Central Quadriceps Tendon Harvest With Patellar Bone Plug: Surgical Technique Revisited

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Abstract: The objective of this article is to review the surgical technique for quadriceps tendon graft harvest while highlighting an additional technical note that has not been previously emphasized. The quadriceps tendon typically inserts eccentrically on the superior pole of the patella. By shifting the soft-tissue harvest to a location just off the medial edge of the tendon, the adjoining patellar bone plug will be centered on the superior pole of the patella, reducing the risk of an iatrogenic patellar fracture.

Though less commonly used compared with autologous bone–patellar tendon–bone (BPTB) and quadruple-stranded hamstring tendon grafts, the central quadriceps tendon (CQT) graft has been shown to be a viable alternative tendon. With a mean width of 7 mm, the graft is nearly double the mean 4-mm thickness of the BPTB graft tendon. The ultimate tensile load of the CQT graft is 2,352 N, which exceeds that of the native anterior cruciate ligament (ACL) graft (1,725 N) and nears that of the BPTB graft (2,977 N) and hamstring tendon graft (range, 2,422 to 4,590 N). Although donor-site morbidity remains inherent to all autograft options, CQT graft recipients have been shown to have less anterior knee pain, kneeling pain, and postoperative numbness compared with BPTB graft recipients. The harvested CQT graft has been successfully used in primary ACL reconstructions with and without a bone plug, revision ACL reconstructions, single-bundle and double-bundle posterior cruciate ligament reconstructions, lateral collateral ligament reconstructions, and rotator cuff repairs.

Since the surgical technique for CQT graft harvest, as described by Fulkerson and Langeland, was published in 1995, several iterations of the same process have been reproduced in various articles and textbooks with minimal change in the main principles of the procedure. Harris et al. published a morphometric analysis of the quadriceps tendon in which they correctly pointed out that the tendon “develops proximally from its insertion asymmetrically, toward the lateral side.” More recently, Lippe et al. confirmed this observation with a cadaveric study, reporting that maximum tendon length was located at a point 61.6% ± 4.1% of the tendon width from the medial border of the distal insertion point. On the basis of this finding of an asymmetric insertion, Harris et al. made the perhaps logical recommendation to “err laterally” when harvesting the graft, which we have since found to be the wrong conclusion when the plan includes harvesting an adjoining patellar bone plug. Because the quadriceps tendon insertion is asymmetric toward the lateral side of the superior pole of the patella, we have noted both in vivo and in cadaveric specimens (Fig 1), erring laterally for the graft harvest to acquire the longest available portion of soft-tissue graft will dictate that the adjoining patellar bone plug is dangerously lateral on the patella. Consequently, one must avoid the temptation to harvest the central 10 to 11 mm of quadriceps tendon, as is
performed when harvesting BPTB graft. This practice will consistently place the bone plug in the superolateral quadrant of the patella, as opposed to centered on the superior pole (Fig 2). An eccentrically located bone plug harvest has previously resulted in multiple patellar fractures at our institution (Fig 3), which provided the initial impetus for investigating this issue further and subsequently modifying our harvest technique.

We describe our preferred technique for quadriceps tendon harvest with an associated patellar bone plug (Table 1).

**Technique**

The quadriceps tendon is exposed through a standard 4- to 6-cm midline longitudinal incision extending proximally from the superior pole of the patella. The paratenon and prepatellar fascia are cleanly incised for subsequent repair. From the superior aspect of the patella, a minimum of 7 to 8 cm of CQT in length is obtainable with a desired medial-to-lateral width of 10 to 11 mm. Maintaining this width limits proximal extension as the tendon narrows in a tapered fashion moving proximally. Most surgeons publishing on the topic, including the initial description of Fulkerson and Langeland, advocate harvesting a portion of all of the quadriceps layers, from the rectus tendon superficially to the vastus intermedius tendon deep, to obtain a graft thickness of 7 to 9 mm. Prudence is recommended to avoid venturing into the suprapatellar pouch because the resulting fluid extravasation can make further arthroscopic surgery challenging.

We prefer to harvest the tendon before the bone plug, but we begin by extrapolating where the bone plug will be located based on our projected portion of tendon to

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Fig 1. Cadaveric anatomic exposure showing lateral-based insertion of quadriceps tendon on superior pole of patella. The probe is centered on the patella.

Fig 2. Quadriceps tendon harvest with patellar bone plug. In the left image, the red lines show the dangerously lateral position of the patellar bone plug if the harvest location is based on the longest and most central portion of the quadriceps tendon. The blue lines depict the more medially based location of the harvested tendon when the patellar bone plug is centered, as proposed in our technique.
be harvested to confirm that it will be adequately positioned. Next, by use of a new No. 10 blade, the medial longitudinal incision is made first, from distal to proximal, extending up the tendon. This is the key step in the harvest, and we have found that this incision should be positioned just off the medial border of the tendon as it extends up proximally, adjacent to the vastus medialis oblique muscle. This will leave approximately 3 to 4 mm of tendon medial to the incision at the patella and 1 mm of tendon more proximally so that adequate tendinous tissue remains for subsequent tendon healing (Fig 2). The incision through the tendon should be made with a smooth pushing motion, as opposed to a “sawing” technique, to avoid incising across the longitudinal tendon fibers. In addition, forceps can be inserted within the incision, behind the knife blade, once the initial cut has been made, to spread open the incision and help further visualize the tendon fibers to minimize cross-cutting. The same process is then completed 11 mm lateral to the first cut, to produce a 10- to 11-mm-wide graft. Care must be taken to avoid “bulleting” the tendon proximally, which results in a progressively narrowed width extending cephalad up the soft-tissue graft. The incisions are carried proximally until the overall tendon width narrows to about 12 to 14 mm, which usually produces a soft-tissue graft length of 7 to 9 cm. Depth is more difficult to estimate but should be through the entire rectus and the majority of the vastus intermedius, leaving a thin deep raphe layer over the suprapatellar pouch. As Lippe et al. and other authors have previously documented, using the known 7-mm width of a No. 10 scalpel blade can be helpful in estimating the depth of the tendon harvest. If the blade inadvertently extends into the suprapatellar pouch, the defect can be closed with interrupted No. 1 Ethibond (Ethicon, Somerville, NJ), which will allow one to continue with the arthroscopy with minimal fluid extravasation.

On the basis of various authors’ techniques, the adjoining bone plug is recommended to measure 20 to 25 mm in length, 8 to 10 mm in width, and 6 to 10 mm in depth and should be centered on the patella. We prefer a 10 × 10 × 23-mm bone plug. A Steri-Strip (3M, St. Paul, MN) is placed at the 1-cm mark on the saw blade to allow easy recognition of our target depth when the blade is oscillating (Fig 4). On the longitudinal cuts,
the saw blade is angled approximately 30° away from midline to produce a trapezoid-shaped plug. One may also drill the 2 corners of the plug to avoid cutting past the plotted rectangle-shaped cut. Once the 3 cuts have been made, a half-inch osteotome is used to gently loosen the plug with side-to-side motions at various positions around the plug (Fig 5). Care must be taken to avoid levering on the bone plug because this can lead to fracture of the plug or the patella. Once the bone plug is elevated from the patellar bed, the overall graft length can be accessed and the tendinous portion is truncated proximally at an appropriate length (Fig 6).

For closure, the patellar defect is bone grafted with either autograft tunnel reamings or allograft cancellous bone and the fascia closed tightly over the top to hold the graft within the defect. The remaining quadriceps tendon segments are then closed with 2 to 3 interrupted No. 1 Ethibond sutures, reapproximating the medial and lateral portions of tendon, and the paratenon/peri-tendon layer is closed with running No. 0 Vicryl (Ethicon). The remainder of the wound is closed in a layered manner.

The graft is prepared by drilling 3 tunnels through the bone plug with a 2-mm drill bit. This can be performed before the graft has been entirely freed from the patellar bed (Video 1) or after it has been harvested and passed to the back table. The drill holes are spread evenly along the bone plug longitudinally and are offset from one another, to decrease the risk of suture pull-through across all 3 holes. Two holes or all 3 of the holes are loaded with a nonabsorbable super-strength suture (either No. 2 FiberWire [Arthrex, Naples, FL] or No. 2 Orthocord [Ethicon]). The final 20 to 30 mm of tendon on the soft-tissue end is then either left whole or split into 2 limbs in line with the fibers and whip-stitched with a Krackow locking suture technique. The graft is then ready for sizing and implantation (Fig 7).

Discussion

Though rare, iatrogenic intraoperative patellar fracture after bone plug harvest in CQT harvest has been previously reported. In response to this
complication, as well as the additional theorized morbidity associated with bone plug harvest, use of a free quadriceps tendon graft without an associated bone plug has been proposed and trialed. Geib et al. showed no significant clinical differences comparing CQT grafts with and without an associated bone plug for ACL reconstruction at intermediate follow-up. Despite these observations, the bone plug adds additional length to the graft, and on the basis of extrapolation from the BPTB literature, it affords alternative, proven fixation methods and arguably incorporates into the bone tunnel more quickly than a soft-tissue graft. Other general surgical complications such as infection and wound healing problems have not been commonly encountered in our experience with this technique. If one chooses to use a CQT graft with a bone plug, our technical tip should allow for a safe harvest.

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