Technical Note

Knotless Tensionable Anchors: Versatility, Tips, and Tricks

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Abstract: Arthroscopic surgery, including implants and advanced techniques, continues to advance in the field of orthopaedics. The evolution of suture anchors has undergone design changes, passing from first-generation metal anchors, biodegradable materials, different plastic polymers, to all-suture constructs. Knotless technology also has been found to be a more reproducible method and have comparable outcomes with those found using knotted anchors. This Technical Note describes the advantages and different ways this tensionable anchor can be used in arthroscopic procedures. This implant and its understanding will be useful in the sports medicine area by simplifying procedures and making them more reproducible. The aim of the present Technical Note is to detail the simplicity and versatility of the anchor and discuss different scenarios in which this technology can be used to address common hip pathologies.

Arthroscopic surgery has become one of the predominant areas in sports medicine due to its minimally invasive nature and less morbidity with efficient results compared with open procedures. With that being said, there is a great interest in the improvement and development of new arthroscopic implants and techniques. In order to maximize their function, anchor design has undergone many advances in terms of both form and material properties since its initial manufacture in 1985 by Goble et al.,[1] which consisted of bonding of polyester suture to a metallic headless hex screw, introducing metal anchors. Following this, different materials have been used in anchor designing, such as polyacetal, polyether ether ketone (PEEK), and most recently, all-suture anchors, in order to improve and avoid the complications of the previous generation.[2] Arthroscopic knots became an essential part of the success rate of many arthroscopic techniques using anchors as part of the procedure.[3,4] That success has always been in close relationship with the strength, accuracy, and reproducibility of the knots being tied, which require a surgeon's learning curve due to the level of complexity. New anchors with tensionable, knotless technology not only allow surgeons to perform faster and more reproducible procedures but also allow them to provide unique tensioning options that can be used in many different techniques during hip preservation procedures.

Knotless technology has been widely adopted during arthroscopic procedures and has several advantages with similar biomechanical properties to knotted ones.[5] Knotless anchors avoid pitfalls found in traditional knot-tying, such as soft-tissue- and cartilage-abrasive knots, possible adhesions, knot failure due to their technical difficulty, and knot inconsistency.[6,7] In addition, knotless anchors can help reduce operating time. Knotless anchors, since their invention, have always been manufactured with a tensionable inserter-in design, which requires the tension to be applied before deploying the device. The most novel implementation in knotless anchors is an inserter-out design with self-locking technology. The first anchor with this feature was the Knotless SutureTak (Arthrex, Naples, FL), which consisted of a PEEK anchor body with sutures. The implementation of a self-locking mechanism on this design makes soft tissue compressed and rolled over the anchor, which gives surgeons the option of using different stitch configurations. At the same time, the anchor's adjustable tensioning technology allows

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precise structural positioning and anatomical restoration. The most recent version is the Knotless FiberTak anchor (Arthrex), which is a soft all-suture anchor, allowing us to evade previous design complications[8] without compromising its biomechanical properties,[9,10] and it is also equipped with different guide options such as straight, curved, flexible, and different lengths. As a result of having different guide options, the anchor is able to be placed correctly and simply in anatomic areas where other anchors will not reach so easily.

This study was performed at the American Hip Institute Research Foundation in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act (HIPAA). Details that might disclose the identity of the subjects under study have been omitted. This study was approved by the institutional review board (IRB ID: 5276).

Shuttle Mechanism

The Knotless FiberTak is equipped with a shuttling suture mechanism, which allows the repair suture to be passed through its locking mechanism. This unique feature has become a game changer. Once the anchor is inserted and secured in the cortical bone, there will be 3 suture ends: the repair suture (blue), the flat SutureTape (Arthrex) end, and the looped end of the shuttle suture (both black/white). The repair suture is loaded through the looped end of the shuttling suture and folded such that only the thinner aspects of repair suture are being pulled through the locking mechanism. Next, the SutureTape shuttle is pulled through the splice locking mechanism and is then continually tugged to give the desired tension to the construct.

Versatility and Application to Arthroscopic Surgery

The versatility of the anchor allows surgeons to use a variety of configurations to achieve the different desired results based on the procedure and anatomical area. We will now name and briefly discuss each of these anchors in this specific circumstance. Table 1 and Video 1 list and depict the techniques performed with knotless tensionable anchors.

Hip/Shoulder Labral Treatment

The possibility of being able to choose the direction that our labral repair will undergo provides us with an accessible decision-making tool depending on the quality and characteristics in which the labrum is found.

Table 1. Summary of Common Procedures Depicting the Versatility of Knotless Tensionable Anchors

Procedure
• Hip/shoulder labral treatment ○ **Bone/labral function:** ▪ **Eversion:** Anchor placed on acetabular rim. Repair sutured is passed through labral defect into chondrolabral junction. ▪ **Inversion:** Anchor on acetabular rim. Looped end of shuttling suture is passed through labral defect into chondrolabral junction. ○ **Chondrolabral junction:** ▪ **Eversion:** Anchor is placed in chondrolabral junction, Looped end of shuttling suture is passed through labral defect to the bone/labral junction. ▪ **Inversion:** Anchor is placed in chondrolabral junction. Repair suture is passed through defect to the bone/labral junction.
• Tendon repair ○ **Suture staple:** ▪ Insert anchors in previously prepared tendons insertion site. Pass repair sutures through adjacent anchors in an interlocking configuration (A-B, B-A.) or (A-B, B-C, C-D, D-A).
• Miscellaneous ○ **Labral reconstruction:** ▪ Prepare acetabular rim and place anchors throughout its circumference. Secure graft in an eversion construct. ○ **Labral augmentation:** ▪ Place anchors on acetabular rim above deficient labrum. Pass repair suture is passed behind the graft and through the native chondrolabral junction. ○ **Capsular reconstruction:** ▪ Two anchors are placed at the corner of the acetabular-side capsular defect. Graft is secured to the anchors and stitched to the remaining femoral capsular tissue. ○ **Capsular augmentation** ▪ Two anchors are placed on the subspine cortical bone to secure the graft above the capsular tissue. Distal dermal graft is stitched to the capsule. ○ **Femoral remplissage** ▪ Locate defect. Place anchor on the center of defect. Pass sutures through dermal graft in a mattress configuration. Add 4 anchors to secure the corners of the graft.

Bone/Labral Junction: Eversion, Inversion

Eversion. Once the Knotless 1.8 Hip FiberTak Suture Anchor with #2 Suture, VE1 is securely placed on the acetabular rim, above the identified labral tear between it and the joint capsule, the repair suture is passed circumferentially through the chondrolabral junction. Following passage of the repair suture through the looped end of shuttle suture, the nonlooped end is tensioned, creating an eversion-type labral repair construct. Figure 1 depicts this construct.

Inversion. Again, with the Knotless Hip FiberTak Suture Anchor with #2 Suture, VE1 securely in place on the acetabular rim above the identified labral tear, between it and the joint capsule, the loop end of the

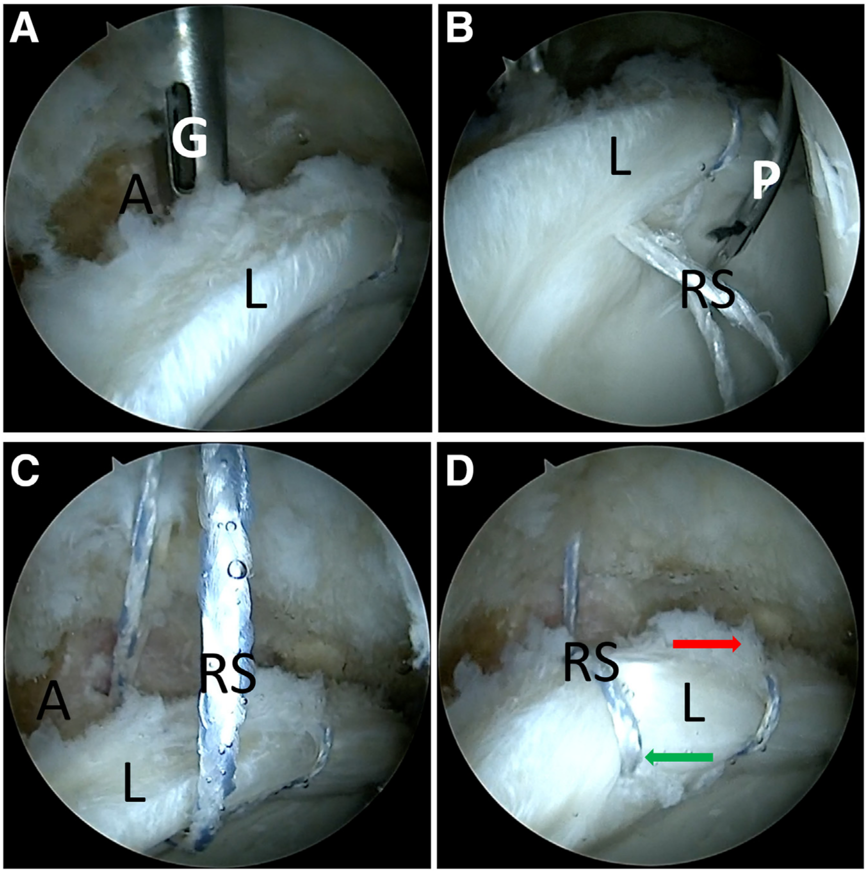

Fig 1. Images of a right arthroscopic hip labral repair with visualization from the anterolateral (AL) portal. (A) FiberTak anchor guide (G) is shown to securely place the anchor on the acetabular rim (A) above the labrum (L). (B) The repair suture (RS) is passed through the chondrolabral junction with suture-passing device (P) and then retrieved intra-articularly. (C) The repair suture is passed into the knotless mechanism through the shuttle suture and around the labral tissue. (D) Tension is applied to create an eversion-type construct. The inverted construct is shown (red arrow) next to the everted construct (green arrow).

shuttle suture is first passed circumferentially through the chondrolabral junction. Following this, the anchor's repair suture is then fed through the loop and shuttled into the knotless mechanism, thereby creating an inversion-type labral repair construct. Figure 2 depicts this step.

Chondrolabral Junction: Eversion, Inversion

Eversion. Having a Knotless 1.8 Hip FiberTak Soft Anchor securely in place on the chondrolabral junction underneath the identified labral tear, the loop end of the shuttle suture is passed through the defect circumferentially. Following this, the anchor's repair suture is fed through the loop and shuttled into the knotless mechanism creating an eversion-type labral repair construct.

Inversion. Once the Knotless 1.8 Hip FiberTak Soft Anchor is securely placed on the chondrolabral junction above the identified labral tear, the repair suture is passed circumferentially through the defect toward the capsule–labral junction. After this, passage of the repair suture through the shuttling mechanism, creating an inversion-type repair construct. Figure 3 depicts this in more detail.

Tendon Repair (Tendon Compression Bridge)

The suture staple technique is indicated in the setting of a partial-thickness tendon tear. This technique eliminates the need to split the tendon and replaces bone decortication with micropuncture of tendon's footprint. Following the steps in the suture staple technique,[11] the tendon's insertion area is identified and examined with the use of a probe to identify any undersurface delamination. After the site's preparation, the surgeon inserts adjacent. Knotless 2.6 FiberTak Anchor with an interlocking configuration. The tendon compression bridge technique works with the anchor by shuttling repair suture from anchor A through loop suture of anchor B. Anchor B's repair suture can be shuttled via loop suture of anchor A or an alternate anchor C. this process can be repeated as many times as desired with adjacent anchors creating either a staple (A-B, B-A), or a box (A-B, B-C, C-D, D-A) configuration. Figure 4 depicts the technique.

Miscellaneous

Labral Reconstruction

Labral reconstruction is indicated when our native labrum is not functionally viable to create the hip's

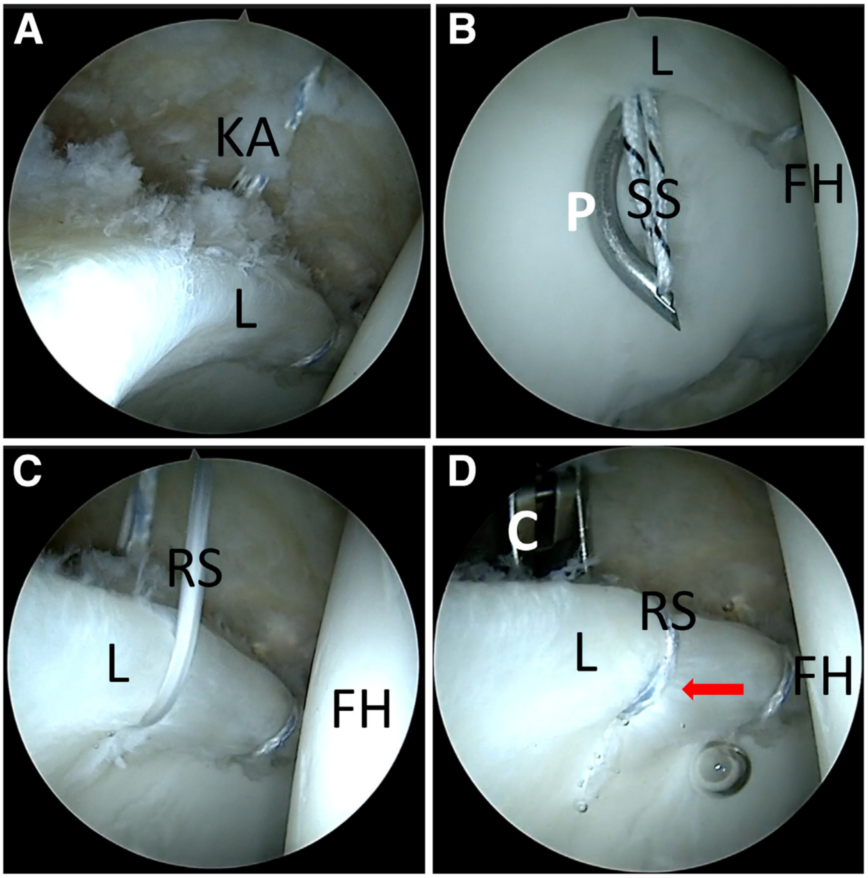

Fig 2. Images of a right arthroscopic hip labral repair with visualization from the anterolateral (AL) portal. (A) Knotless anchor (KA) is securely placed on the acetabular rim above the torn labrum (L). (B) The loop end of the shuttle suture (SS) is passed through the chondrolabral junction with a suture-passing device, cautiously to avoid damaging the femoral head (FH). (C) The repair suture (RS) is fed and shuttled into the knotless mechanism through the shuttle suture from inside to outside. (D) Tension is applied to create an inversion-type construct (red arrow), cutting the remaining repair suture with a cutting device (C).

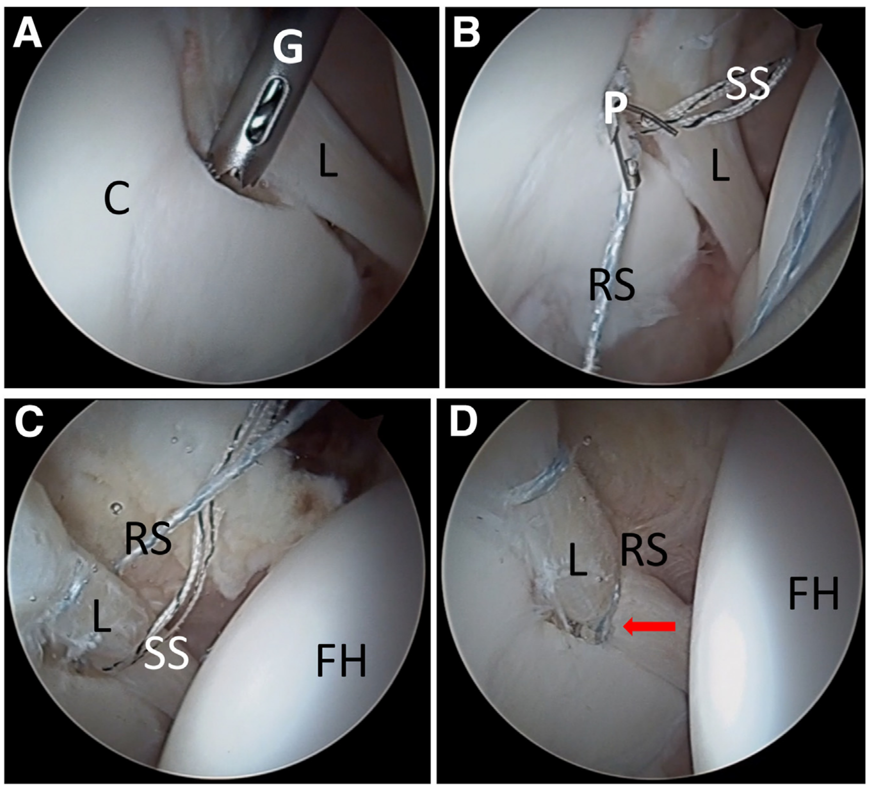

Fig 3. Images of a right arthroscopic hip labral repair with visualization from the anterolateral (AL) portal. A) (A) FiberTak anchor guide (G) is shown to securely place the anchor on the junction between the labrum (L) and the acetabular cartilage (C). (B) The repair suture (RS) is passed through the labral defect with a suture-passing device (P). (C) The repair suture is passed into the knotless mechanism through the shuttle suture (SS). (D) Tension is applied to create an inversion-type construct (red arrow). (FH, femoral head.)

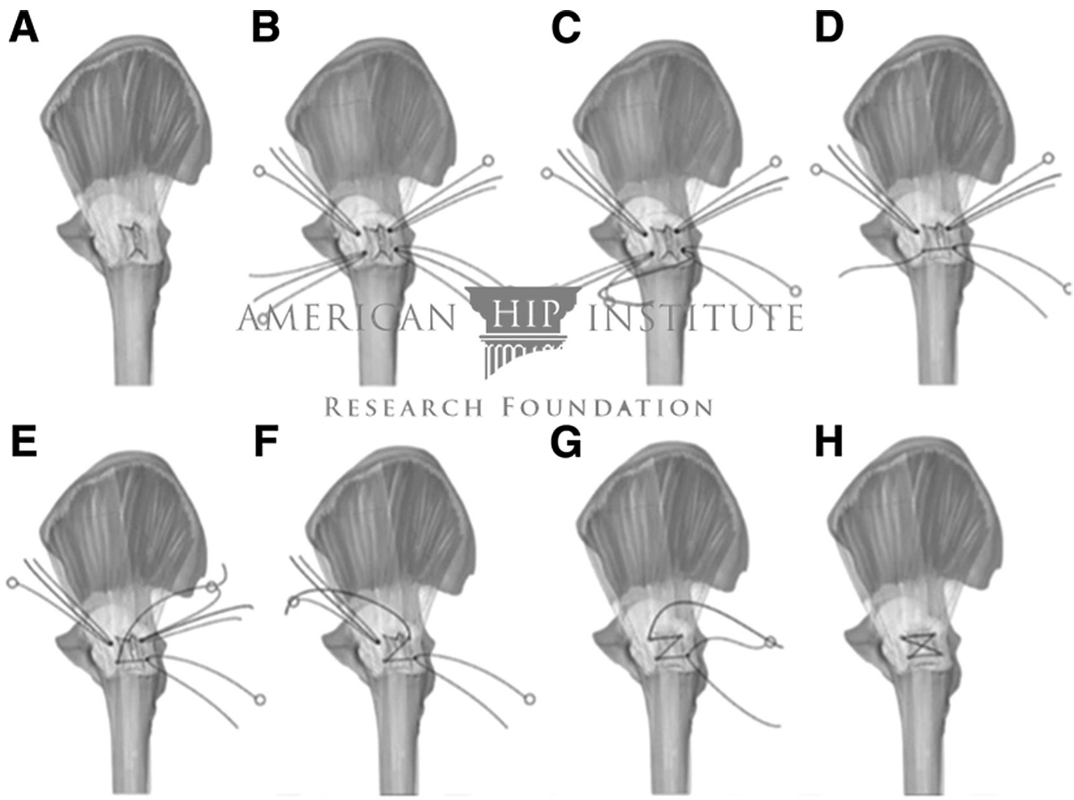

Fig 4. Illustration of the technique for knotless suture staple endoscopic repair of abductor tendon tears. (A) Partial-thickness tear is located endoscopically. (B) Four knotless FiberTaks are then placed through the tendon and into trochanteric bone under fluoroscopic guidance. Two in the anterior leaflet and 2 in the posterior leaflet as demonstrated (C). Shuttling begins with the FiberWire from the posterodistal anchor through the anterodistal anchor using the FiberLoop from the anterodistal anchor (D). After the suture has been shuttled (E), the FiberWire from the anterodistal anchor is then shuttled through the posteroproximal anchor using the posteroproximal FiberLoop (F). The FiberWire from the posteroproximal anchor is shuttled through the anteroproximal anchor using the antero-proximal FiberLoop (G). Finally, the anteroproximal FiberWire is shuttled through the posterodistal anchor using the posterodistal FiberLoop (H). Permissions were obtained for this previously published figure by Hartigan et al.[11]

suction seal. With the pull-through technique,[12] we prepare the acetabular rim by removing the nonviable labral tissue and burring the edges to stimulate a bleeding bony bed. The Knotless 1.8 Hip FiberTak Suture Anchor with #2 Suture, VE1 on the most anterior aspect of the acetabulum is used to fixate the anterior part of the graft, passing its sutures end through the shuttle suture. To fixate the reconstruction anchors, we pass the repair suture circumferentially around the graft, then into the joint to then retrieve it and pass it through the shuttle suture to fixate the graft. This is subsequently repeated until all the anchors have fixated the graft around the acetabular rim.

Labral Augmentation

This technique is indicated in patients that have a preserved chondrolabral junction but the native labrum is hypoplastic or insufficient to create the suction seal mechanism of the hip. Using the previously described technique,[13] the acetabular rim is prepared on top of the native labrum placing anchors from medial to lateral as needed. The anterior part of the graft is attached to the anchor of the most anterior aspect of the acetabulum, by passing its suture through the shuttle suture. To fixate the augmentation anchors, we pass the repair suture through the chondrolabral junction into the joint to then retrieve it and pass it through the shuttle suture to fixate the hypoplastic labrum with the graft in an everted manner.

Capsular Reconstruction

Performing a capsular reconstruction is a complex procedure in the field of hip arthroscopy. A capsular reconstruction may be required and indicated in cases in which the capsule is needed to help increase joint stabilization but the patient's capsular tissue is not sufficient to perform a plication or in the case of capsular insufficiency due to a previous arthroscopic procedure involving partial capsulectomy.

Table 2. Pearls and Pitfalls

Pearls	
	Load approximately 1 cm after the purple marking on the repair suture to ensure proper anchoring.
	Following the trajectory of the repair suture with a suture retriever before shuttling to ensure smooth passage.
Pitfalls	
	Excessive or insufficient amount of repair suture through looped end can cause shuttling difficulties.
	Soft-tissue bridge might interfere with adequate shuttling through the anchors mechanism.

Table 3. Advantages and Disadvantages

Advantages	
	Inserter-out device allowing an easier and swifter use.
	Tensionable device, which allows the surgeon to adjust tension as needed during direct visualization.
	All-suture implant, avoiding possible implant-related arthropathy.
	Small diameter, which allows different points of fixation for the best construct necessary.
	Linked constructs creating compression when needed.
Disadvantages	
	The anchor system is a suture-only design, not allowing the use of tape, if needed.

Following the previously described technique,[14] the subspine cortical bone is located and 2 Knotless 1.8 Hip FiberTak Soft Anchors are inserted in the acetabular rim at the corners of the capsular defect, and then passed through the dermal graft using the shuttle mechanism. With the graft secured to acetabular rim, the remaining capsular tissue on the femoral side is secured to the dermal graft's corners using a No 2. FiberWire suture (Arthrex) in a mattress fashion. Additional sutures are passed between the corners: medial, lateral, and distal. Also, additional anchors may be placed as needed.

Capsular Augmentation

Capsular augmentation is an indicated procedure when a repair or plication alone may not be sufficient to restore adequate joint stability due to poor tissue quality. Following the previously described technique, the subspine cortical bone is located and prepared for anchor insertion to posteriorly pass the repair suture through the dermal graft and secure it using the shuttle mechanism. Finally, the dermal graft is attached to the capsular tissue with simple stitches. This will avoid knot stacks, bridging the dermal graft to the insufficient capsule.

Femoral Head Remplissage

This procedure has been described to address cam deformity over-resection as a complication for arthroscopic femoroplasty developing subsequent microinstability. By following the technique,[15] once the defect is located, measured and prepared, a Knotless 1.8 Hip FiberTak Soft Anchor is placed in the center of the defect. Afterwards, we pass the repair suture through the middle of the graft with a suture passer and then both the shuttle suture ends through another. Following these steps, a mattress configuration stitch is created, and the graft is evenly adhered to its desired position. We finalize by adding an additional 4 anchors into the corners of graft.

Discussion

The purpose of the present publication is to show the versatility of knotless tensionable anchors and the different possible scenarios in which it can be used to treat common pathologies found in sports medicine. The simplicity of the design allows surgeons to be more precise in an already complicated surgical area (Table 2). Having the possibility to approach all the previously mentioned procedures with only one type of implant makes for a more reproducible surgical scenario.

Another advantage to this implant is found in its small low-profile size (Table 3). Using a smaller diameter anchor decreases the bony footprint required for fixation, increasing the opportunity for multiple points of fixation within the existing surface area of bone−soft-tissue interface. This implant has not only proven to be a good resource, achieving satisfactory results at short-term outcomes in Bankart repair,[16] it has also proven other benefits from its versatility, such as technical improvements with its retensioning ability,[17] and its novel implementation as an alternative for posterior meniscal root repair.[18] In conclusion, the use of a knotless tensionable anchor is a versatile, precise, and reproducible tool to address different scenarios in arthroscopy surgery.

Disclosures

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American Hip Institute Research Foundation that includes: board membership; a relationship with AANA Learning Center Committee that includes: board membership; a relationship with *Journal of Arthroscopy* that includes: board membership; and a relationship with American Hip Institute that includes: equity or stocks. B.G.D. has a patent, "Method and instrumentation for acetabular labrum reconstruction," with royalties paid to Arthrex; a patent, "Knotless suture anchors and methods of tissue repair," with royalties paid to Orthomerica; a patent, "Knotless suture anchors and methods of tissue repair," with royalties paid to DJO Global; a patent, Adjustable multi-component hip orthosis," with royalties paid to Arthrex; and a patent with royalties paid to Medacta. A.C.L. reports a relationship with Arthrex that includes: consulting or advisory, nonfinancial support, and travel reimbursement; a relationship with Stryker Corporation that includes: consulting or advisory, nonfinancial support, and travel reimbursement; a relationship with Medwest that includes: nonfinancial support and travel reimbursement; a relationship with Smith & Nephew that includes: nonfinancial support and travel reimbursement; a relationship with Vericel that includes: nonfinancial support and travel reimbursement; and a relationship with Zimmer Biomet that includes: nonfinancial support and travel reimbursement. A.C.L. is Medical Director of Hip Preservation at St. Alexius Medical Center and a clinical instructor at the University of Illinois College of Medicine. All other authors (P.A.P., J.S.O., W.T.H., P.W.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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