeling and shorter operation time compared with traditional labral reconstruction using autologous transplantation.

There are several limitations in this study. First, we have no idea whether partial capsulectomy will affect the stability of the hip joint. Biomechanical tests will be performed to provide evidence to this issue in the future. Last but not least, we excluded some cases of junctional hip dysplasia with CE angle less than 25°. Therefore, the clinical results of this study are preliminary and further research of large samples and related biomechanical studies are needed.

Conclusions

We recommend labral reconstruction for patients with labral dysplasia, complex tear and severe degeneration. It restores the labral anatomy and the integrity of labral complex. Local articular capsule reconstruction not only reduces the complexity of surgery but also ensures improved donor tissue blood supply, and reduces the complications of donor site.

Acknowledgements

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Kan Ouyang, Department of Sports Medicine, The First Affiliated Hospital of Shenzhen University, Shenzhen Second People's Hospital, No. 3002 West Sungang Road,

Shenzhen 518035, Guangdong, China. Tel: +86-18665348601; E-mail: okszey@126.com

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