Mini-Invasive Harvesting of Quadriceps Tendon Graft With Patellar Bone Block for ACL Reconstruction Using a Dedicated Harvester

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Background: The selection of the type of graft used to reconstruct the anterior cruciate ligament (ACL) remains a matter of debate. In the past, the quadriceps tendon (QT) was associated with considerable morbidity and less favorable outcomes than other grafts. Improvements in harvesting methods have decreased morbidity of the surgical procedure and led to an increase in the use of QT in recent years.

Indications: The QT graft with patellar bone block is a viable option for all patients with closed physis undergoing ACL reconstruction. It is especially suitable for young and active patients who practice activities that require kneeling or athletes in which hamstrings preservation is advisable.

Technique Description: A vertical mini-invasive longitudinal incision starts 1 cm proximal to the middle of the patellar pole. After dissection, the bone block is marked and detached with an oscillating saw. A drill hole is performed in the bone block to serve for the passage of a traction suture. The bone block is lifted with the help of the traction suture, and the graft is trimmed to the desired diameter. The layer between tendon and capsule is separated by blunt dissection to spare the capsule of the suprapatellar pouch. Harvesting is achieved using a dedicated QT harvester. Usually, a graft length of 8 cm is harvested. The defect in the QT is closed using a suture passer at the proximal end. Finally, the graft is prepared and calibrated according to the planned technique for ACL reconstruction.

Results: There was no major intraoperative complication in the senior author's series (more than 50 patients) using the dedicated QT harvester. On rare occasions (<10% of the cases), the device opened the suprapatellar joint capsule, creating the additional need for capsular repair during defect closure. On two occasions, the graft was shorter than expected, which may have been caused by insufficient dissection or improper use of the harvester.

Discussion/Conclusion: ACL reconstruction with minimally invasive QT graft harvesting methods has shown very good clinical outcomes with few complications. It can be recommended for primary and revision ACL reconstruction.

Patient Consent Disclosure Statement: The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

Keywords: ACL reconstruction; quadriceps tendon; knee arthroscopy; mini-invasive harvesting technique; graft preparation

VIDEO TRANSCRIPT

In this video, we present our technique for mini-invasive harvesting of quadriceps tendon graft with patellar bone block in adult anterior cruciate ligament (ACL) reconstruction.

These are the authors' disclosures.

This is an overview of the topics that will be discussed in the video. The goal of this video is to describe the surgical technique, including surgical indications and tips and tricks to obtain an optimal quadriceps tendon autograft with low donor site morbidity.

Graft choice remains a hot topic of debate when discussing about ACL reconstruction.

The main options that the surgeon can choose from are patellar tendon or BPTB (bone patellar tendon bone), hamstrings, and quadriceps tendon (also called QT).[2] Other options include allografts, tensor fascia Lata grafts, and

Video Journal of Sports Medicine (VJSM®), 3(5), 26350254231207405
DOI: 10.1177/26350254231207405

artificial bands or augmentations, but these are usually reserved for rare cases or in the event of multiligament reconstructions requiring multiple transplants.[2,8,9]

The BPTB historically has been considered the gold standard and has been the most commonly used graft for many years.[10] However, it has been gradually overtaken by the use of hamstrings that have become the most popular choice for primary ACL reconstruction both in the United States and in Europe.[1] The quadriceps tendon remains a third choice for most surgeons, but it has been gaining a lot of traction over the last decade. In our personal experience, in fact the use of the QT has increased exponentially going from 3% in 2011 to about 34% in 2021.[7]

What are reasons that lead us to shift our preference toward the QT over hamstrings and BPTB? When choosing a graft, the main criteria the surgeon has to consider are the biomechanical properties of the graft, the biological properties, donor site morbidity, and last but not least, risk of re-rupture.

The QT is a stiff and robust graft, it has shown comparable biomechanical properties to quadrupled hamstrings and BPTB, with ultimate failure loads comparable to those of the native ACL.[8,9]

The QT offers the possibility of harvesting a graft with bone block. Bone-to-bone healing has shown to be faster and more physiologic than tendon-to-bone interface. The possibility of harvesting a QT with bone block enhances its biological healing potential, placing it as a valid alternative to the classic BPTB.[8,9]

The QT has also shown lower morbidity rates compared with both hamstrings and BPTB, reducing anterior knee pain, donor site morbidity, and difficulty in kneeling.[4]

Regarding re-rupture rates recent meta-analyses showed similar re-rupture rates to both BPTB and hamstrings.[4,8,9]

In conclusion, the QT should be considered as a viable option for all patients, but it proves especially adapted for young and active patients who practice activities or professions that require kneeling, or athletes in which hamstrings preservation is advisable like sprinters or martial arts athletes.[2,8,9] The main advantages of using the QT are a predictable tissue mass, and adjustable length. With the quadriceps tendon in fact, one can control the length of the graft, which is not the case with the BPTB, and can also control the diameter, unlike with the hamstrings. In addition, there is no weakness in ACL agonists.[3,5,6] Disadvantages can include quadriceps tendon weakness, a higher risk of arthrofibrosis and the risk of patellar fractures.[8,9]

Patellar fracture in particular is a complication related to bone-block quadriceps tendon and BPTB harvesting. A recent review and meta-analysis reported a higher proportion of patellar fractures for QT.[11] However, the overall proportion of extensor mechanism complications using either a BPTB or a QT autograft is low. We will discuss later some tips and tricks to try to minimize the risk of patellar fracture.

We describe now our mini-invasive quadriceps harvesting technique.

The patient is positioned supine. A tourniquet is placed on the proximal thigh and the operated leg is placed in a motorized leg holder.

With the operated leg flexed at 90°, the proximal pole of the patella is identified and the medial and lateral borders are marked. A longitudinal skin incision is made, starting 1 cm proximal to the apex of the patella and then continued distally in a direction parallel to the bulge formed by the vastus medialis. The length of the incision is about 2 to 3 cm. The incision is then deepened into the subcutaneous plane, and the tissues overlaying the tendon are released. Some veins are usually identifiable in this phase directly over the tendon and should be coagulated. The QT, vastus medialis, and patella are identified to determine the exact site for graft harvesting. The outline of the bone block is marked at the proximal pole of the patella using a No. 15 blade scalpel. We usually try to achieve a length of 20 mm and width of 10 mm. Once the outline is established the bone block is harvested using an oscillating saw with a small blade.

To minimize the risk of fracture, the longitudinal saw cuts are made from proximal to distal, following the markings and angulating the blade by about 45°. The ideal depth of the cuts is about 10 mm. Eventually, a small osteotome is used to gently push up and release the bone block. If a gentle push does not allow complete extraction, a recut with the saw should be considered as using the osteotomes and hammer might bring an increased risk of fracture.

After releasing the bone block a 1.5-mm hole is drilled in the proximal third and a No. 2 high strength traction suture is passed through the hole. The wire is then used to control the tendon during dissection, which is carried out using a scalpel or Metzenbaum scissors.

We always aim for harvesting of a full-thickness QT graft while sparing the joint capsule. Possible complications of this technique are capsular disruption and premature graft amputation. We will discuss and show some tips and tricks to help avoid these complications. It is very important in this phase to trim down the distal 3 to 4 cm

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Submitted May 1, 2023; accepted September 25, 2023.

The authors declared that they have no conflicts of interest in the authorship and publication of this contribution. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

of the graft in order to spare the capsule of the suprapatellar pouch. A thin fat layer exists deep to the tendon and superficial to capsule. If encountered, it should alert the surgeon to avoid deeper dissection or risk capsular violation. Furthermore, the graft needs to be trimmed to the desired circumference to avoid asymmetric bulging and facilitate passage into the tendon harvester.

To harvest the tendon, we are using a new single use dedicated tendon harvester. Once the distal 3 to 4 cm of the tendon is released, a suture passer is used to aid in shuttling the suture through the cannula of the harvester. The bone block and distal part of the tendon are then passed into the cannula. In this phase the bone block edges can impede graft passage. It is important to model the bone block, using a small bone rongeur and scissors, to avoid over tensioning the traction suture as this might lead to a bone block fracture or suture breakage. Usually, we choose a 9- or 10-mm diameter harvester when performing adult ACL reconstruction, resulting generally in a 7- to 9-mm graft and tunnel diameter.

Once the distal end of the graft is inserted in the cannula of the harvester, the knee is held at 90° of flexion to ensure appropriate tension on the tendon. While applying tension on the traction suture, we advance the harvester proximally while maintaining it parallel to the tendon and rotating in a clockwise fashion. On the side, the harvester is graduated, indicating the length of the graft isolated. When performing ACL reconstruction, our goal is to achieve at least 8 cm of graft, including the bone block.

Once the appropriate length is reached the harvester is backed out of the incision and the suture is retrieved along with the graft through the so-called amputating window. The instrument is then advanced back through the incision to the desired length. Keeping the graft adjacent to the graduations on the harvester's handle, we insert the push rod. At this point, the graft is cut proximally by applying a strong squeeze while maintaining tension on the traction suture. The harvesting site is then inspected under endoscopic view to look for a breach in the joint capsule, which must be sutured to avoid fluid leakage during the arthroscopic phase. Importantly, the proximal myotendinous junction must remain intact to avoid weakening of the quadriceps complex.

After harvesting, tendon closure has to be performed to facilitate healing and reduce donor site morbidity. The edges of the quadriceps tendon donor site have to be approximated to one another. The mini-invasive incision often makes reaching the proximal part of the tendon difficult when using a standard suturing needle. Flexion and extension movement of the knee can be modulated to facilitate access to the proximal part by relieving tension on the skin. However, our preferred method involves using a suture passer loaded with an absorbable braided size 2 suture. The suture passer is used to pass the wire alternatively from one edge to the other. A knot pusher is then used to tension the suture and complete the repair. Endoscopic view can be obtained in this phase to aid in suture placement and to confirm the adequacy of the tendon closure.

The graft can then be moved to the dedicated graft preparation station and be prepared according to the planned technique for ACL reconstruction. Our preferred method involves placement of two high strength sutures on each side using interlocking stitches.

We usually perform ACL reconstruction with a femoral half tunnel using an anteromedial portal approach coupled with a complete outside-in tibial tunnel. The graft is shuttled through the tunnels placing the bone block in the femoral socket. Graft fixation is then obtained using a double bioabsorbable interference screw on tibia and femur.

In our experience, screw fixation has proven reliable without the need for further back-up techniques. The main advantage is the fact that it provides a direct fixation. Screw fixation however presents some drawbacks. For example, to use tibial screw fixation, the length of the quad graft needs to be longer than for suspensory all-inside, but bone block harvesting in this instance helps achieving an adequate graft length. Other methods like suspensory devices or crosspin fixation can be considered valid alternatives.

In conclusion, QT graft with patellar bone block is a viable option for adult ACL reconstruction, especially in young and active patients. Minimally invasive QT graft harvesting has shown good clinical outcomes with low donor site morbidity and complication rates. The aim of this video was to provide some insight on how to efficiently and safely perform this technique.

Thank you for the attention.

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