Technical Note

Minimally Invasive Quadriceps Tendon Anterior Cruciate Ligament Reconstruction Using the Quadriceps Tendon Harvest Guide System

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Abstract: Anterior cruciate ligament (ACL) reconstruction using the quadriceps tendon (QT) autograft is an increasingly utilized technique that confers less donor site morbidity and comparable outcomes to other historically used graft options. The graft harvest and implantation process present vast variability—particularly regarding the achievement of adequate graft site visualization, consistently attaining a uniform and appropriately sized graft, and subsequent reconstruction of the ACL with the all-soft tissue graft. The purpose of this Technical Note and video is to describe and demonstrate minimally invasive quadriceps tendon autograft harvesting using the Quadriceps Tendon Harvest Guide System (QUADTRAC), and its subsequent implantation within a single-bundle ACL reconstruction with suspensory fixation.

Reconstruction of the anterior cruciate ligament (ACL) following rupture remains the gold standard of treatment for this very common orthopaedic sports injury. Several autograft choices and graft fixation strategies are available and commonly utilized within contemporary surgical practice. Historically, the most common autograft harvest sites for ACL reconstruction include bone-patellar tendon-bone (BPTB) and quadrupled hamstring autograft. Quadriceps tendon (QT) autografts have grown in popularity within recent years, owing to the ability to harvest in a minimally invasive manner, noninferior clinical outcomes compared to alternative autograft sources, and decreased anterior knee pain.[1,2] If a minimally invasive approach is employed, however, consistent achievement of a uniform graft of appropriate size—particularly, while avoiding iatrogenic injury to nearby musculoskeletal structures—may prove difficult secondary to limited intraoperative visualization of the harvest site.

The purpose of this Technical Note and video is to demonstrate a method for minimally invasive quadriceps tendon autograft harvesting using the Quadriceps Tendon Harvest Guide System (QUADTRAC; Smith & Nephew), and subsequent graft implementation within a single-bundle ACL reconstruction using suspensory fixation. This technique affords many advantages over other methods (Table 1).

Surgical Technique (Video 1)

Patient Preparation

This investigation was performed primarily at the Mayo Clinic (Rochester, MN). The patient is positioned supine on a radiolucent surgical bed. The operative extremity is fashioned within an arthroscopic leg holder, while the contralateral extremity is supported by foam padding along its undersurface. A nonsterile tourniquet is applied to the proximal thigh. To obtain intraoperative fluoroscopy, a mini-C arm is present within the room. Following induction of general anesthesia, an examination of the surgical limb is performed to assess knee stability and range of motion

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Received September 11, 2023; accepted November 2, 2023.

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2212-6287/231306

https://doi.org/10.1016/j.eats.2023.11.009

Table 1. Benefits and Risks of Quadriceps Autograft Harvest and Single-Bundle Anterior Cruciate Ligament Using the QUADTRAC System

Benefits
Minimally invasive technique and improved visualization with the Q-VIEW Retractor
Reproducible 6-mm partial-thickness cut depth of quadriceps graft using the TRAC-Cutter
Measured QUAD-Cutter allows for reliable confirmation of tendon graft length prior to truncation
Decreased incidence of anterior knee pain compared to bone-patellar tendon-bone, given the ability to harvest an all soft-tissue graft (patellar bone plug is optional)
Q-VIEW arthroscopic visualization allows for bioaugmented repair of quadriceps harvest site defects
Risks
Potential injury to surrounding musculoskeletal structures during the graft harvest process
Risk of persistent quadriceps (knee extension) weakness compared to the contralateral leg
Patients may have altered knee proprioception at terminal extension compared to the contralateral knee

preoperatively. The operative extremity is then prepped and draped in our institution's standard sterile fashion.

Graft Harvest with QUADTRAC System

The graft harvest and repair are performed according to the author's previously described technique.[3] Anatomic landmarks are identified and the tourniquet is inflated to 250 mmHg. An ~3-centimeter linear incision is made extending from the superior pole of the patella. The suprapatellar fat pad are excised with use of electrocautery (Fig 1A). The Guide-TRAC handle is used for blunt dissection, and the transparent Q-VIEW Retractor is attached and introduced through the incision until its flange lies flush with the skin edges. An appropriately sized TRAC-Cutter is selected and inserted. With downward pressure, the semicircular blades of the TRAC-Cutter make two longitudinal cuts along the length of the quadriceps tendon (Fig 1B). The apparatus is removed from the surgical incision, and a scalpel is used to continue to the longitudinal cuts distally to the superior pole of the patellar, sharply release the tendon from its patellar insertion, and complete the release of the graft from the underlying residual quadriceps tendon. Using a looped suture tape, a tagging stitch is placed onto the distal end of the graft (Fig 1C). The tagging stitch and graft are loaded through the eye of the QUAD-Cutter, the graft is tensioned to confirm its length using the measured laser lines on the device, and the graft is truncated through actuation of the QUAD-Cutter (Fig 1D).

The graft is removed, and the harvest site is arthroscopically inspected. Special care is taken to assess for potential damage to the underlying articular capsule (Fig 2A). Capsular defects are repaired with 0 Vicryl suture, if present. A Regeneten bioinductive implant is then introduced and placed over the harvest site. The graft is secured with soft-tissue staples (Fig 2B). The subcutaneous tissues and skin are subsequently closed with 2-0 vicryl sutures, and a 3-0 Monocryl suture with overlying Dermabond, respectively.

Femoral and Tibial Tunnel Creation and Graft Placement

The graft is prepared on a separate table according to the author's previously described technique.[3] Diagnostic arthroscopy of the knee is performed with use of anterolateral and medial portals. Once any additional intra-articular pathology is identified and addressed, attention is turned to the notch, where the torn and remnant ACL is identified and debrided with use of arthroscopic shaver and/or radio frequency ablation devices. Care is taken to thoroughly debride the site of the ACL femoral footprint on the lateral femoral condyle (LFC), just posterior to the lateral intercondylar ridge. After adequate visualization of the bony landmarks is achieved, the site of the intended femoral tunnel graft placement is identified and demarcated with gentle mallet impaction of an arthroscopic 5-mm awl (Fig 3A). Through the medial portal, a guide and guide pin are inserted into the joint, and the guide pin is advanced through the demarcated site of the femoral tunnel, through the far cortex of the LFC and skin. A reamer is then introduced over the guide pin, and the femoral tunnel is subsequently reamed to a width that corresponds to the width of the harvested and prepared quadriceps autograft, and to a depth of ~20 mm. The depth of the tunnel is verified arthroscopically to ensure back wall blowout has not occurred (Fig 3B). Looped shuttling sutures are inserted through to the end of the guide pin, and subsequently passed through the reamed femoral tunnel and out of the skin.

Next, the site of the tibial footprint is, likewise, identified and debrided. Through the medial portal, a tibial point-to-point guide is introduced and placed to rest just adjacent to the posterior border of the anterior horn lateral meniscus attachment (Fig 3C), in the center of the tibial footprint. Outside of the knee, the tibial guide is positioned to rest medially to the tibial tubercle, and laterally to the MCL. A small longitudinal incision is made over the corresponding area of skin, down to the cortical bone. A guide pin is then

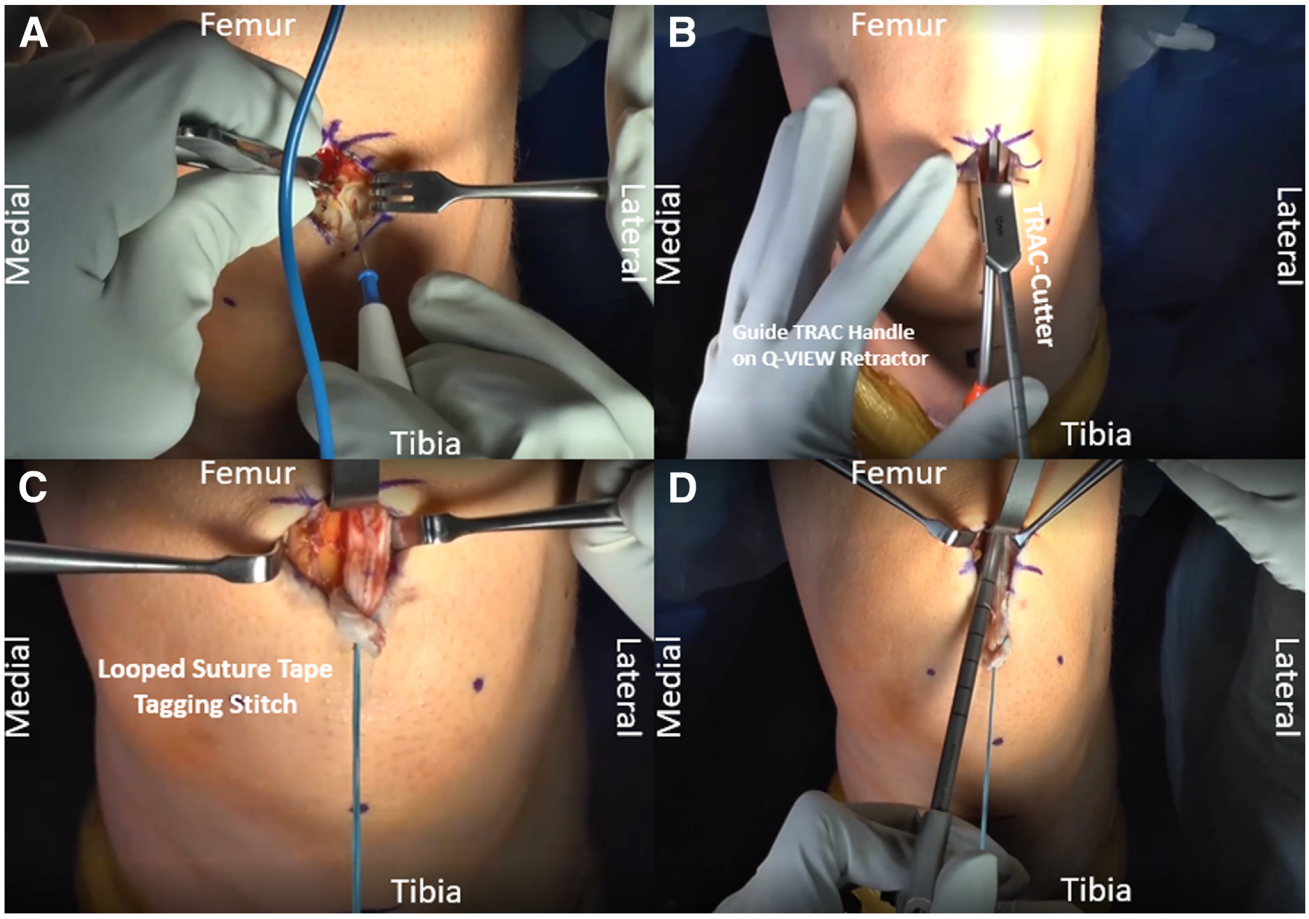

Fig 1. To harvest a quadriceps tendon for an anterior cruciate ligament reconstruction, the patient is placed supine with the left knee in 90° of flexion. (A) A three-centimeter incision is made extending proximally from the superior pole of the patella, and the suprapatellar bursa is excised with the use of electrocautery. (B) The quadriceps tendon is exposed, the Q-VIEW Retractor is centered over the tendon, and the TRAC-Cutter is introduced over the Guide TRAC Handle to perform longitudinal cuts of 6-mm depth. A scalpel is then used to sharply dissect the distal quadriceps tendon insertion off of the superior patellar pole. (C) A tagging stitch is created with use of a looped suture tape on the distal end of the freed tendon. (D) The tendon is inserted through the eye of the QUAD-Cutter, gentle tension is maintained on the tagging stitch, and the actuation of the cutter truncates the graft to the desired length.

introduced through the sleeve and advanced with a drill into the joint. A reamer (corresponding to the size of the measured graft) is then advanced in an antegrade fashion over the guide pin and into the joint (Fig 3D). The reamer is oscillated several times to ensure a smooth tunnel and facilitate ease of graft passage.

With the use of the shuttling sutures, the prepared graft with its associated femoral UTLRABUTTON is passed into the knee through the tibial tunnel (Fig 4A). The femoral button is passed through the femoral tunnel first, and once completely through (verified under arthroscopic visualization), the button is flipped onto the lateral femoral cortex using tactile feedback. The placement of the button against the LFC is then confirmed with fluoroscopy (Fig 4B). The graft preparation system's self-tensioning suture mechanism is then employed until the graft is arthroscopically visualized to sit snugly within both the femoral and tibial tunnels. The knee is then cycled several times and brought into full extension. The tightrope mechanism is then tensioned until the tibial cortical endobutton lies flat on the tibia (Fig 4C). The Lachman test is performed to ensure that a firm endpoint with no anterior tibial translation has been restored. Several knots may then be tied over the button for added fixation. Back-up fixation in the form of a knotless anchor may then be used.

A final arthroscopic assessment is performed to verify appropriate graft position and tension (Fig 5), and final fluoroscopic images are obtained to verify appropriate cortical button positioning. All surgical wounds are thoroughly irrigated, local anesthetic is administered,

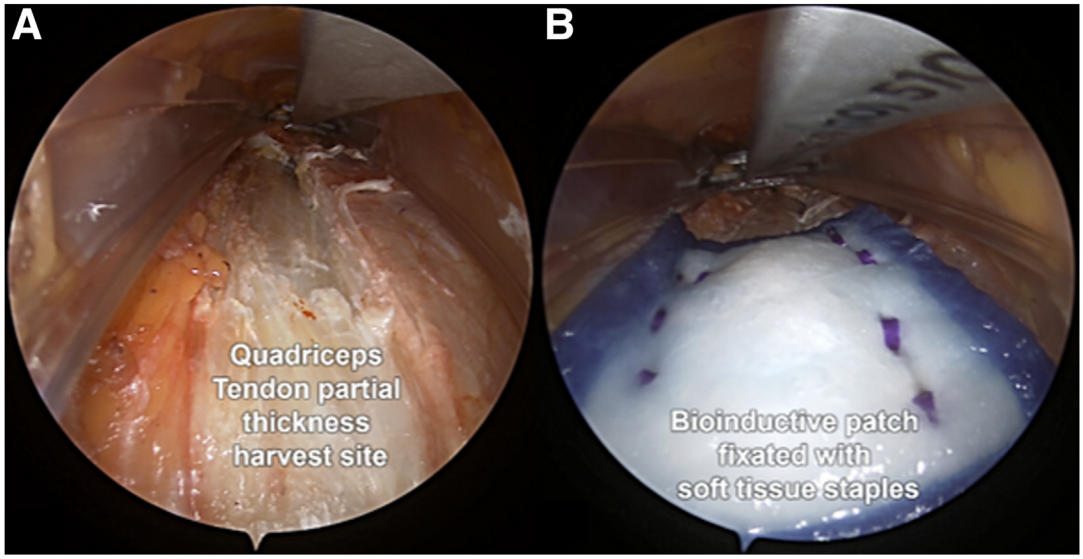

Fig 2. A dry arthroscopic view of a left knee quadriceps tendon harvest site. (A) After the harvest and truncation of the knee quadriceps tendon autograft with use of the QUADTRAC-Cutter, second-look arthroscopy of the harvest site is performed through the Q-VIEW retractor to ensure that the deep rectus femoris tendon has not been violated and that there are no defects in the underlying articular capsule. (B) A bioinductive patch is then placed onto the wound, moisturized with scope fluid, and fixated with soft tissue staples so as to provide an augmented healing environment for the graft harvest site.

incisions are closed with 2-0 deep dermal Vicryl and/or 3-0 Monocryl sutures, and sterile dry dressings are applied prior to awakening the patient from anesthesia.

Postoperative Care

The patient is weightbearing, as tolerated, in a TROM knee brace locked in extension. The brace is locked in extension for sleeping and walking and is unlocked for full motion when seated or exercising. The brace can be removed for sleeping at 1 week, unlocked while walking at 2 weeks and discontinued at 4 weeks. Straight leg raise, quadriceps/hamstring sets, and patellar mobs are started on postoperative day 1.

Discussion

This Technical Note serves as a comprehensive surgical technique for minimally invasive QT autograft harvest using the QUADTRAC Quadriceps Tendon Harvest Guide System, and the subsequent single-bundle ACL reconstruction. This technique provides improved visualization of the graft harvest site, reliable acquisition of a QT graft with the desired length and cross-sectional area, and decreased incidence of anterior knee pain compared to BPTB graft selection due to the ability to harvest an all soft-tissue graft.

Historically, critiques of the use of QT grafts within ACL reconstruction include the risk of non-uniform

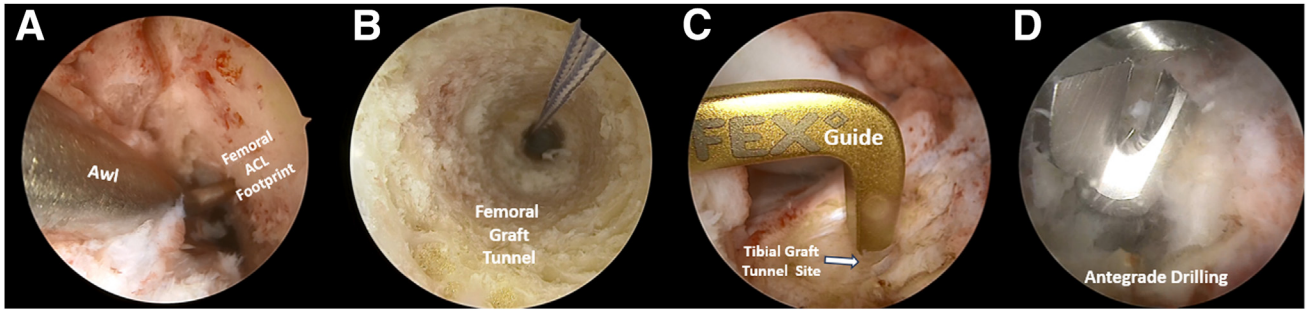

Fig 3. (A) After arthroscopically debriding the left knee anterior cruciate ligament (ACL) remnant and footprint, identification and demarcation of the femoral ACL footprint with an arthroscopic awl is performed. (B) The femoral graft tunnel is then drilled and arthroscopically inspected to ensure that back wall blowout has not occurred. (C) Next, arthroscopic identification and guide demarcation of the intended tibial graft tunnel site at the tibial ACL footprint are performed. (D) Lasty, the tibial tunnel is reamed in antegrade fashion to a width corresponding to the measured QT graft size.

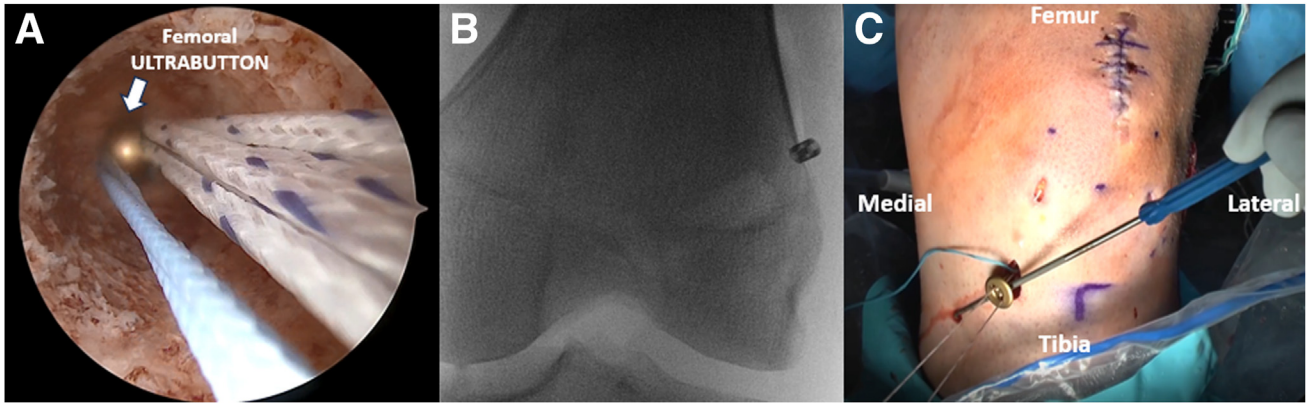

Fig 4. (A) After left knee femoral and tibial tunnels have been drilled, to pass the harvested left knee quadriceps tendon autograft, the femoral ULTRABUTTON is first passed into the knee and femoral tunnel using shuttling sutures under arthroscopic visualization. (B) After the button has completely passed through the femoral tunnel and flipped onto the LFC with use of tactile feedback, a fluoroscopic image is taken to confirm appropriate orientation and positioning. (C) Once the QT graft has been passed into the femoral and tibial tunnels, the tightrope mechanism is tensioned until the tibial cortical Endobutton lies flat onto the tibial surface.

graft harvest owing to limited visualization, and higher failure rates. Further investigation, however, has demonstrated that increased revision rates were associated with the infrequent performance of this graft harvest technique by the surgeon.[4] With technological advancements and improvements in surgical technique, this harvest site has been found to consistently produce robust grafts and have noninferior surgical outcomes and graft durability compared to the BPTB and hamstring autografts, while simultaneously conferring a decreased risk of anterior knee pain and hamstring weakness.[1,2]

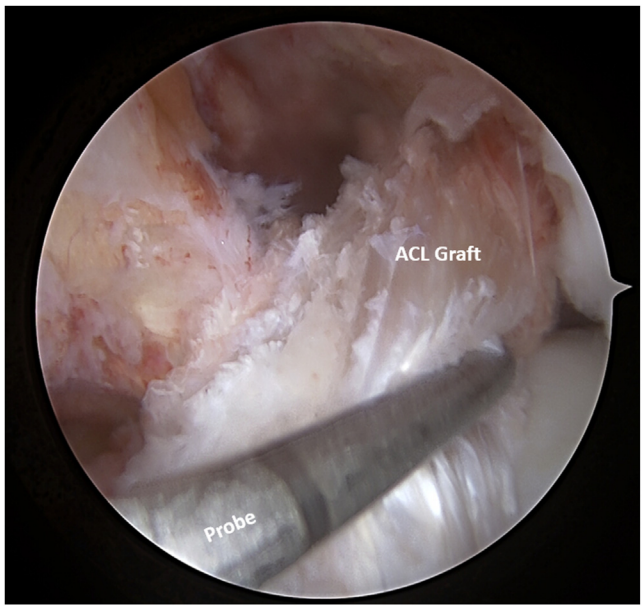

Fig 5. Following quadriceps tendon graft suspensory fixation into the left knee with use of the QUADTRAC system, a final arthroscopic evaluation with a probe is performed to ensure the graft is appropriately positioned and tensioned.

The two most common techniques for soft tissue ACL graft fixation are aperture (interference screw) and suspensory fixation. Interference screw fixation relies on the utilization of an appropriately sized screw and avoidance of screw divergence.[5] The technique provides an ideal anatomic site of fixation but confers a greater risk of graft maceration and tunnel enlargement compared to cortical fixation.[6] In recent years, suspensory fixation has been more commonly employed, as it allows for smaller implants and easier adjustment of graft tension during and following implantation. Compared to interference fixation, the success of cortical suspension is less dependent on tunnel size or integrity and is often considered as a bailout method if posterior wall blowout occurs during femoral tunnel reaming.[7]

Limitations of the present technique include the risk of persistent quadriceps (knee extension) weakness and altered proprioception at terminal extension compared to the contralateral knee.[8] Patellar fracture following QT graft harvest has been reported, but infrequently so, and solely within the setting of patellar bone plug harvest.[9-12] Without careful visualization of the quadriceps tendon, it is also possible to violate the rectus femoris muscle belly during graft harvest, or violate the knee's articular capsule, necessitating its repair.

Conclusions

The QUADTRAC system offers an effective method to perform QT autograft harvesting with improved visualization and ensure consistent production of

appropriately sized grafts for the use of a single-bundle ACL reconstruction. Ongoing investigation is warranted to evaluate the outcomes of ACL reconstructions performed with use of the QUADTRAC system.

Disclosures

The authors report the following potential conflicts of interest or sources of funding: Support was received from the Foderaro-Quattrone Musculoskeletal-Orthopaedic Surgery Research Innovation Fund. This study was partially funded by the following: National Institute of Arthritis and Musculoskeletal and Skin Diseases for the Musculoskeletal Research Training Program (T32AR56950). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH. C.C. reports consulting fees from Arthrex, research support from Major League Baseball; publishing royalties and financial and material support from Springer. M.H. reports consulting fees from DJO-Enovis; publishing royalties and financial and material support from Elsevier; editorial or governing board membership in *Journal of Cartilage and Joint Restoration*; consulting fees from Moximed and Vericel. K.O. reports consulting fees from Arthrex and Smith & Nephew. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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