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Extensor Mechanism Macrotraumatic Complications

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Summary: Macrotraumatic extensor mechanism complications do occur after central third patellar tendon harvest for anterior cruciate ligament (ACL) reconstruction and include intra- or postoperative patella fracture and patellar tendon rupture. These are significant complications that often require additional surgery. Intraoperative precision when harvesting the patellar tendon, bone grafting the donor sites and implementing contemporary postoperative rehabilitation and bracing protocols may minimize their occurrence. **Key Words:** Anterior cruciate ligament—-Patellar autograft—Reconstruction—Patella fracture—Patellar tendon rupture.

Anterior cruciate ligament (ACL) injury is extremely common, especially in the athletic population. It is estimated that 100,000 new ACL injuries occur annually, and one out of every 3,000 people will suffer injury to the ACL in a given year.[24] In the past these injuries would often preclude return to high-level sports activities. Today, with current reconstructive surgical techniques, an injured athlete can predictably regain knee stability and return to strenuous athletics in over 90% of cases, usually within 6 months of surgery. Given this success rate, individuals wishing to return to demanding activities are often candidates for ACL reconstruction. When counseling these patients it is important to communicate potential complications of ACL reconstruction.

Central third bone-patellar tendon-bone autograft is a common graft choice for ACL reconstruction. Despite the consistent long-term success with this graft, donor site morbidity has been identified as a concern.[1,30] Unusual macrotraumatic extensor mechanism complications do occur and include intra- or postoperative patella fracture and patellar tendon rupture. These complications have been related to biologic factors, graft harvest technique and possibly postoperative management. The purpose of this article is to discuss the potential causes, prevention, and proper treatment of these complications.

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PATELLA FRACTURES

Patella fractures are rare after patellar autograft procedures with a reported prevalence of 1% to 2%.[3,6,8] These fractures can occur either intra- or postoperatively. Intraoperative fractures are less common but likely underreported, are usually longitudinal and nondisplaced, and occur during patellar bone block removal. Postoperative fractures typically occur within 12 weeks of the reconstruction and are displaced stellate or transverse fractures that disrupt the extensor mechanism. These occur secondary to direct trauma or an excessive eccentric quadriceps contraction because of postoperative brace noncompliance or aggressive rehabilitation.[8] On the other hand, if weight bearing or range of motion is excessively limited postoperatively, secondary osteopenia could also place patients at risk for subsequent fracture.

Christen et al.[8] described 6 intraoperative and 3 postoperative patella fractures in a series of 490 patellar autograft ACL reconstructions. All 6 intraoperative fractures were vertical splits and occurred during bone block removal; only 3 were treated with internal fixation. The three postoperative fractures occurred between 1 and 8 weeks postoperatively and all were treated with internal fixation. Viola et al.[35] described three displaced transverse patella fractures in a series of 1320 ACL reconstructions. These fractures occurred between 8 and 12 weeks postoperatively and were treated with open reduction and internal fixation with subsequent hardware removal. At final follow up this complication did not affect

long-term clinical outcome in either series.[8,35] Other studies have also confirmed that early fracture recognition and internal fixation allows adequate rehabilitation without compromising final clinical outcome.[3,32]

Benson et al.[2] reported a late avulsion fracture of the superior pole of the patella 1 year after the index reconstruction and 6 months after return to full athletic activities. McCaroll[19] reported a transverse fracture that occurred during a golf swing 6 months postoperatively. It has been proposed that these delayed patella fractures may represent failure of a relatively devascularized and weakened portion of the patella.[2] During graft harvest the midpatellar and inferior polar components of the intraosseous blood supply are disrupted. Whether this blood supply reconstitutes and its relevance to early or late postoperative patella fractures remains unclear.

PREVENTION

Bone block removal creates an inherent stress riser at the junction of the graft bed corners and the remaining patella. Proper graft harvesting techniques may reduce the risk of both intra- and postoperative patella fracture. In fashioning the patellar bone plug, the cortex is scored with an oscillating saw and an equilateral triangle is made on profile with the saw to avoid penetrating the articular cartilage; the blade is angled approximately 30 degree centrally and the final blade depth should not exceed 6 to 7 mm (Fig. 1). When making the proximal crosscut, the saw blade is held at 45 degrees to the cortex to avoid overshooting the sagittal cuts and to minimize the resulting stress riser. The senior author does not use cylindrical saws or create tapered cuts on the patella. The trapezoidal profile patellar block is gently removed with a curved three-eighths inch osteotome being sure not to lever it from its osseous bed. Using this technique the senior author has had 1 intra-operative fracture in 600 patellar autograft ACL reconstructions.

Primary bone grafting of the harvest site with autograft from the bone blocks and canal reamings is recommended, especially if the patellar bone block is wider than 10 mm or deeper than 6 mm.[9] Tsuda et al.[34] demonstrated a significant reduction in patellar pain symptoms at an average of 35 months postoperatively when grafting produced less than 2 mm of residual patellar defect depth. The statistical power necessary to prove that grafting significantly reduces the possibility of postoperative fracture virtually precludes performing such a study.

Contemporary postoperative rehabilitation programs emphasize patellar mobilization and immediate full passive extension combined with night extension bracing.

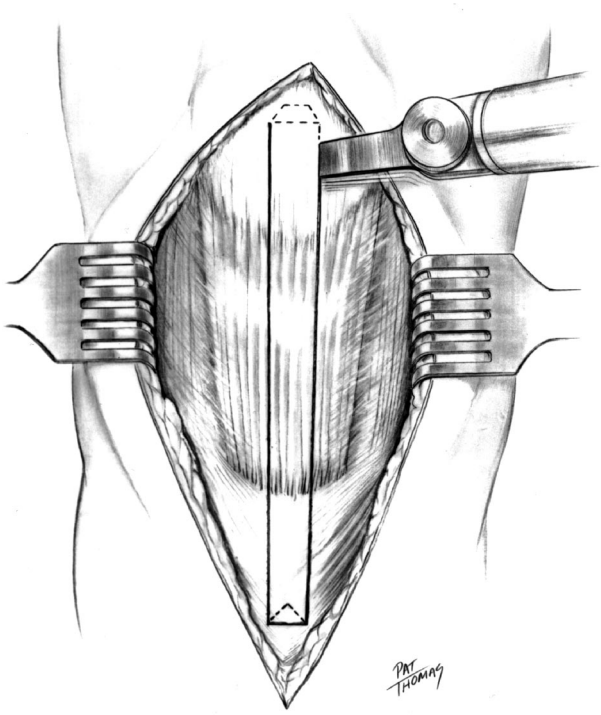

FIG. 1. The graft is harvested with an oscillating saw. The patellar plug is trapezoidal on profile whereas the tibial plug is an equilateral triangle on profile. (Reprinted with permission from Hardin GT, Bach BR, Jr., Bush-Joseph CA, et al. Endoscopic single incision ACL reconstruction using patellar tendon autograft: surgical technique. *J Knee Surg* 2003;16:135–147.)

Early active range of motion, straight-leg raises, and closed kinetic chain exercises as well as immediate weight bearing in extension are allowed to promote early muscle control and quadriceps reactivation. While some authors advocate postoperative bracing with ambulation to protect the donor site for 6 weeks postoperatively,[9,31] several studies failed to show that bracing significantly effects the rates of postoperative extensor mechanism complications.[13,14,20,29]

TREATMENT

Management of intraoperative patella fractures relies first on recognition of the fracture followed by appropriate fixation. Longitudinal fractures may be repaired using transverse K-wires or lag screws (Fig. 2). Transverse fractures are fixed using lag screws and/or a tension band wire technique. Postoperative patella fractures are managed in a similar fashion when displaced; if the fracture is nondisplaced a period of immobilization with close clinical and radiographic follow up may be appropriate. Rehabilitation after surgical fixation of a patella fracture

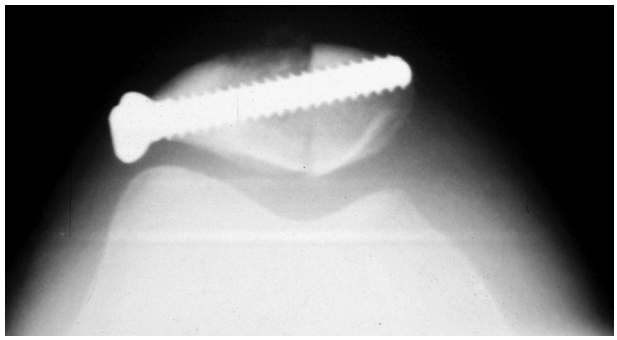

FIG. 2. Radiograph showing fixation of an intraoperative patella fracture.

warrants immediate gentle range of motion and weight bearing in extension. A hinged knee brace to control knee motion and prevent loss of fracture fixation is used until radiographic healing is confirmed.

PATELLAR TENDON RUPTURE

Patellar tendon rupture is also an unusual complication after central third harvest. We are aware of only 16 cases reported in the English orthopaedic literature; however, this complication is likely similarly underreported. Of these 16 cases, 13 have occurred within 10 months after the index procedure.[4,5,10,12,15,16,23,26,33] The 3 other ruptures occurred at 3[18,22] and 6[18] years after graft harvest. Six ruptures occurred at the tibial insertion and 3[5,15,26] were associated with a patella fracture. Ten ruptures involved proximal avulsions with 1[23] concomitant patellar fracture, and 6 of these occurred after a Marshall/MacIntosh procedure. In 15 of the 16 cases, some form of trauma could be identified (eg, direct impact, hyperflexion, or forceful quadriceps muscle contraction). No related trauma could be identified in the remaining case.

With contemporary harvesting techniques, it has been postulated that devascularization, an alteration in tendon healing and remodeling, or injury to the remaining tendon at the time of graft harvest or defect closure may be possible causes of this rare complication. In addition, the Marshall/MacIntosh procedure transfers a large portion of the prepatellar retinaculum in continuity with the central third patellar tendon and may cause additional vascular compromise. With respect to defect closure, either excessive tension in the closure causing proximal focal tendon necrosis or iatrogenic tendon shortening and secondary increased insertional shear force may lead to rupture. However, of the cases described, only 4 defects had been closed, 4 had paratenon closure only, and the remaining 8 did not identify closure or otherwise. Thus, whether closure of the defect increases the risk of rupture is unclear. We prefer to loosely close the defect with the knee flexed at 70 degrees and subsequently close the paratenon over the tendon.

In principle the remaining two-thirds of the patellar tendon should be of adequate strength to withstand quadriceps muscle contraction. The general consensus is that a tendon must be compromised either by 50% of its diameter before it will fail under significant loads and 75% before rupture occurs under physiologic loads.[21] Clinically, this appears to be true as patellar tendon ruptures are unusual after harvest of the central third. Of note, we have observed that the affected patellar tendon is universally wider postoperatively than the contralateral tendon, frequently by 20% to 30%.

PREVENTION

Tibial block geometry when harvesting the patellar tendon may affect the tendon's insertional integrity and thus specifically impact the risk of distal rupture. Similar to patellar block creation, we feel that attention to detail may minimize this risk. In fashioning the tibial bone plug, the cortex is scored with an oscillating saw and an equilateral triangle is made on profile with the saw with the blade angled approximately 45 degrees centrally. The triangular profile block is similarly removed with a curved three-eighths inch osteotome. This minimizes bone loss deep to the remaining patellar tendon and should maximize its insertional strength (Fig. 3).

TREATMENT

Early recognition of a postoperative patellar tendon rupture allows primary suture repair through bone holes proximally or distally. In the described cases in the literature,[4,5,10,12,15,16,18,22,23,26,33] this repair technique is commonly reinforced with a temporary McLaughlin-type wire with good results. In contrast to repairs described after patellar tendon rupture in the total knee arthroplasty population,[7,11,17,25,27,28] autograft or allograft tissue supplementation has not been extensively used and results of primary repair are superior in the ACL patient population. Postoperative rehabilitation includes immediate gentle passive range of motion and protected weight bearing in extension. The initial amount of flexion allowed is usually 45 degrees but is also based on an intraoperative assessment of the tension and stability of the repair during passive flexion. Range of motion is slowly progressed at 4 weeks postoperatively and active knee extension begins at 8 weeks postoperatively. The

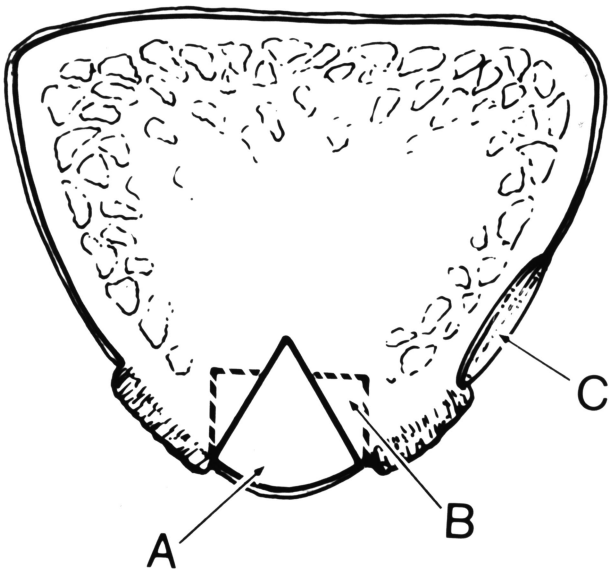

FIG. 3. Illustration of an axial cut depicting the shape of the tibial bone plug. The tibial plug is an equilateral triangle on profile (**A**) because this minimizes bone loss deep to the remaining patellar tendon and maximizes the tendon insertional strength. This is not the case if a rectangular bone plug (**B**) is harvested. The tibial tunnel entrance point is represented by (**C**). (Reprinted with permission from Nogalski MP, Bach BR, Jr. Acute anterior cruciate ligament injuries. In: Fu FH, Harner CD, Vince KG, eds. *Knee Surgery*. Baltimore: Lippincott Williams & Wilkins, 1994:708; Fig. 35.23.).

hinged knee brace is discontinued at 12 weeks postoperatively.

CONCLUSIONS

Macrotraumatic extensor mechanism disruptions are uncommon after ACL reconstruction. However, they are significant complications often requiring surgical intervention. Intraoperative precision when harvesting the patellar tendon, bone grafting the donor sites and implementing contemporary postoperative rehabilitation and bracing protocols may minimize their occurrence.

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