Technical Note

Quadriceps Tendon Allograft for Anterior Cruciate Ligament Reconstruction With and Without a Bone Block

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Abstract: Of the grafts available for anterior cruciate ligament (ACL) reconstruction, the quadriceps tendon (QT) autograft has seen increased attention in recent years. However, the use of quadriceps allograft has lagged behind. Quadriceps allograft has several advantages similar to those which have driven the use of quadriceps autograft, such as biomechanical properties, histological similarity to the native ACL, and increased cross-sectional area. This article presents the use of QT allograft with bone block and without bone block. Surgical techniques, fixation methods, and clinical indications of each graft are discussed, as well as the advantages of each technique.

A large number of allografts exist for anterior cruciate ligament (ACL) reconstruction. These include semitendinosus and/or gracilis hamstring, tibialis anterior, tibialis posterior, peroneal tendon, iliotibial band, bone–patellar tendon–bone (BTB), Achilles tendon, and quadriceps tendon. The quadriceps tendon (QT) autograft has become more popular because of its biomechanical properties being similar to that of the native ACL.[1] Studies have shown that the cross-sectional area of the QT graft is nearly twice that of the BTB graft and that it demonstrates higher load to failure and stiffness.[2,3] In addition, a QT graft has around a 40% higher load to failure than a similar thickness BTB graft.[4] Such properties could be extrapolated to the QT allograft. In this article, we describe surgical techniques, fixation methods, and clinical indications for the use of quadriceps tendon with bone block (QT-B) and quadriceps tendon without bone block (QT-S), as well as the advantages of each technique (Table 1).

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Surgical Technique

Surgical techniques for graft preparation are presented in Video 1.

Graft Preparation

Quadriceps Tendon Allograft All Soft Tissue (QT-S): Graft Dimensions

The graft measures 70 mm in length. In general, the senior author's preference is a 9 mm diameter for females or smaller patients, while for males and larger patients it is 9.5 mm. This may be chosen at the surgeon's discretion, as there is a concern for a higher risk of cyclops lesion with larger graft size in smaller patients.[5] Since the allograft is large, the appropriate graft size is marked out using a sterile ruler, which is cut down to form a template of the desired length (70 mm) and width (9 or 9.5 mm), and care is taken to incise the graft with a fresh 15-blade scalpel to make clearly defined borders (Fig 1).

Preparation: Femoral Side

A single Vicryl stitch placed in the tibial end of the graft can be used to pass the graft through the size block to ensure proper sizing and then be used to secure the graft to the graft station during preparation of the femoral side (Fig 2). Iris tissue scissors or sharp Metzenbaum scissors can be used to taper each end of the tissue to facilitate graft passage.

Table 1. Pearls and Pitfalls of Quadriceps Tendon Bone versus Quadriceps Tendon Soft Tissue

Aspect	Pearls	Pitfalls
Graft type	QT allograft offers high biomechanical strength and versatility and can be used with (QT-B) or without bone block (QT-S).	Limited clinical outcome data for QT allografts.
QT-S graft preparation	Uses tapered ends and FiberTag TightRope with cortical button for secure fixation. Pretension and compress in an undersized graft tube to ease passage.	Graft swelling can complicate tunnel passage.
QT-B graft preparation	Bone block offers potential for bone-to-bone healing and interference screw fixation on tibial side adds stability.	Improper bone block sizing can complicate tunnel passage.
Tunnel drilling	QT-S allows for an all-inside technique, which minimizes cortical disruption. QT-B uses traditional tibial tunnel and femoral socket approach.	QT-B requires more extensive tibial tunnel drilling.
Fixation	QT-S uses suspensory fixation on both sides while QT-B uses suspensory fixation on the femoral side and interference screw fixation on the tibial side.	Use of suspensory fixation can lead to tunnel widening due to graft micromotion within the tunnel.
Sizing and tensioning	Use 9-9.5-mm diameter depending on patient size; pretension to 20 lbs. improves graft handling.	Oversized grafts may lead to loss of motion and arthrofibrosis.
Clinical considerations	QT allograft avoids donor site morbidity, especially advantageous in revision or multiligament procedures.	Allografts might have higher failure in young or high-demand patients. This is heavily dependent on level of irradiation.

QT, quadriceps tendon; QT-B, quadriceps tendon with bone block; QT-S, quadriceps tendon without bone block.

In Video 1 and Fig 3, the FiberTag TightRope with cortical button (Arthrex, Naples, FL) is used to prepare the graft using whipstitching (Video 1 and Fig 3). The femoral side of the graft is marked 20 mm from its end, and the needle is passed from superior to inferior through the tissue until the FiberTape (Arthrex) is flush against the graft. The FiberTape is then laid along the surface of the graft and held with a clamp. Three passes from superior to inferior are performed, each progressing toward the end of the graft and clamp and each passing through the FiberTape until the end of the graft is reached.

The needle is then carefully passed through the designated loop in the card, which holds the FiberTag TightRope device. Care must be taken to ensure that the needle does not pass through and damage any strand of the TightRope device and that all 4 limbs of the interlocking loop are included. Whipstitching then proceeds back up the graft with 2 or 3 passes, each moving progressively away from the graft end and each

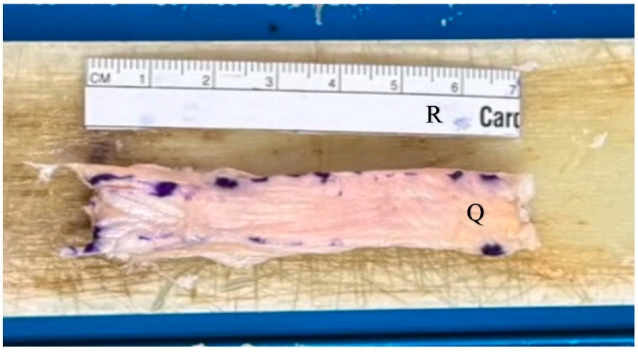

Fig 1. Demonstrates an open view of a quadriceps allograft tendon (Q). The end to the right has been cut off the patella and will become the femoral end of the graft. The thinner portion to the left of the graft is the more proximal end of the quadriceps tendon graft and will become the tibial side of the anterior cruciate ligament graft. The ruler (R) has been cut from a standard plastic ruler that comes with many sterile OR marking pens. It has been cut to a width of 9 mm. The purple marks seen on the graft show where the template was marked on the larger allograft from which it was removed.

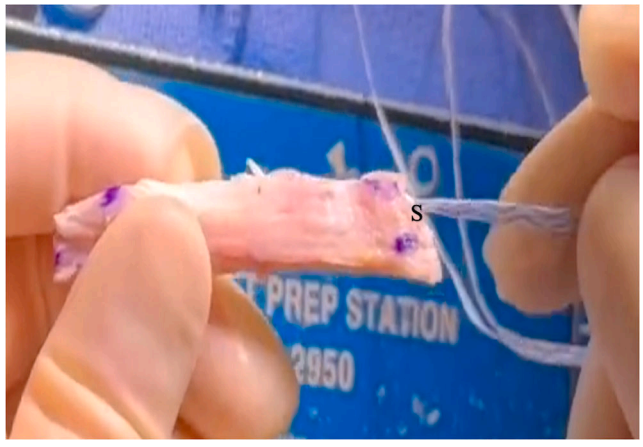

Fig 2. Demonstrates a single Vicryl stitch (S) placed in the tibial end of the soft tissue graft.

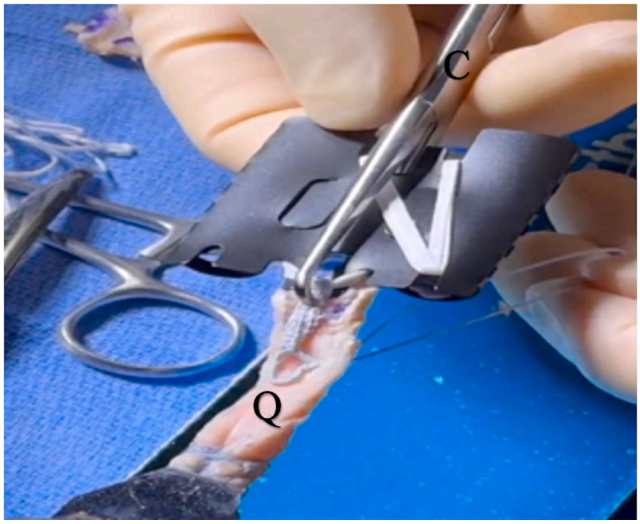

Fig 3. Demonstrates an open view of a quadriceps tendon allograft (Q) where the FiberTag device (black card) and clamp (C) are secured at the end of the graft. Whipstitching proceeds from the initial point where the FiberTape pierces the graft 20 mm from the graft end and then proceeds back to the starting point after passing through the TightRope device.

passing through the FiberTape until the starting point is reached. The needle and suture loop are then cut, and the resulting suture tails may be tied together. The knot may be buried if desired.

Since the suture material and FiberTape mark 20 mm from the endpoint of the graft, the surgeon may watch for this portion to enter the bone socket and then know that the desired 20 mm has entered the femoral tunnel, leaving no exposed suture material in the joint (Fig 4).

Tibial Side

Tibia-sided preparation proceeds similarly to the femoral side with a few changes. In this example, an open-ended attachable button system (ABS) FiberTag (Arthrex) is used. This similarly comes on a card that facilitates suture management and allows for placement of a clamp through the tip of the graft and the FiberTape material from the FiberTag. With the femoral button and TightRope device removed from their card, these can be shortened to ~100 mm and attached to the graft station. The 0 Vicryl suture previously on the tibial side may be removed to avoid tangling during tibia-sided preparation. Once the ABS card and clamp are in place, the steps for whipstitching to the end of the graft, passing through the loop in the TightRope, and passing back toward the starting point, remain the same as for the femoral side.

Once preparation is completed on both sides, the femoral suture tails may be grasped through the end of a graft tube that is 0.5−1 mm smaller than the intended tunnel diameter. For example, if the initial sizing was a 9, the graft should be passed into the 8.5-mm graft tube. If this is not snug, then it should be drawn into an 8-mm graft tube. These tubes compress the graft, which is particularly useful in the case of allograft use as, anecdotally, allografts tend to swell and graft size may increase by 0.5 mm, making graft passage more difficult. Compression in a graft tube mitigates this effect.

Final Preparation

Finally, the graft will be pretensioned to 20 pounds using the graft station with suture fixation on both ends. No clamps should be applied to the TightRope devices, as they can cause weakening or breakage of the adjustable loop mechanism. The senior author routinely soaks the graft in a vancomycin solution of 5 mg/mL (1 g in 200 mL solution), and a Raytec soaked in this solution is laid over the graft until the time of implantation, as this has been shown to reduce infection rate without compromising the biomechanical

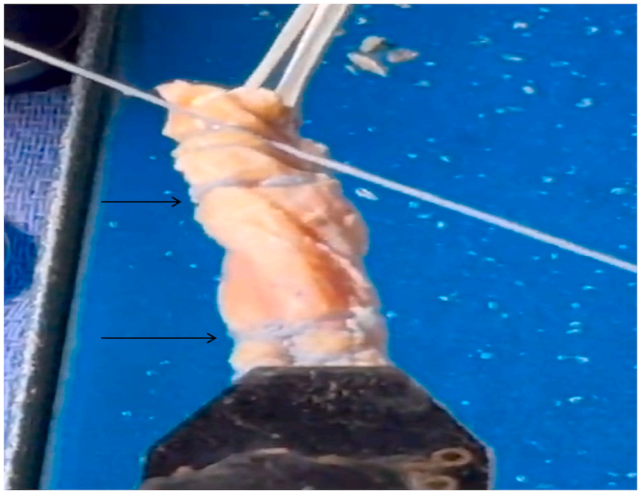

Fig 4. Indicates arrows marking the suture material and FiberTape mark, which are each 20 mm from the end of the grafts.

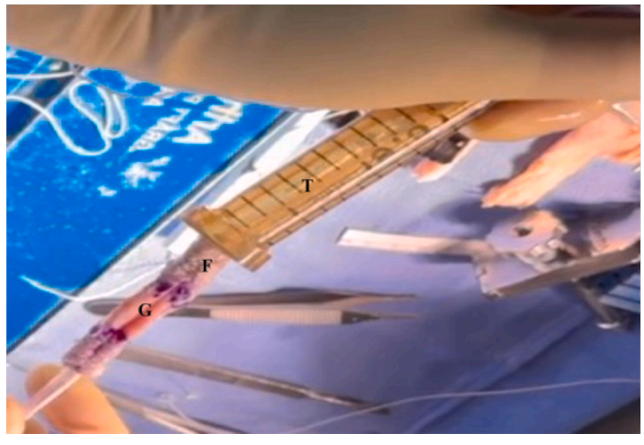

Fig 5. Shows an open view of a prepared quadriceps tendon without bone block allograft. The graft (G) is being drawn into the back of a graft tube (T), femoral side (F) first to mimic the direction of graft passage into the knee.

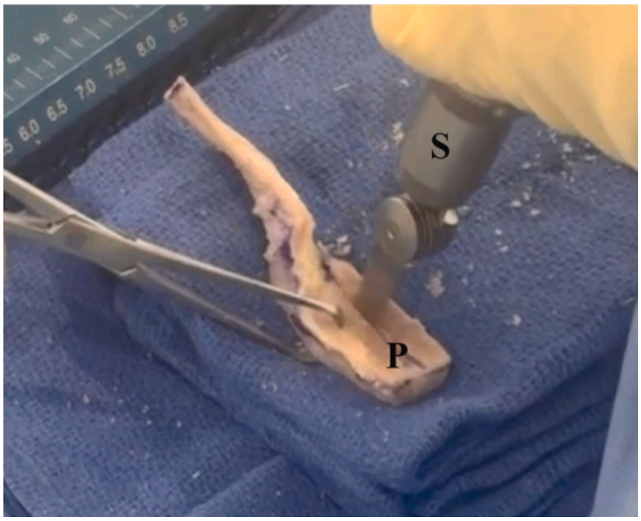

Fig 6. Shows use of a saw blade (S) to size the patellar bone block (P) to the appropriate size.

properties of the graft (Fig 5).[6] The entire graft and station are then covered in a sterile blue OR towel until time for graft implantation.

Quadriceps Tendon Allograft with Bone Block (QT-B): Graft Dimensions

The graft measures 80 mm in length, with 25−30 mm of that coming from the bone block harvested from the superior patella. Since the allograft is large, the appropriate graft size is marked out using the GraftPro Preparation station (Arthrex). Care is taken to incise

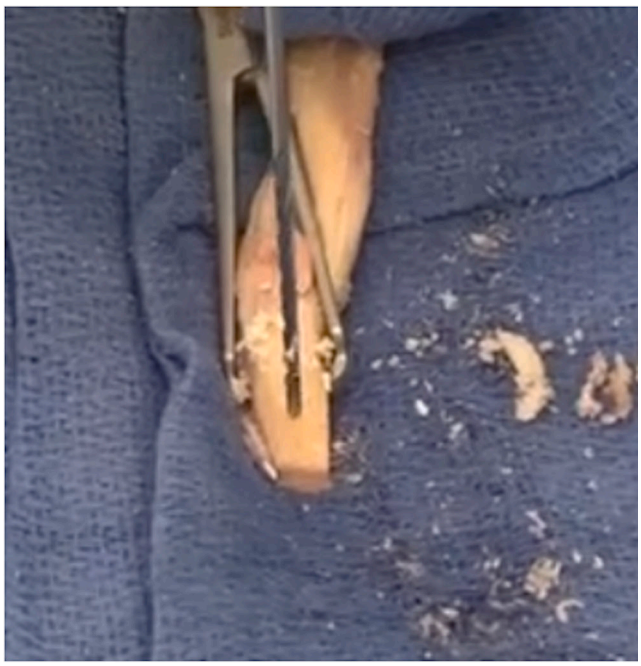

Fig 7. Shows drilling of the patellar bone block. Two #2-0 FiberWire can be placed through each hole that is drilled.

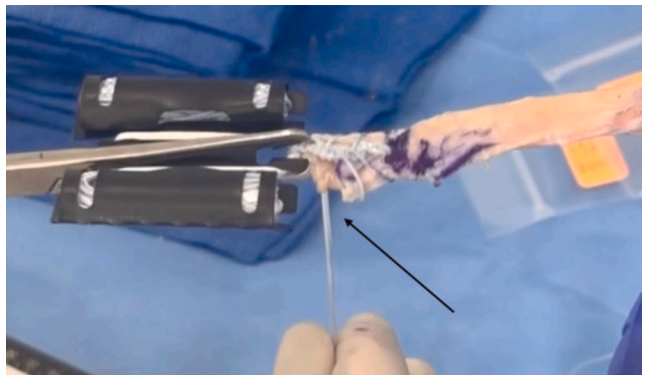

Fig 8. Shows use of the FiberTag device. Whipstitching (arrow) is done in similar fashion to the all-soft tissue femoral side.

the soft tissue end of the graft with a fresh 15-blade scalpel. A saw blade is used to size the bone to ∼25−30 mm in length and 9−10 mm in diameter, followed by tapering with a rongeur to facilitate smooth tunnel passage (Fig 6).

Preparation

Tibial End

The bone end of the graft is drilled, and two #2-0 FiberWire (Arthrex) are passed through the bone with needle drivers (Fig 7).

Femoral End

The soft tissue end of the graft was prepared using FiberTag (Arthrex) in a similar fashion as the femoral side in the QT-S graft (Fig 8).

Grant Placement

Tunnel Drilling

When using all soft tissue grafts, the surgeon can drill sockets on the femoral and tibial side for an all-inside technique (Fig 9). When utilizing a graft with a bone plug, full tunnel drilling can be done on the tibial side (Fig 10), and on the femoral side a socket can be drilled using the FlipCutter (Arthrex).

Fixation

When using all soft tissue grafts the surgeon uses suspensory fixation on both the femoral and tibial sides for ACL reconstruction. When utilizing a graft with bone plug, suspensory fixation is used on the femoral side, and interference screws are used on the tibial side (Fig 11).

Discussion

This proposed technique demonstrates use of QT allograft with and without bone plug for ACL reconstruction. The quadriceps tendon (QT) autograft has emerged as a reliable and versatile option for ACL reconstruction due to its favorable biomechanical and

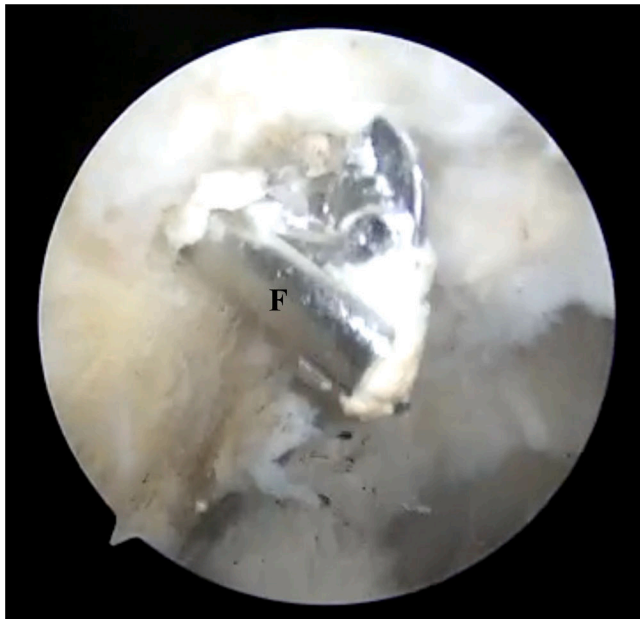

Fig 9. Demonstrates an arthroscopic view of the right knee joint. A FlipCutter (F) is used for drilling the femoral socket in the quadriceps tendon bone technique. The all-soft tissue quadriceps allograft does this in a similar fashion for both the femoral and tibial sides for an all-inside technique.

anatomical properties and has several distinct advantages in comparison to other grafts. Its thickness and width allow for individualized graft sizing, making it suitable for both single-bundle and double-bundle reconstruction techniques. Its length allows for the accommodation of knees of all sizes.

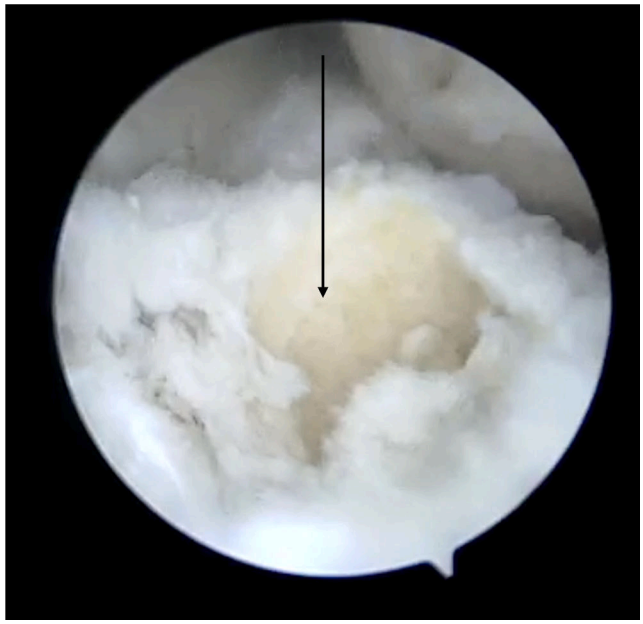

Fig 10. Shows an arthroscopic view of the right knee joint. An arrow is showing the tibial tunnel that has been drilled for use in the bone plug end of the quadriceps tendon bone technique.

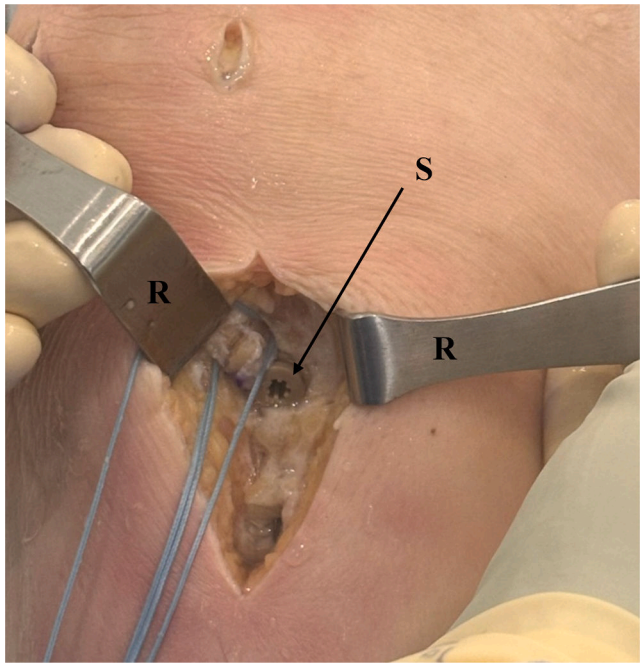

Fig 11. Demonstrates a right knee in 90° of flexion in the supine position on the operating table. Two army navy retractors (R) are used to protect the soft tissue while placing the interference screw (S). This fixation is done on the patellar bone block of the quadriceps tendon bone allograft.

Additionally, the QT can be harvested with or without a bone plug, providing further flexibility in surgical approach.[1] Several studies have found no significant differences between QT-B and QT-S autografts in terms of patient-reported outcomes, revision ACL reconstruction rates, or contralateral ACL.[7,8] The choice between them can be guided through surgeon preference and patient-specific factors.

Tunnel widening is another factor when selecting graft types and fixation methods during ACL reconstruction. While it has not been shown to have a significant impact on clinical outcomes, it could complicate revision procedures and necessitate a two-stage revision.[9] Tunnel widening is more pronounced with soft tissue grafts, such as hamstring autografts, compared to BTB autografts.[10] This could be extrapolated to QT grafts, where the presence of a bone plug in QT-B may help reduce tunnel widening compared to QT-S, although direct comparisons are limited. In addition, fixation methods influence tunnel widening, with suspensory methods of fixation showing more tunnel widening due to the “bungee” and “windshield wiper” effects that allow graft micromotion within the tunnel. In contrast, fixation with interference screws, particularly when used with bone plugs, helps minimize graft motion and leads to less tunnel widening.[11]

Use of allografts is an alternative to autograft that allows for shorter surgical time, as well as reduced donor site morbidity.[12] Studies have shown that allografts that are not irradiated or treated with low-dose irradiation have similar failure rates to equivalent autografts.[13–15] Other studies have shown that older patients with allografts did not have observable differences in revision rates when comparing BTB autograft to hamstring allograft.[16]

Overall, the quadriceps tendon allograft, which can be used with or without a bone plug, offers a clinically effective option for ACL reconstruction, with graft selection best guided by patient-specific factors and surgeon preference.

Disclosures

B.G. reports a relationship with Miach Orthopaedics Inc that includes: consulting or advisory; reports a relationship with AlloSource that includes: consulting or advisory; reports a relationship with CONMED Corporation that includes: consulting or advisory; reports a relationship with Vertex Pharmaceuticals Incorporated that includes: speaking and lecture fees; reports a relationship with Arthrex Inc that includes: consulting or advisory. "Given his on the Editorial Board of Arthroscopy, he had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor. A.M. reports a relationship with CONMED Corporation that includes: consulting or advisory. Given his role serving on the Editorial Board of Arthroscopy, he had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor. All other authors (R.S., C.B., I.H., A.N.) 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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