Quadriceps and Patellar Tendon Pie-Crusting as a Treatment for Limited Flexion in Total Knee Arthroplasty

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Abstract

The pie-crusting method of ligament and tendon lengthening has been used successfully in various tissues but is not reported in the literature as an option for patellar or quadriceps tendons to address flexion limitation.

Our case report discusses a patient with longstanding flexion limitation who underwent primary total knee arthroplasty. The report reviews the literature on intraoperative treatments, which primarily pertains to the condition of patella baja, and demonstrates that the pie-crusting technique should be included as a treatment option for a tight extensor mechanism while having some advantages over tibial tubercle osteotomy or Z-plasty.

The extensor mechanism of the knee comprises 5 parts: quadriceps muscles, quadriceps tendon, patella, patellar tendon, and tibial tubercle. Contracture or tightness in the tendons of this mechanism creates a flexion limitation that can limit knee arthroplasty outcomes. There is little available literature describing the intraoperative treatment of a tight extensor mechanism, and it almost exclusively pertains to patella baja.

Patella baja, or infera, is a well-documented condition that causes a tight extensor mechanism and can be encountered in patients that require primary or revision total knee arthroplasty. Patella baja, congenital or acquired, refers to the lowered height of the patella due to pathologic changes in the extensor mechanism. Acquired patella baja is the result of injury or surgery where scarring, adhesion, and contracture of the patellar tendon take place. Untreated, it can lead to detrimental effects in the prosthetic knee including decreased range of motion, impingement, and tendon rupture.[1] Operative treatment during primary or revision arthroplasty includes reestablishing the joint line with distal femoral augments (specifically for pseudo-patella baja), a proximally displaced tibial tubercle osteotomy, patellar tendon lengthening, shaving the anterior portion of the polyethylene, and cephalad placement of the patellar component.[1] Contouring the polyethylene can help prevent impingement of the patella on the prosthesis, especially in deep flexion; however, it will not directly treat patella baja.[2] Likewise, placing the patellar implant in a more cephalad position only slightly corrects the condition and doesn't address a tight extensor mechanism.[3] The literature on tibial tubercle osteotomy and tendon lengthening for patella baja is limited and primarily focuses on surgically acquired patella baja not undergoing arthroplasty.[1,3-8]

In this report, we discuss a patient with longstanding flexion limitation who underwent primary total knee arthroplasty and propose "pie-crusting" as a novel treatment option when encountered during total knee arthroplasty. To the best of our knowledge, this technique has not been demonstrated in the literature; however, due to its success and low complication rate in similarly contracted soft-tissues of the knee, we believe this technique should be considered as a legitimate treatment for flexion limitations due to a tight extensor mechanism.[9,10] The patient provided written informed consent for print and electronic publication of this case report.

Case Report

A 58-year-old woman presented with bilateral knee pain and stiffness. She walked with a rolling walker and a stiff-legged gait at all times. Her medical history included diabetes, obesity, and fibromyalgia. Another orthopedic surgeon had recommended total knee arthroplasty 7 years earlier. Her family history contained several family members undergoing bilateral total knee arthroplasty in their 40s. On physical examination, both knees lacked 5° of full extension and flexed roughly 20° bilaterally. Radiographs were obtained which showed "bone on bone" medial compartment arthritis (**Figures 1-4**).

More than 2 years after initial presentation, left total knee arthroplasty was performed through a medial parapatellar approach. The patella was dislocated and not everted. After freeing the fat pad, quadriceps mechanism, and gutters, the knee could be flexed to 90°, bone cuts were made in the usual manner, and osteophytes were removed. Resecting the posterior cruciate ligament (PCL) added some flexion. The medial collateral ligament (MCL) was judged to be one-fourth its nor-

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Figure 1. Anteroposterior (AP) view of left knee before surgery.

Figure 2. Lateral view of left knee before surgery.

Figure 3. AP view of right knee before surgery.

Figure 4. Lateral view of right knee before surgery.

mal thickness and insufficient; therefore, a semi-constrained prosthesis was placed.

There was also some laxity in extension relative to flexion, and patella baja, so we placed 5 mm distal augments on the femoral component. At the time of trial reduction, the knee could be flexed to 100° with the patella dislocated, but only 45° with the patella in a reduced position due to a tight extensor mechanism. With the knee flexed, our team then performed pie-crusting of the patella tendon. Using a 15 blade scalpel poking straight through the tendon, we made 3 rows of cuts

at staggered levels: 1 row midline, 1 row medial, and 1 row lateral. The longitudinal fibers at the medial and lateral edges of the tendon were not cut. The cuts began just distal to the distal patella and additional cuts in the row were made at approximately 15 mm intervals distally until reaching the insertion of the patellar tendon on the tibial tubercle. Each small cut appeared to gap open approximately 1 mm. The quadriceps tendon was pie-crusted in a similar manner with 3 staggered rows of cuts (**Figures 5, 6**). After pie-crusting, the knee could flex to 100° with some pressure and was limited by posterior adipose tissue. The patient had an uneventful postoperative course, her postoperative protocol was not altered, and she was discharged home on day 3.

Because the patient lived far from the office, she did not return for her initially scheduled postoperative appointment but returned 6 weeks after surgery. Although she had not received the prescribed physical therapy, she did use the continuous passive motion (CPM) machine daily for 2 weeks after discharge. Upon physical examination, she had 0° to 80° of motion compared to 5° to 20° preoperatively. Three months after the operation, she was pleased with the progress of her left knee, and surgery for her right knee was scheduled.

Total knee arthroplasty of the right knee was performed 4 months after the surgery for her left knee. Again, the patella was dislocated rather than everted and scar tissue was released. Unlike the other knee, ligament balancing was relatively straightforward: the PCL was not released and the MCL was in good condition. With the patella dislocated, the knee would flex to 95°. With the patella located, the extensor mechanism was extremely tight in flexion and would cause the tibia to translate anteriorly and the trial implant to slide out anteriorly, and flexion was limited to 45°. The patella and quadriceps tendons were pie-crusted and a quadriceps "snip," at the most proximal point of the quadriceps incision, was performed. The knee would then flex to 90° with the patella located and the tibia would no longer anteriorly subluxate. She was discharged home on postoperative day 3 after an uneventful course (**Figures 7-10**).

The patient returned postoperatively at 1 month; again, she had not been compliant with therapy but had used a CPM machine for 2 weeks after discharge. At that time, active flexion of the right knee was 70°. Therapy was prescribed, but she did not attend therapy or return for her scheduled postoperative visits. When she returned 2 years postoperatively at our request, both knees had 0° to 90° of motion with 5/5 quadriceps strength, and she was very happy with her pain relief and functional improvement.

Discussion

This patient had long-standing stiffness limiting flexion during trial reduction of her primary total knee. Options included no treatment, revising the joint line (despite standard femoral resection), tibial tubercle osteotomy with proximal reattachment, or tendon lengthening. For the first knee, 5 mm distal augments were added to address relative tightness in flexion and to lower the joint line in relation to the patella, yet the knee

Figure 5. Intraoperative photograph of the knee with trial components in place after multiple pie-crust incisions made in the quadriceps and patellar tendons to increase flexion.

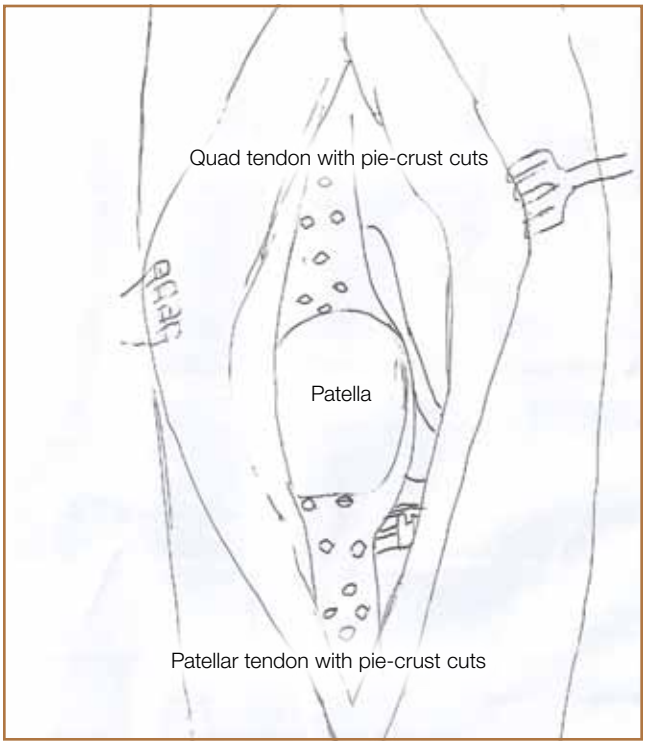

Figure 6. Diagram of the knee with trial components in place with multiple pie-crust incisions made in the quadriceps (quad) and patellar tendons.

Figure 7. AP view of left knee after surgery.

Figure 8. Lateral view of left knee after surgery.

Figure 9. AP view of right knee after surgery.

Figure 10. Lateral view of right knee after surgery.

still had very limited flexion due to the tightness in the extensor mechanism; quadriceps and patellar tendon pie-crusting helped the patient gain flexion. For the second knee, we performed tendon pie-crusting before assessing the tightness in flexion, and distal augments were not necessary.

Most of the literature dealing with patella baja and subsequent flexion limitations sampled patients who were not undergoing arthroplasty. Paulos and colleagues,[4] in a review of 75 cases, recommended open debridement of the patellar tendon and adding a tibial tubercle osteotomy when patella baja

was ≥ 8 mm. All the knees were nonprosthetic and a greater increase in motion than function was noted.[4] Dejour and colleagues[8] reviewed 35 cases that used an extended Z-plasty, which was developed due to disappointment with results of tibial tubercle osteotomies, to lengthen the patellar tendon. The success of the treatment increased with the severity of the condition, and poor results were noted when Z-plasty was used in combination with tibial tubercle osteotomy. Over 25% of the patients had poor functional results, and in moderate cases, results were uncertain.[8] Again, none of these surgeries were on prosthetic knees.

Tibial tubercle osteotomy is a well-known technique to facilitate the approach for difficult knees and allows for positioning the patella in a more proximal position.[11,12] Translation of the tibial tubercle is not often seen in literature reports but is associated with a mean multifactorial gain of 15° in flexion and is used most often in revisions.[12] Complications of this procedure include the following: nonunion (or proximal migration) of the osteotomized fragment, tibial shaft fracture, detachment of patellar tendon from tibial insertion, and prominent hardware.[11,12] Proximal advancement of the tubercle decreases efficiency of the extensor mechanism and has been associated with increased difficulty in kneeling as well as stooping compared with other methods.[3,11] A recent literature review discussing tubercle osteotomy as an approach for total knee arthroplasty classified the technique as relatively safe and reproducible with serious complications arising in 8% to 9% of cases.[13] A quadriceps "snip," which was used in the right knee of our patient, is also useful for exposure and requires no change in postoperative rehabilitation, but it does not correct patella baja.[11,14]

The few studies that mention tendon lengthening as a possible treatment for patella baja are often referring to Z-plasty.[1,3,4,8] Gideroglu and colleagues,[15] in an in vivo study, compared Z, V-Y, and U-T plasties for tendon lengthening. U-T plasty was found to be the easiest to perform, had greater load capacity, and caused fewer adhesions to form. The issue with all 3 techniques was that they were only as strong as the suture technique used to hold the severed parts together. Failure always manifested as loosening or breaking of the sutures.[15] These techniques can limit early range of motion therapy and active extension.

More recently, Farshad and colleagues[16] developed a complex helical cutting technique, demonstrating that maintaining the continuity of the tendon allowed for greater tensile strength, and implied improved healing by not fully disrupting the nutritive paratendon. However, this technique presented its own problems by causing the tendons to become too compliant, and it lacks feasibility in tendons that don't have nearly circular cross-sections.[16] Importantly, it showed that maintaining some tendon continuity likely decreases postoperative failure and immobilization time compared with techniques that completely bisect the tendon.

The pie-crust technique has been used extensively to release tight lateral structures in the valgus knee during total knee arthroplasty.[9] These structures include the lateral collateral ligament, iliotibial band, and arcuate ligament that have become contracted in the arthritic knee due to pathologic changes similar to those seen in tight extensor mechanisms, specifically patella baja.[9,17] The relatively simple technique is best described as a progressive lengthening of structures by use of multiple horizontal stab incisions with a small surgical blade until soft-tissue balance is achieved. Clarke and colleagues[9] reported no failures or instability when pie-crusting was used on lateral structures in 24 mild to moderate valgus deformity patients with posterior stabilized prostheses. Another study followed 53 knees in which pie-crusting had been used to correct moderate to severe valgus deformities with a mean follow-up of 8 years and only recorded 1 case of instability.[10] Furthermore, pie-crusting is frequently used to lengthen the Achilles tendon.[18]

We have some concern regarding the possible downside of this technique in the patellar tendon, because rupture of the tendon would require reconstruction and prolonged immobilization. Also, this patient did not undergo vigorous therapy or exercises that typically are used in this difficult group of patients and that may have put the tendon at greater risk. However, Benner and colleagues[19] reported only 6 patellar tendon ruptures in 2553 patients (0.24%) after harvest of the central third of the patellar tendon for ACL reconstruction, and we feel that pie-crusting poses less of a threat than harvest of the central third. The technique carries very few of the complications of tibial tubercle osteotomy while theoretically retaining a higher tensile strength and improved healing over tendon-lengthening techniques that completely bisect the tendon.[3,9-13,15,16]

The senior author, Dr. Wagner, has used this pie-crusting technique during roughly 20 operative procedures, predominantly in revision total knee arthroplasty with arthrofibrosis, without complication; however, the pie-crusting technique seems to provide more effective tendon lengthening in the more normal tendon that is not overly thickened by scar tissue. It is likely that tibial tubercle osteotomy with proximal translation provides a greater degree of correction, and we recommend this technique for more severe flexion limitation. Several authors have reported that there is a positive correlation of the success of various treatments with the severity of the patella baja.[1,3,4,8] Future research should be aimed at the comparison of treatments for various degrees of flexion limitation during total knee arthroplasty, in large patient numbers, to further assess the safety and efficacy of the procedure.

Conclusion

Pie-crusting of the quadriceps and patellar tendons was quick and easy, allowed standard rehab and strengthening, and was very effective in this patient with a tight extensor mechanism. This technique avoids some of the possible complications of tibial tubercle osteotomy, but it may pose a risk of patellar tendon rupture.

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