



# Kite Measurement Technique for Enhanced Accuracy and Technical Proficiency of Graft Preparation in Segmental Labral Reconstruction of the Hip

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**Abstract:** Preserving labral integrity has become a guiding principle in hip preservation surgery given the recent understanding of the importance of the acetabular labral suction seal. When labral tissue is deficient, a labral reconstruction may be indicated to re-create the suction seal and improve hip biomechanics. One of the main challenges of segmental labral reconstruction techniques is obtaining an accurate measurement of the defect because incorrect sizing of the graft could result in incomplete restoration of the labral seal or an oversized graft that requires amputation. In this report, we present a kite measurement technique that allows for easy, accurate measurement of the segmental defect during segmental labral reconstruction.

Preserving labral integrity has become a guiding principle in hip preservation surgery given the recent understanding of the importance of the acetabular labral suction seal.<sup>1-4</sup> Clinical studies in patients who have previously undergone partial labral resections have shown a faster progression of hip arthritis.<sup>5</sup> In patients with deficient labral tissue—often due to ossification from chronic impingement, a hypoplastic or degenerative native labrum, iatrogenic causes, or revision situations—labral reconstruction has emerged as a viable solution for symptoms of microinstability, pain,

and discomfort.<sup>6,7</sup> In cadaveric investigations involving partial labral resection and subsequent labral reconstruction using an iliotibial band graft, Philippon et al.<sup>2</sup> and Nepple et al.<sup>3</sup> reported that segmental labral reconstruction significantly improved hip intra-articular fluid pressurization—potentially reducing hip contact pressures<sup>4</sup>—and dramatically improved distractive stability.

Previously, we published a technique guide describing a kite technique for segmental labral reconstruction that allows for safe and efficient introduction, control, and fixation of a labral reconstruction graft into the hip joint.<sup>8</sup> One potential downfall and technical difficulty of any segmental technique is the need for accurate measurement of the defect to prevent graft-defect mismatch and optimize re-creation of the suction seal. Currently available techniques have relied on the use of a probe, single suture limb, or non-hip-specific instrumentation to measure the defect, all of which limit the accuracy of measurement and increase the risk of graft-defect mismatch.

In this report, we present a kite measurement technique that allows for easy, accurate measurement of the segmental defect. Similarly to flying a kite with 2 fly lines and similarly to the principles described previously for our kite reconstruction technique,<sup>8</sup> the principles of this method are founded on the belief that 2 tied sutures, 1 from each end anchor, in an arthroscopic

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The authors report the following potential conflicts of interest or sources of funding: M.B.E. receives teaching fees from Stryker Education. J.H. is an education manager for Stryker. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

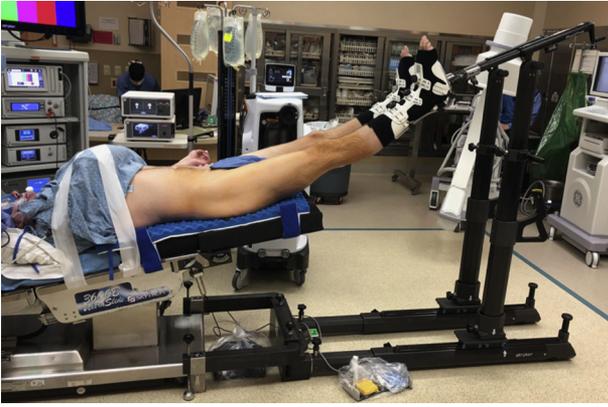
Received March 26, 2019; accepted May 12, 2019.

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2212-6287/19408

<https://doi.org/10.1016/j.eats.2019.05.017>



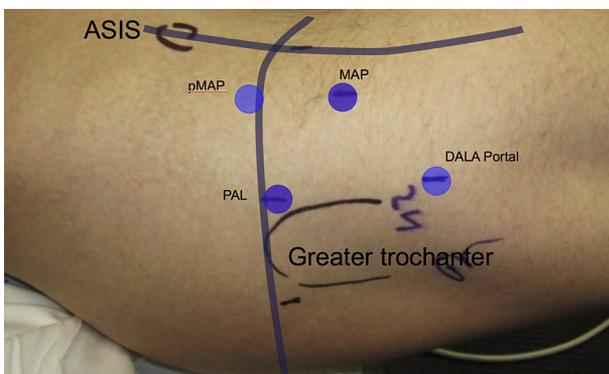
**Fig 1.** Patient positioning. The patient is placed supine, and the operative leg (right leg) is placed under traction with a post-less system.

environment are easier to guide into position using a pulley system to provide an accurate measurement, rather than using the methods described earlier. Although in this article, we detail the technique as it applies to segmental labral reconstruction in the hip using our previously published kite technique for labral reconstruction,<sup>8</sup> the principles of this measurement technique may also be used in any labral reconstruction method that requires measurement of a segmental defect, arthroscopic-assisted soft-tissue reconstructions of other joints, or capsular reconstruction techniques in the hip.

## Surgical Technique

### Patient Positioning and Anesthesia

After general anesthesia is induced, the patient is positioned supine on a post-free distraction table with all bony prominences appropriately padded (Pivot



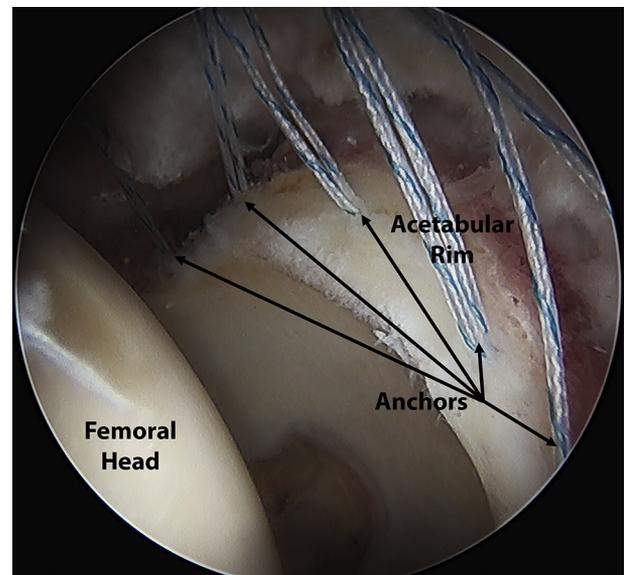
**Fig 2.** Intraoperative photograph of a right hip showing the locations of the portals and their relation to the greater trochanter. (ASIS, anterior superior iliac spine; DALA, distal anterolateral accessory; MAP, midanterior portal; PAL, proximal anterolateral portal; pMAP, proximal midanterior portal.)

Guardian Distraction System; Stryker, Kalamazoo, MI). The operative leg is placed in a neutral position (Fig 1). Post-free distraction affords the benefit of excellent distraction by using Trendelenburg positioning of the bed while negating the risk of iatrogenic pudendal nerve palsy or perineal soft-tissue compression.

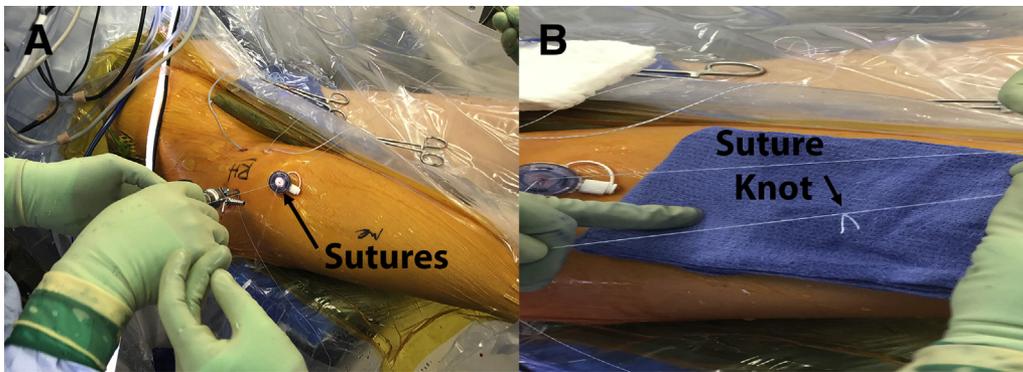
### Diagnostic Arthroscopy

The operative leg is placed under traction, and fluoroscopy is used to guide entry into the hip joint via the proximal anterolateral (PAL) portal. Four standard arthroscopic portals are used: the PAL portal, a mid-anterior portal (MAP), a proximal midanterior portal located 3 cm proximal to the MAP to allow for suture storage, and a distal anterolateral accessory (DALA) portal created 3 to 4 cm distal and 1 to 2 cm anterior to the PAL portal (Fig 2). An interportal capsulotomy is performed between the MAP and PAL portal, with care taken to preserve at least 1 cm of acetabular capsular remnant tissue for closure or plication at the conclusion of the case.

A standard diagnostic arthroscopy is performed, noting the size and quality of the native labrum and labral tear, status of the articular cartilage, and presence or absence of an adequate suction seal. If the labrum is of adequate quality, a labral repair is performed using previously described techniques.<sup>2</sup> However, if the labral tissue is inadequate for repair (i.e., <3 mm in width, segmental defect, inflamed or adhered labrum from prior surgery, or ossified labrum), a decision for reconstruction is made.



**Fig 3.** Suture anchors are placed at the anterior- and posterior-most aspects of the defect (3- and 11-o'clock positions in this patient) using the distal anterolateral accessory portal, as shown in an arthroscopic image of a right hip viewed through the proximal anterolateral portal.



**Fig 4.** (A) One suture limb from the anterior segment anchor is retrieved out the distal anterolateral accessory cannula, and 1 suture limb from the posterior segment anchor is retrieved out the same cannula (right hip). These suture limbs are the non-post limbs from each anchor. Care is taken to ensure the sutures are not tangled within the cannula. (B) The 2 suture limbs are tied together near the ends of the sutures, leaving a 1- to 2-cm tail for each suture limb.

### Acetabuloplasty

The interval between the proximal capsule and labrum is developed using a mechanical shaver and radio-frequency probe. We prefer to perform this step with the hip flexed to 25°, off traction, with suspension sutures placed within the proximal capsular leaflet to better preserve this tissue for later repair. A standard acetabuloplasty is performed to reshape the acetabular rim and eliminate the pincer lesion, thereby providing a bleeding environment amenable for graft incorporation.

### Femoral Osteochondroplasty

A femoral osteochondroplasty is performed to correct head-neck offset and eliminate cam impingement. During this step, 2 traction sutures are placed in the distal leaflet of the capsule to ensure adequate visualization of the anterior, superior, and distal femoral head-neck junction.

### Labral Reconstruction

The technical details of the kite technique were previously described.<sup>8</sup> In brief, the damaged labral

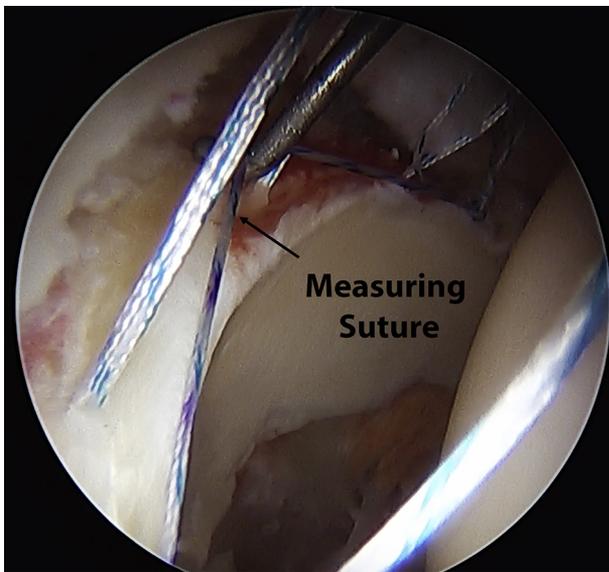
tissue is excised from the affected portion of the acetabulum, leaving a “segment” of exposed acetabular rim devoid of soft tissue. Multiple anchors (1.4-mm NanoTack anchors; Stryker) are sequentially placed around the acetabular rim using a curved guide via the DALA portal without breaching the joint (Fig 3), with the most anterior and posterior segment anchors placed 2 to 3 mm from native labral tissue, directly off the edge of the acetabular rim to prevent eversion of the graft. The anchors are spaced approximately 8 mm from one another along the rim.

### Suture Management

The anterior segment anchor suture limbs are retrieved and stored out of the MAP. The midbody sutures are retrieved from the proximal midanterior portal for suture storage until final graft fixation later in the case. The posterior segment anchor suture limbs are retrieved out the PAL portal. This facilitates measurement, graft passage, and fixation while minimizing the risk of suture entanglement.



**Fig 5.** Intraoperative photographs before (A) and after (B) marking 5-mm intervals on sutures for future measurement.



**Fig 6.** The kite technique is used to pull the knot into the joint (right hip). The post suture limbs from the anterior segment anchor (via the midanterior portal) and posterior segment anchor (via the proximal anterolateral portal) are alternatively pulled until the knot enters the joint. Care is taken to gently pull on the anterior post limb with more tension to position the knot directly over the anterior segment anchor. A probe is then inserted via the distal anterolateral accessory portal to line the posterior limb of suture along the segment of the rim where the graft will eventually lie, forming a bridge of suture between the 2 end anchors.

### Kite Measurement Technique

Attention is then turned to measuring the segmental defect. A large adjustable cannula (Pivot TransPort 789 cannula, 110-140 mm; Stryker) is inserted through the DALA portal into the joint via the interportal capsulotomy. One suture limb from the anterior segment anchor is retrieved out the DALA cannula, and 1 suture limb from the posterior segment anchor is retrieved out the same cannula (Fig 4A). These suture limbs are the “non-post limbs” from each anchor. Care is taken to ensure the sutures are not crossed within the cannula. The 2 suture limbs are then tied together near the ends of the sutures, leaving a 1- to 2-cm tail for each suture limb (Fig 4B, Video 1).

Outside the cannula, the sutures and knot are positioned under slight tension on a dry lap (Fig 5A). By use

**Table 1.** Case Example of Measurement Using Kite Measurement Technique

	Measurement, mm
Distance between end anchors	45
Distance from anterior native labrum to anterior segment anchor	3
Distance from posterior native labrum to posterior segment anchor	4
Total length of graft to be prepared	52 (i.e., 45 + 3 + 4)

of a fine-tipped marking pen, 5-mm hash marks are made along the posterior suture limb, starting at the knot and moving along the posterior suture limb. These are continued until the surgeon is certain that the segment will be at least 10 to 15 mm shorter than the last mark on the suture (Fig 5B). For example, if the surgeon estimates the segment to measure 45 mm, markings should be made every 5 mm on the suture until approximately 60 mm to ensure the entire segment will be included in the measurement.

At this time, the kite technique is used to pull the knot into the joint. The “post” suture limbs from the anterior segment anchor (via the MAP) and posterior segment anchor (via the PAL portal) are alternatively pulled until the knot enters the joint. Care is taken to gently pull with more tension on the anterior post limb to position the knot directly over the anterior segment anchor. Once the knot is positioned over the anterior anchor, the posterior post limb is pulled with gentle tension to create tension along the posterior limb and remove any slack. A probe is then inserted via the DALA portal to line the posterior limb of suture along the segment of the rim where the graft will eventually lie, essentially forming a bridge of suture between the 2 end anchors (Fig 6). The hash marks are counted moving from anterior to posterior until the suture inserts into the posterior segment anchor, giving the exact distance between the 2 end anchors. An example of the measurements using this technique is shown in Table 1. At this time, the probe tip is used to measure the distance between the native labrum and anchor anteriorly and posteriorly. The graft should be prepared exactly to the measured length of the entire segment to minimize the risk of graft-defect mismatch. After the measurement, an arthroscopic grasper is inserted via the DALA cannula and the knot is pulled out and cut off. A suture retriever is then used to match the sutures with their

**Table 2.** Steps of Kite Measurement Technique for Segmental Labral Reconstruction

Place anchors sequentially within the defect.
Perform suture management to avoid suture entanglement.
Retrieve 1 strand of each end anchor (anterior and posterior anchors within the segment) out the DALA cannula.
Tie the sutures together outside the cannula.
Use a ruler to mark hash marks starting from the knot and moving along the posterior suture strand, with 5-mm intervals.
Use the corresponding post suture strands to pulley the knot into the joint, guiding the knot directly over the anterior anchor.
Pull on the posterior post suture strand with tension to create a bridge of suture between the anterior and posterior segment anchors.
Guide along the edge of the acetabular rim using a probe via the DALA portal.
Count the hash marks.
Add the distance between the anchor and native labrum on each end.
Measure the exact distance of the defect for graft preparation.

DALA, distal anterolateral accessory.

**Table 3.** Pearls and Pitfalls of Kite Measurement Technique

Suture management	
Ensure the non-post sutures are not tangled within the cannula to prevent suture entanglement.	
Leave only a 1- to 2-cm tail when tying both the anterior and posterior non-post sutures outside the cannula to provide an adequate length for knot tying of the segmental reconstruction graft later in the case.	
Use a fine-tipped marking pen for hash marks to minimize “bleeding” of markings on the suture after placement into arthroscopic fluid in the joint.	
Defect measurement	
Use 1 or 2 probes to “line up” the suture bridge along the rim.	
Measure the distance between each end anchor and the native labrum (typically 2-3 mm on each end) and add this to the between-anchor segmental distance, giving the exact measurement of the entire defect.	
Graft preparation	
Prepare the graft at the exact length of the measured segment.	
Mark a point on each end of the graft where each non-post suture should pierce the graft, typically 2-3 mm from the end of the graft, to correspond to the exact distance between the end anchor and native labrum in the joint.	
Pass the graft using the previously described kite technique.	

corresponding limbs (i.e., anterior limb retrieved out MAP and posterior limb retrieved out PAL portal). The steps for the kite measurement technique for labral reconstruction are summarized in Table 2, and pearls and pitfalls are outlined in Table 3.

### Graft Preparation

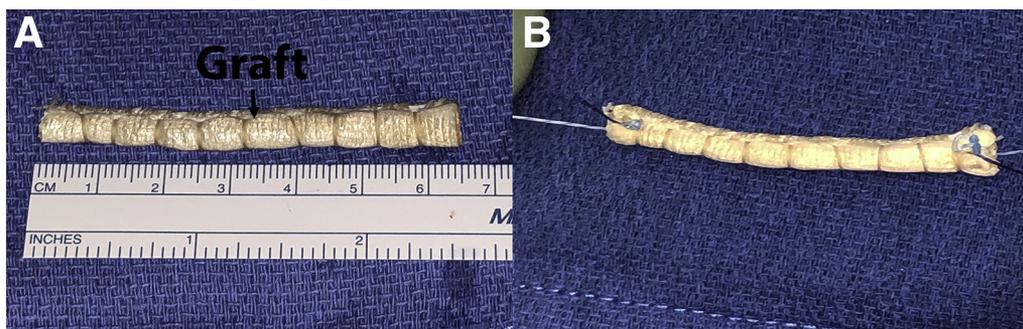
We prefer a tibialis anterior allograft (AlloSource, Centennial, CO) for labral reconstructions, but various autograft and allograft tissues have been described as acceptable alternatives.<sup>7,9</sup> After thawing and measuring to the appropriate length, as noted earlier, the graft is tubularized to 6 to 7 mm in diameter and whipstitched with several No. 2-0 Vicryl sutures (Ethicon, Somerville, NJ), as previously described (Fig 7A).<sup>9</sup> The sutures are then tied and cut in preparation for graft insertion.

### Graft Insertion

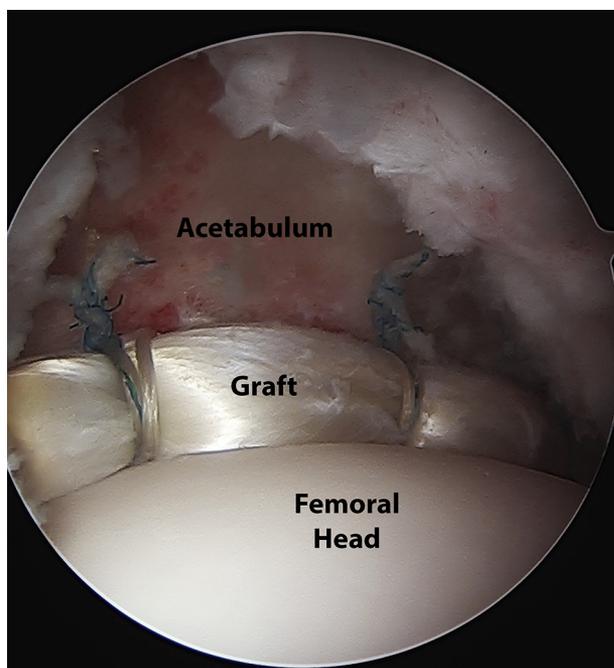
The graft is inserted and fixed using the kite technique, as previously described.<sup>1</sup> A second cannula is inserted into the MAP to aid with suture passage and knot tying. One suture limb from the anterior anchor and 1 from the posterior anchor are retrieved out the

DALA cannula. These are termed the “non-post” sutures, similarly to our measurement technique. The graft is brought from the back table and positioned outside the DALA cannula. By use of a free needle, the non-post suture strand out the DALA portal from the most anterior anchor is pierced through 1 end of the graft, and multiple half-hitches are used to create a knot to itself at the end of the suture. The same procedure is performed for the posterior anchor non-post suture as it is pierced through the opposite end of the graft with a free needle and tied to itself (Fig 7B).

At this time, the graft is inserted into the joint using the kite technique. The 2 post sutures, 1 out the MAP and 1 out the PAL portal, are tensioned in an alternating manner, similar to fly lines on a kite, and the knots on the ends of the anterior and posterior non-post sutures effectively pull each end of the graft into position along the rim. An arthroscopic grasper and probe may be used to aid in positioning the graft, but typically, this is not necessary. Once the graft is provisionally placed along the rim, the anterior anchor sutures are retrieved and tied via the MAP using standard knot-tying techniques, securing the anterior end of the graft. The posterior end is then secured in a similar



**Fig 7.** (A) The graft is tubularized to 6 to 7 mm in diameter and whipstitched with several No. 2-0 Vicryl sutures. (B) By use of a free needle, the non-post suture strand out the distal anterolateral accessory portal from the most anterior anchor is pierced through 1 end of the graft, and multiple half-hitches are used to create a knot to itself at the end of the suture. The same procedure is performed for the posterior anchor non-post suture as it is pierced through the opposite end of the graft with a free needle and tied to itself.



**Fig 8.** Intraoperative photograph of the completed labral reconstruction viewed through the proximal anterolateral portal in a right hip.

fashion via the DALA portal. Once the ends are secured, the midbody sutures are retrieved sequentially, looped around the graft, and tied using a standard technique to secure the graft into place (Fig 8).

After fixation of the graft, traction is released and a dynamic examination is performed to verify that the reconstruction is stable, the impingement is adequately decompressed, and the suction seal is restored. To complete the procedure, the anterior portion of the capsule is closed per a standard technique.

## Discussion

The kite measurement technique offers easy, safe, reproducible, and accurate measurement of a segmental labral reconstruction graft, mitigating the risk of graft-defect mismatch (Table 4). Using this technique, we have noted improved consistency of graft measurement for segmental reconstruction, allowing for an improved suction seal and helping to mitigate a potential technical difficulty of the previously described kite labral reconstruction technique.<sup>8</sup>

To date, 2 methods of hip labral reconstruction used clinically have been described: (1) segmental labral reconstruction, in which the torn or poor-quality segment of native labral tissue is excised and replaced with autograft or allograft, maintaining as much healthy native labral tissue as possible,<sup>8,10</sup> or (2) front-to-back labral reconstruction,<sup>9,11</sup> in which the entire native labrum is removed and replaced with graft tissue. Although both methods have inherent technical

difficulties,<sup>6,7,9</sup> both have the capability of restoring the native suction seal and improving native hip stability.

The advantages of segmental reconstruction include maintaining native, healthy labral tissue anteriorly and/or posteriorly, thereby preserving native proprioceptive fibers, and providing a scaffold of native labral soft tissue to which the ends of the graft can heal. Moreover, a segmental labral reconstruction technique requires less capsular disruption, is more cost-effective because of the use of fewer anchors and a shorter operative time, and requires less cadaveric soft tissue—to-bone healing given its shorter grafts compared with the longer ones required in front-to-back reconstructions.<sup>2,3,8,9,11</sup>

The primary disadvantage of the segmental technique, however, is the possibility of graft-defect mismatch. For example, a labral graft that is too long may result in decreased graft tension or excess tissue in the joint, increasing the risk of adhesions or creating psoas or capsular impingement. Excess tissue may require partial graft amputation within the joint, which can be a technically difficult challenge for the surgeon and disrupt graft integrity. A graft that is too short, on the other hand, may result in a smaller segmental defect on 1 end of the defect, inhibiting the establishment of an adequate suction seal and minimizing the biomechanical benefit of a reconstruction. It is for these reasons that the kite measurement technique was created, helping to mitigate the risk of mismatch while concurrently optimizing creation of a suction seal. Anecdotally, we have noted a more consistent, reproducible creation of an excellent suction seal using this modified technique while minimizing concern for graft-defect mismatch.

The kite measurement technique is not without limitations (Table 4). First, there is a small learning curve with this measurement technique to prevent suture entanglement. This learning curve is estimated at approximately 3 to 5 cases, which is a relatively high number for a rare procedure. Second, this technique is intended for use during segmental labral reconstruction only.<sup>8,10</sup> For patients with a completely deficient labrum requiring a front-to-back, 270° labral

**Table 4.** Advantages and Limitations of Kite Measurement Technique

Advantages	
Enhanced accuracy and reproducibility of measurement of segmental defect, limiting risk of graft-defect mismatch	
Safe and expeditious measurement technique	
Measurement of exact distance of segment for graft preparation, optimizing suction-seal effect	
Elimination of use of non-hip-specific instrumentation or management of free suture limb in joint	
Limitations	
Only intended for use in segmental labral reconstruction of hip	
Learning curve estimated between 3-5 cases before achieving technical ease and proficiency	

reconstruction, a technique has been previously described that allows for reconstitution of labral hoop stresses with an entirely new labrum.<sup>9</sup> In most cases, however, most of the native labrum is intact with a segment that is irreparable, and segmental reconstruction is preferred by us.

In conclusion, the principles of both the kite technique and kite measurement technique, namely using post and non-post sutures for accurate positioning, measurement, and fixation of soft-tissue grafts, can be applied successfully to soft-tissue reconstructions of the hip and shoulder or to any arthroscopic procedure in which control of soft-tissue grafts is desired. To date, midterm and long-term outcomes of this technique are not available, but the technical pearls presented in this article may help to improve efficiency, reduce operative time, and provide excellent and secure fixation of segmental labral reconstruction grafts.

### References

1. Bedi A, Kelly BT, Khanduja V. Arthroscopic hip preservation surgery: Current concepts and perspective. *Bone Joint J* 2013;95-B:10-19.
2. Philippon MJ, Nepple JJ, Campbell KJ, et al. The hip fluid seal—Part I: The effect of an acetabular labral tear, repair, resection, and reconstruction on hip fluid pressurization. *Knee Surg Sports Traumatol Arthrosc* 2014;22:722-729.
3. Nepple JJ, Philippon MJ, Campbell KJ, et al. The hip fluid seal—Part II: The effect of an acetabular labral tear, repair, resection, and reconstruction on hip stability to distraction. *Knee Surg Sports Traumatol Arthrosc* 2014;22:730-736.
4. Ferguson SJ, Bryant JT, Ganz R, Ito K. An in vitro investigation of the acetabular labral seal in hip joint mechanics. *J Biomech* 2003;36:171-178.
5. Espinosa N, Rothenfluh DA, Beck M, Ganz R. Treatment of femoro-acetabular impingement: Preliminary results of labral refixation. *J Bone Joint Surg Am* 2006;88:925-935.
6. Philippon MJ, Briggs KK, Hay CJ, Kuppersmith DA, Dewing CB, Huang MJ. Arthroscopic labral reconstruction in the hip using iliotibial band autograft: Technique and early outcomes. *Arthroscopy* 2010;26:750-756.
7. Philippon MJ, Carreira D. Surgical technique: Arthroscopic labral reconstruction using iliotibial band autograft or allograft. In: Leunig M, Nho SJ, Kelly BT, Bedi A, Larson C, eds. *Hip arthroscopy and hip joint preservation*. New York: Springer, 2015;1157-1163.
8. Bhatia S, Chahla J, Dean CS, Ellman MB. Hip labral reconstruction: The “kite technique” for improved efficiency and graft control. *Arthrosc Tech* 2016;5:e337-e342.
9. White BJ, Herzog MM. Labral reconstruction: When to perform and how. *Front Surg* 2015;2:27.
10. Chahla J, Soares E, Bhatia S, Mitchell JJ, Philippon MJ. Arthroscopic technique for acetabular labral reconstruction using iliotibial band autograft. *Arthrosc Tech* 2016;5:e671-e677.
11. White BJ, Herzog MM. Arthroscopic labral reconstruction of the hip using iliotibial band allograft and front-to-back fixation technique. *Arthrosc Tech* 2016;5:e89-e97.