Technical Note

Capsular Reconstruction of the Hip Using Modified Kite Technique: A Technical Guide for Efficient Graft Management and Fixation

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Abstract: Preserving capsular integrity has become an important principle of hip preservation surgery given the increasingly recognized deleterious effects of instability in cases of capsular insufficiency. When capsular tissue is deficient, capsular reconstruction may be indicated to restore function of the iliofemoral ligament and improve hip biomechanics. To date, few studies have presented technical guidance on performing arthroscopic capsular reconstruction of the hip. In this Technical Note, we introduce a modified kite technique for arthroscopic entry, control, and fixation of a capsular reconstruction graft. Similar to flying a kite with multiple fly lines, and to the previously described kite technique for hip labral reconstruction, the principles of this method are founded on the belief that control sutures within a pulley system facilitate safe and efficient graft management during capsular reconstruction procedures.

Preserving capsular integrity has recently become a guiding principle in hip preservation surgery, given the increasingly recognized biomechanical importance of the iliofemoral ligament.[1,2] The iliofemoral ligament provides resistance to hip extension, translation, and rotation and functions as the strongest soft tissue static stabilizer of the hip.[3] Inherent to most hip arthroscopy procedures, the anterior capsule, comprised primarily of the iliofemoral ligament, is cut to aid in adequate visualization of the central and peripheral compartments. Clinical studies have demonstrated higher outcome scores and lower revision rates in patients undergoing arthroscopic hip surgery with capsular preservation/closure than those without capsule closure.[4] In patients with deficient capsular tissue—typically seen in revision arthroscopy settings after inadequate or failed capsular closure or excessive capsular debridement/resection—capsular reconstruction has recently emerged as a viable solution for symptoms of microinstability, pain, and discomfort.[5,6]

Historically, capsular reconstruction procedures have been performed via an open, anterior Smith-Peterson approach to reconstruct the iliofemoral ligament and improve hip biomechanics.[7] However, over the past several years as hip arthroscopic techniques have improved, surgeons have started to perform these procedures arthroscopically. First described by Trindade et al. using iliotibial band allograft in 2015,[5] arthroscopic capsular reconstructions have slowly increased in frequency over the past 5 years, with subsequent publications offering technical pearls.[8,9] For most hip arthroscopists, however, this procedure continues to present a significant degree of technical difficulty, particularly with visualization, graft passage, suture management, and fixation, thereby limiting its efficacy and potentiating the risk of iatrogenic damage within the joint.

Previously, a novel "kite technique" for arthroscopic labral reconstruction of the hip was described to help

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facilitate introduction, control, and fixation of a segmental labral reconstruction graft.[10] Similar to flying a kite with 2 fly lines, the principles of this method are founded on the belief that a soft tissue graft in an arthroscopic environment is easier to guide into position with 2 control sutures using a pulley system. In this narrative, we are the first to extrapolate the kite technique to capsular reconstruction of the hip using dermal allograft, introducing a safe, efficient, and reproducible approach to perform this challenging procedure (Video 1).

Surgical Technique

Patient Positioning and Anesthesia

After general anesthesia is induced, the patient is positioned supine on a postless traction table (Pivot Guardian; Stryker Endoscopy, Kalamazoo, MI) with all bony prominences appropriately padded. The table is placed into 5° to 10° Trendelenberg positioning to assist in gaining adequate distraction of the hip (Fig 1).

Diagnostic Arthroscopy

The operative leg is placed under traction, and fluoroscopy is used to guide entry into the hip joint via the standard anterolateral portal (ALP). Five standard arthroscopic portals are used for this procedure: (1) ALP; (2) mid-anterior portal (MAP); (3) distal anterolateral accessory (DALA) portal, 3 to 4 cm distal and 1 to 2 cm anterior to the ALP; (4) proximal MAP (pMAP), 2 to 3 cm proximal to MAP; and (5) accessory DALA portal, 2 cm anterior to the standard DALA portal (Fig 2). An interportal capsulotomy is performed between the MAP and ALP in standard fashion. A standard diagnostic arthroscopy is performed. In a revision setting, any loose capsular or labral sutures are removed.

Bone Resection

After diagnostic arthroscopy, if bony morphology is abnormal and consistent with femoroacetabular impingement (FAI), this bone is decompressed off the acetabulum or femur in standard fashion.

Labral Treatment

The damaged labral tissue is repaired, augmented, reconstructed, or debrided, depending on the quality of the labrum and integrity of the labral acetabular suction seal. The indications and contraindications for each specific labral procedure are well described in the literature[11] and are beyond the scope of this Technical Note. After appropriate labral treatment, the hip is taken off traction, and attention is turned to the anterior capsule.

Capsular Reconstruction

Preparation

The hip is positioned into 5° to 10° flexion to relax the native capsular remnants. Care is taken to enable visualization of the peripheral compartment extending from the anterior inferior iliac spine and acetabular rim proximally to 1 cm distal, anterior, and posterior to the native capsular leaflet distally. Using an electrocautery device and arthroscopic shaver, the adipose tissue superficial to the capsule is gently excised to provide optimal visualization. This is an important portion of the procedure, as inadequate visualization of the proximal and distal capsule remnants may complicate later steps.

A large adjustable cannula (Pivot TransPort 789 cannula, 110 to 140 mm; Stryker) is inserted through the DALA portal into the joint. Via this cannula, 2 suture anchors (1.4-mm NanoTack anchor; Stryker) are placed into the acetabular rim proximal to the labrum, one at the most anterior aspect of the defect, 3 to 5 mm

Fig 1. Patient positioning. The patient is placed supine, and the operative leg (left) is put in traction, adducted, and internally rotated. The perineum and all bony prominences are appropriately padded.

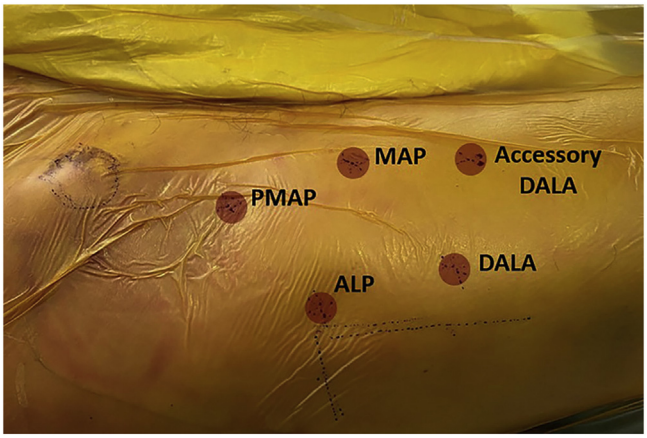

Fig 2. Right hip, supine position. Intraoperative photograph of a right hip demonstrating the location of the portals and their relation to the greater trochanter. ALP, anterolateral portal; DALA, distal anterolateral accessory portal; MAP, mid-anterior portal; PMAP, proximal mid-anterior portal.

proximal to labrum and adjacent to anterior capsule, and one at the most posterior aspect of the defect, 3 to 5 mm proximal to labrum and adjacent to posterior capsule. Next, a triple-loaded all-suture anchor (2.3-mm Iconix 3; Stryker) is placed within the mid-portion of the defect, halfway between the anterior and posterior anchors along the rim, typically within the subspine region of the acetabulum for most capsular defects (Fig 3). Collectively, these 3 anchors will be used to secure the proximal end of the graft in place. The last, perhaps most important, step of the preparation phase is to place 2 distal simple sutures into the native capsule using a suture passage device (Pivot InJector II; Stryker). The distal anterior suture is passed and stored via the accessory DALA portal, and the distal posterior suture is passed and stored via the ALP adjacent to the arthroscope for suture management.

Defect Measurement

At this time, the defect is measured in a manner similar to the previously described kite measurement technique for labral reconstruction.[12] The hip is placed into full extension. Precise measurement is important to avoid graft/defect mismatch and prevent oversizing or undersizing the graft. Briefly, with the arthroscope in the ALP and cannula in the DALA portal, a suture retriever instrument (Smith & Nephew, London, UK) is used to pull 1 strand of suture from each of the anterior and posterior anchors out of the DALA cannula. These 2 suture strands are then tied together, and hashmarks are placed along the posterior suture strand from the knot, as previously described[12] (Video 1). The knot is then shuttled into the joint and placed directly over the anterior anchor, and a probe or grasper is used to line the posterior suture strand (with hashmarks) along the rim, moving posteriorly to span the length of the defect. The hashmarks are counted, and the anterior-posterior length is recorded. The same technique is used extending from the anterior anchor to the distal capsule to measure the proximal-distal length of the defect, and an oblique measurement is performed as well from anterior proximal to posterior distal (Fig 4). If the defect is large, an additional midbody anchor may be used if necessary. Each anchor should be separated by 8 to 10 mm along the proximal acetabular rim.

Graft Preparation

The authors prefer to use a dermal matrix allograft for capsular reconstruction (AlloSource, Centennial, CO), but various autograft and allograft tissues have been described as alternatives.[5,8,9] The dermal matrix allograft is cut to size using the above measurements for the appropriate length and width (Fig 5). Using a free needle or suture passing device, a suture is then passed through each of the distal anterior and distal posterior corners for graft control and future suture passage. The authors prefer these sutures to be different colors to aid in later suture retrieval.

Graft Insertion

The adjustable cannula is removed from the DALA portal and replaced with a slotted cannula to facilitate graft passage. Care is taken to ensure the pathway into the joint is free of soft tissues to prevent a soft tissue bridge upon entering the joint. With the arthroscope in the ALP portal, the following sutures are sequentially removed from the joint: (1) 1 strand of suture from the anterior anchor, (2) 2 separate strands from the triple-loaded

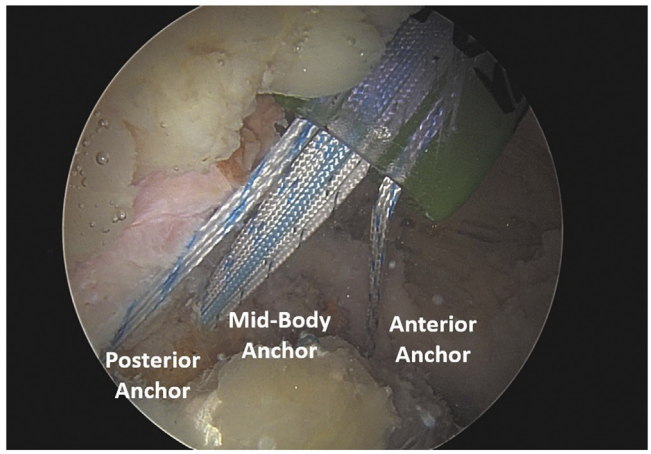

Fig 3. Right hip, supine position. Intraoperative photograph demonstrating placement of the anterior, midbody, and posterior anchors along the acetabular rim of right hip with the arthroscope in the anterolateral portal. Anchors are placed 3 to 5 mm proximal to the labrum, with the anterior and posterior anchors placed at the most anterior and posterior portions of the capsular defect, respectively. The midbody anchor is placed halfway between the anterior and posterior anchors, proximal to the labrum.

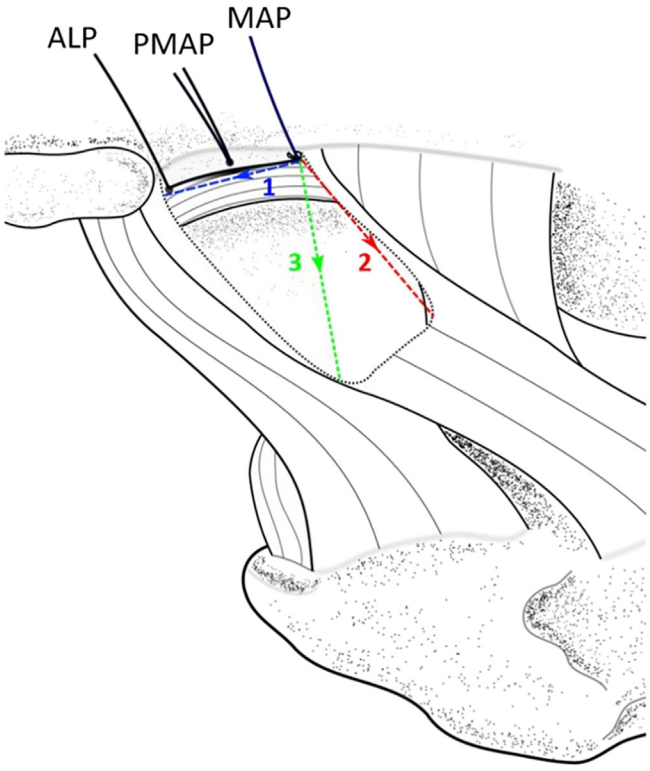

Fig 4. Diagram showing the 3 capsular defect measurements taken during the kite measurement technique. Hashmarks in 5-mm increments are placed along the posterior suture strand starting at the knot to span the length of the defect. Using a probe or grasper, the length defect is then measured by counting the hashmarks in 3 dimensions: anterior-posterior (1), proximal-distal (2), and oblique from anterior-proximal to posterior-distal (3). ALP, anterolateral portal; MAP, mid-anterior portal; PMAP, proximal mid-anterior portal.

midbody anchor, and (3) 1 strand from the posterior anchor. Care is taken to ensure these respective sutures are parallel and taut, to decrease the risk of suture entanglement. These suture strands are termed the "non-post" sutures, while their opposite ends out the proximal portals are termed the "post" sutures. A second adjustable cannula (Pivot TransPort cannula) is then inserted into the MAP to aid with suture passage and knot tying. Of note, the third suture from the midbody triple-loaded anchor is left in place and used only if the graft requires additional security after proximal fixation.

Kite Technique

The graft is retrieved from the back table and positioned carefully outside the DALA cannula (Fig 6). Using a free needle, the non-post suture strand out of the DALA portal from the anterior anchor is pierced through the proximal anterior corner of the graft, ~3 mm from the anterior and proximal edge, and tension is maintained. Next, the 2 midbody non-post sutures are pierced through the midbody of the graft 3 mm from the anterior edge of the graft, separated by 2 mm. These 2 sutures are tied to each other ~1 to 2 cm from the tail of each suture and will be used to pulley the graft into place. Finally, the posterior non-post suture is pierced through the posterior corner of the graft, and tension on the suture is maintained. At this time, all proximal sutures have been passed through the proximal end of the graft to facilitate graft passage and control in the joint. The number of additional sutures depends on the length of the defect and number of anchors previously placed in the acetabular rim.

At this time, the graft is inserted into the joint using the modified kite technique. The 2 midbody post sutures out of the proximal MAP are tensioned together, similar to fly lines on a kite, and the knot in the center of the graft effectively pulls the graft into position along the rim, while the anterior and posterior non-post sutures are held taught to prevent the graft from flipping as it travels into the joint (Fig 7). A knot pusher or grasper may be used to help guide the graft down the cannula and into the joint, but typically this is not necessary. Once the graft is provisionally placed along the rim, all proximal sutures are sequentially retrieved and tied, securing the proximal edge of the graft into place.

Attention is then turned to distal fixation, which is accomplished via a simple suture shuttling technique. The hip is positioned into full extension off traction. Via the MAP cannula, a suture retriever is used to retrieve

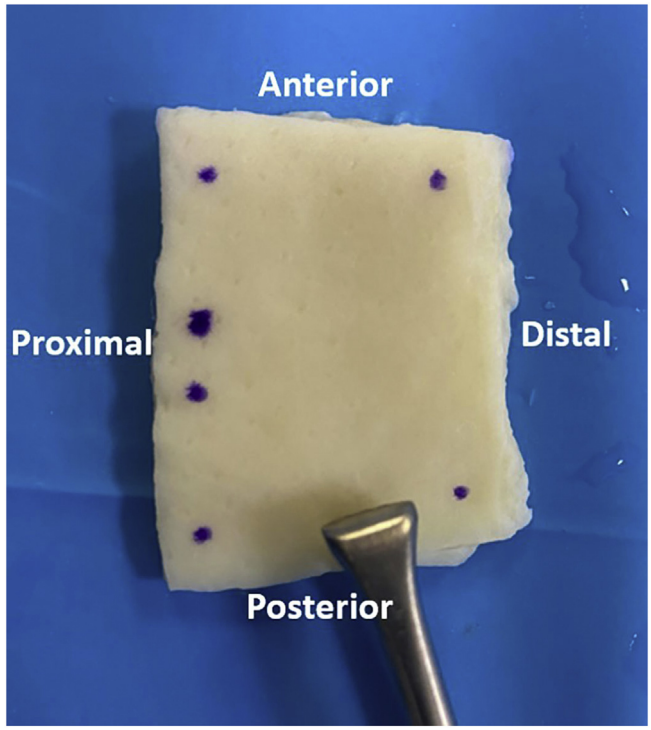

Fig 5. The prepared dermal matrix allograft is marked for placement of sutures before graft passage. Markings are placed 3 mm from the graft edge at all 4 corners, with 2 additional markings placed at the center of the proximal edge for the midbody sutures, ~2 mm apart.

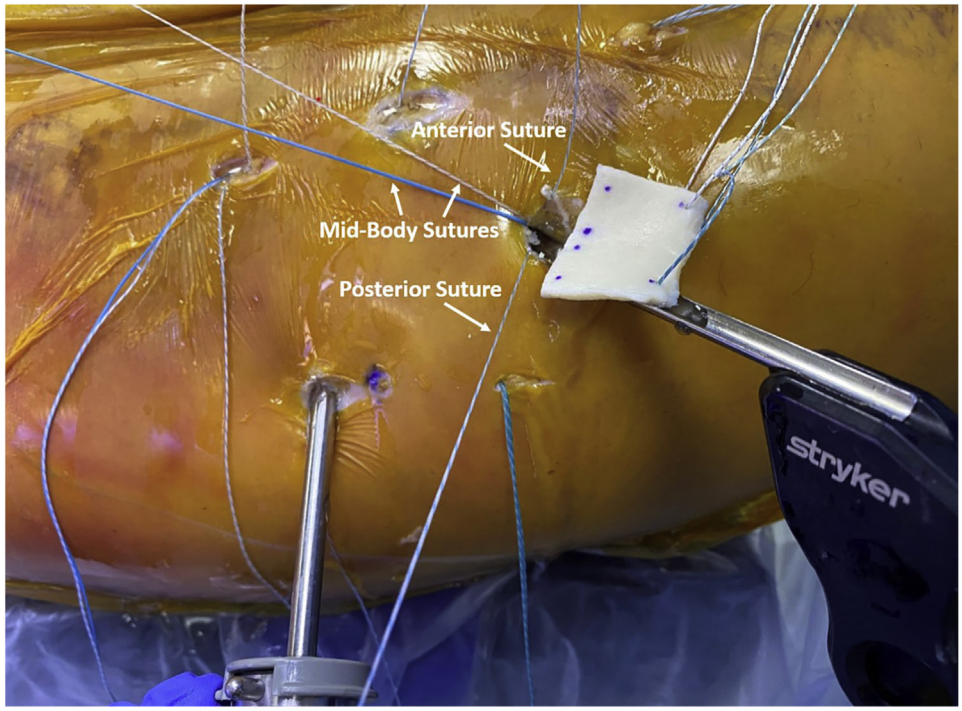

Fig 6. Right hip, supine position. Intraoperative image demonstrating suture management of the "non-post" anterior, midbody, and posterior sutures outside of the distal anterolateral accessory (DALA) cannula. The prepared graft with free sutures at the anterior-distal and posterior-distal corners is placed outside of the DALA cannula in preparation for suture placement and graft passage.

the articular-sided strand of the previously placed distal anterior graft suture and the corresponding strand of the distal anterior native capsule suture. A loop is tied using the native capsular suture, and the graft suture is shuttled from the graft through the native capsular tissue, eliminating the need to pierce a free corner of the graft once it is in the joint (Video 1). This suture is tied, securing the anterior corner of native capsule to

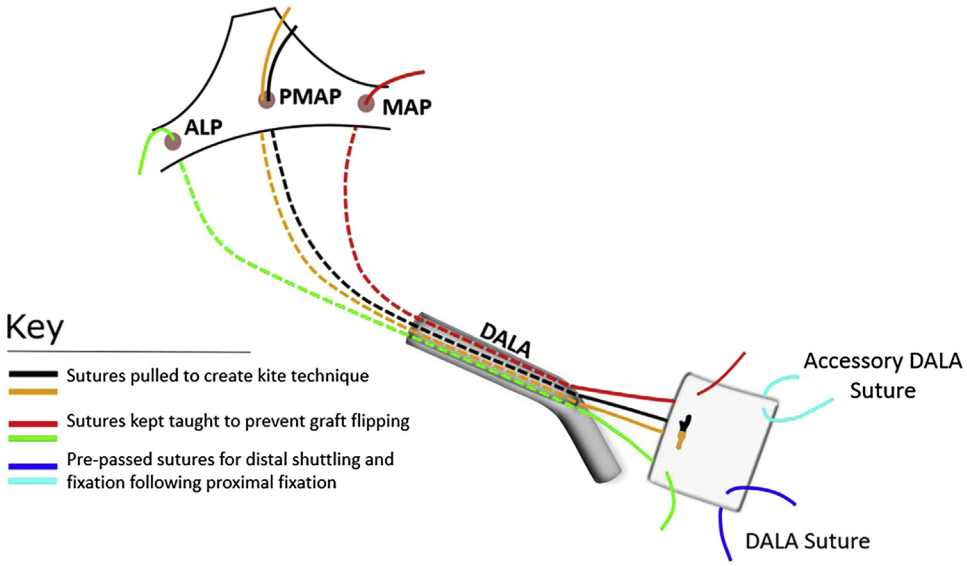

Fig 7. Diagram depicting the kite technique for graft passage. The orange and back sutures represent the 2 midbody anchor sutures, which are tied together at the proximal edge of the graft. These sutures are tensioned during graft passage to pulley the graft into the joint. The red and green sutures represent the anterior and posterior anchor sutures, respectively, which are held taught during graft passage to prevent graft flipping. The dark and light blue sutures at the distal edge of the graft represent the 2 prepassed sutures of the graft, which are later used for distal suture shuttling and graft fixation after proximal graft fixation. ALP, anterolateral portal; DALA, distal anterolateral accessory portal; MAP, mid-anterior portal; PMAP, proximal mid-anterior portal.

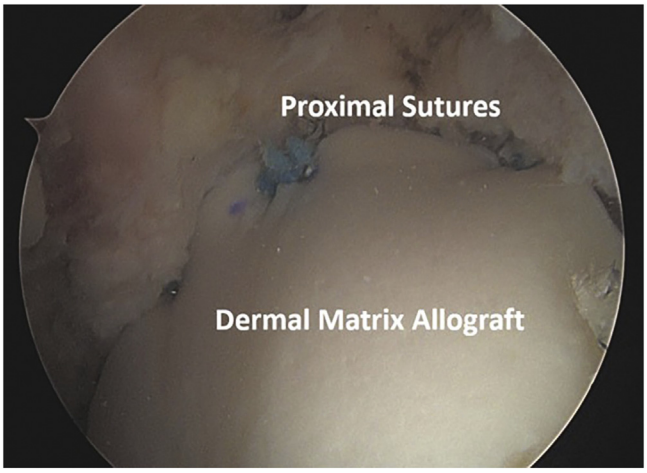

Fig 8. Right hip, supine position. Intraoperative photograph of the finished capsular reconstruction viewed through the anterolateral portal.

graft. The posterior distal graft suture is shuttled and fixed in a similar fashion, securing the distal posterior corner of the graft to native capsule. Finally, using a standard suture passing device, any remaining gaps between native capsule and graft are eliminated using simple sutures anteriorly, posteriorly, and distally, similar to a standard capsular repair.

After fixation of the graft (Fig 8), a dynamic examination is performed to verify the reconstruction is secure with the proper tension. Pearls for the kite technique for capsular reconstruction are summarized in Table 1.

Postoperative Management

Postoperatively, the patient is placed in a hip abduction brace for 6 weeks (DJO Hip Brace; DJO Global, Vista, CA). The brace is locked from 0° to 90° flexion, preventing excessive extension and external rotation. Partial weightbearing (20 lb) with crutches is maintained for the first 6 weeks postoperatively. Passive circumduction is performed starting within the first 3 to 4 days after surgery. After 6 weeks, the patient is transitioned to full weightbearing with full passive followed by active range of motion. Progressive strengthening and conditioning are carried out with formal physical therapy, per standard hip arthroscopy rehabilitation protocols.[13]

Discussion

The kite technique for capsular reconstruction of the hip offers a novel method for safe and efficient graft passage and fixation. Similar to flying a kite with multiple fly lines, and to the previously described kite technique for labral reconstruction,[10] the concepts of this technique involve using sutures—from either anchors or free sutures—to control a soft tissue graft in an arthroscopic environment. This technique introduces several novel modifications to previously described capsular reconstruction techniques,[5,8,9] notably (1) use of the kite technique for graft entry, allowing for more controlled delivery; (2) an intraoperative measurement technique to provide accurate defect size to avoid graft-defect mismatch, (3) methodology focused on enhanced control of the distal aspect of the soft tissue graft immediately upon insertion into the joint using simple shuttle sutures; and (4) use of nonabsorbable rather than absorbable sutures for direct attachment of graft to native capsule.

For most surgeons, safe and efficient graft entry is one of the most challenging aspects of this procedure. The kite technique allows for technically easy and efficient entry of the graft into the joint and provides an expeditious way to secure the proximal end of the graft to the acetabular rim without suture entanglement. Using a knot tied at the end of the 2 midbody, non-post sutures to pulley the graft into place, as well as 2 taut end anchor sutures acting as fly lines, this methodology minimizes the risk for suture and graft entanglement and allows for safe, reproducible entry of the graft into its desired position along the acetabular rim.

Table 1. Pearls

Preparation
■ Meticulous dissection of adipose tissue and muscle off proximal and distal native capsule to allow for adequate visualization
■ Kite measurement technique with hip in full extension to avoid graft/defect mismatch
Suture management
■ Use a slotted cannula instead of standard 8.25-mm cannula in distal anterolateral accessory (DALA) portal to allow for easy graft passage and clear soft tissue path over cannula to prevent suture/graft entanglement
■ Retrieve 1 strand of each proximal suture pair along slotted cannula (non-post sutures), starting anteriorly and moving posteriorly, and have assistant maintain slight tension on each of these strands within cannula to avoid suture entanglement
■ Organize opposite post ends out proximal portals; i.e., retrieve anterior post suture out mid-anterior proximal (MAP) cannula, midbody post sutures out proximal MAP, and posterior post anchor out anterolateral portal (ALP) adjacent to arthroscope
Graft passage and fixation
■ Use like-colored sutures for anterior distal corner (graft and native capsule), both of which are different from posterior distal corner sutures
■ Before placing proximal non-post sutures into graft with free needle, ensure that non-post suture strands are not crossed within slotted cannula
■ Pierce graft outside of joint with each proximal row suture, as attempting to pierce graft after graft passage into joint may induce iatrogenic damage to underlying labrum
■ Maintain tension on anterior and posterior non-post suture strands while using midbody sutures to pulley graft into joint (i.e., outer brackets on kite)
■ Distal corner fixation is performed with hip in full extension and involves simple suture shuttling techniques followed by arthroscopic knot tying to secure distal graft to native labrum
■ Fill in gaps anteriorly, posteriorly, and distally using preferred capsule closure device

Table 2. Advantages and limitations

Advantages	Limitations
Enhanced control of the soft tissue graft within the joint	Requires accurate measurement of defect size to completely reconstitute soft tissue loss
Precise measurement using kite measurement technique decreases risk of graft/defect mismatch	Intended only for cases with focal (not global) capsular deficiency
Proximal sutures passed into graft outside of joint to avoid iatrogenic injury to labrum	
Simple suture shuttling technique of the prepassed, distal corner sutures eases technical difficulty of securing distal graft once proximal end is fixed	

Yet another technically difficult step of this procedure involves obtaining an accurate measurement of the capsular defect to avoid graft-defect mismatch. Previous authors have proposed measurement based on either the preoperative magnetic resonance imaging (MRI) or use of a probe intraoperatively.[8,9] However, these techniques introduce subjectivity to the length and width of the defect and subsequent graft preparation. In contrast, using the kite measurement technique[12] offers the advantage of obtaining objective and accurate intraoperative measurements, while minimizing the risk for graft-defect mismatch.

Distal edge anastomosis is a third technically challenging aspect of this procedure. The peripheral compartment is a confined space with overlying muscle or adipose tissue that may collapse distally, limiting the visualization of sutures and graft edges. Chahla et al.[9] devised an innovative strategy of placing looped vicryl sutures in the distal edge of their dermal capsular reconstruction graft externally before passing the graft arthroscopically. Once the graft is secured into position proximally, a suture passer is then used to pass a suture through the native capsular tissue distally as well as through the suture loop previously created. Although this approach is effective at securing the graft, it has the potential to be technically challenging if the suture loop is not easily identified, the vicryl loop breaks or frays, or visualization is poor.

Mei-Dan et al.[8] offered another advanced strategy for making the distal anastomosis step easier. The authors describe a suture shuttling device to pass sutures through both the native zona orbicularis and the graft, passing all distal sutures first before tying. This technique necessitates manipulation of the distal "floating" end of the graft after the proximal end is fixed, which requires technical proficiency with graft manipulation in the peripheral compartment and can be challenging in an arthroscopic environment.

Using the kite technique, the technical difficulty of distal anastamosis is minimized by prepassing sutures through the distal graft edge before insertion, as well as prepassing sutures through the distal native capsular edge. Once the graft is introduced into the joint and fixed proximally, the prepassed graft sutures allow for facilitation of graft management and ease of handling by allowing for gentle tension to be pulled on each corner. Further, simple suture shuttling and knot tying at the distal anterior and posterior corners allows for immediate distal fixation without the need for complete visualization of the distal aspect of the peripheral compartment. Finally, use of nonabsorbable sutures during this step eliminates the risk of premature absorption of suture before graft-capsule healing is complete.

The kite technique for capsular reconstruction is not without limitations. First, this technique requires accurate measurement of defect size to completely reconstitute segmental soft tissue loss. The kite measurement technique[12] was developed to help mitigate this risk. Second, this technique is intended for use with focal capsular defects/insufficiency only. For patients with a globally deficient capsule extending to the distal attachment of the iliofemural ligament on the proximal femur, an open technique is a better option to provide a more anatomic reconstruction. In most cases, however, a majority of the native capsule is intact with a focal region that is deficient, and arthroscopic reconstructions may be favorable in this situation to minimize risk to the patient. Advantages and limitations to the kite technique for capsular reconstruction can be found in Table 2.

In conclusion, the principles of the kite technique, namely using post and non-post sutures for accurate positioning and immediate multiple point fixation of soft tissue grafts, can be applied successfully to soft tissue reconstructions of the hip, or any arthroscopic procedure in which control of soft tissue grafts is desired. To date, clinical outcomes of this technique are not yet available and currently in process, but the technical pearls presented here may help to improve efficiency, reduce operative time, and provide excellent and secure fixation of capsular reconstruction grafts.

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