Technical Note

Surgical Treatment for Chronic Rupture of the Patellar Tendon Performed in 2 Stages

José Leonardo Rocha de Faria, M.D., Matheus de Barros Carvalho, M.D., André Cavalcante Marques, M.D., Naasson Trindade Cavanellas, M.D., M.Sc., Eduardo Branco de Sousa, M.D., M.Sc., Ph.D., João Mauricio Barretto, M.D., M.Sc., Ph.D., and Alan de Paula Mozella, M.D., M.Sc.

Abstract: Patellar tendon rupture is an uncommon but disabling lesion. It usually occurs in men younger than 40 years, through direct or indirect trauma. Obtaining satisfactory results with treatment of chronic injuries and re-ruptures in which the patella retracts owing to quadriceps contraction is a challenge. This is of major concern especially in cases in which the patella cannot be positioned in its anatomic position when distal traction is performed. In these cases, V-Y stretching of the quadriceps can be performed in an attempt to perform reconstruction in 1 stage. Instead, a 2-stage procedure can be chosen, in which the first stage relies on patellar trans-skeletal traction to achieve distalization of the patella. In 1981, a technique for the treatment of chronic injuries of the patellar tendon in 2 stages was described. In that procedure, the first stage consisted of transpatellar traction and the second stage was tendon-tendon suturing with fascia lata reinforcement. We describe a surgical technique performed in 2 stages; in the first stage, trans-skeletal traction is performed, and in the second stage, the technique of Kelikian et al. with our modification is performed. This technique is used in patients with chronic rupture of the patellar tendon associated with a high patella with nonreducible quadriceps shortening.

The extensor mechanism of the knee is composed primarily of the quadriceps muscle and tendon, the patella, and the patellar tendon. In addition, it has stabilizing ligaments such as the medial and lateral patellofemoral ligaments, patellar reticular fibers, the Hoffa fat pad, and the prepatellar bursa.1,2 Because of its complex anatomy, the extensor mechanism has been the focus of numerous articles trying to better elucidate its structure and function.3-6

The extensor mechanism is largely responsible for knee extension and stability of the patellofemoral joint. Structural or functional changes in this mechanism, whether congenital or traumatic, may lead to failure of such stabilization.7,8 Rupture of the quadriceps tendon, patellar fracture, and patellar tendon injury are the most common traumatic changes that may occur.9

Rupture of the patellar tendon is an uncommon but disabling lesion, usually occurring in men younger than 40 years, through direct or indirect trauma to the knee.10 When indirect, it is the result of a strong eccentric contraction of the quadriceps with the knee flexed around 60° in a fixed position. It is believed that such lesions occur in tendons with previous micro-lesions in the midsubstance.11,12 Bilateral ruptures are rare but are usually associated with diseases such as chronic renal failure, primary hyperparathyroidism, systemic lupus erythematosus, and rheumatoid arthritis.13-15

Rupture is generally followed by severe pain, an inability to stand up without help, and hemarthrosis. On physical examination, patients present with a palpable gap in tendon topography and difficulty in reaching or maintaining knee extension against gravity.
On radiographs of the affected knee, we can observe the presence of patella alta.\textsuperscript{5,11,16} A great variety of techniques have been described for the treatment of acute lesions, presenting good clinical results.\textsuperscript{13,17} Treatment of chronic lesions and re-ruptures, in which the patella retracts owing to quadriceps contraction, when the patella cannot be positioned in its anatomic position, represents a challenge in terms of obtaining satisfactory results.\textsuperscript{18} In these cases, V-Y stretching of the quadriceps can be performed in an attempt to allow reconstruction in 1 stage. An alternative is a 2-stage surgical procedure using patellar trans-skeletal traction in the first stage to achieve distalization of the patella.\textsuperscript{5}

In 1981, Siwek and Rao\textsuperscript{5} described a technique for the treatment of chronic patellar tendon injuries in 2 stages, with the first stage consisting of transpatellar traction and the second stage involving tendon-tendon suture and strengthening with fascia lata; good clinical results were obtained in their series. Garg et al.\textsuperscript{19} published a study in 2012 using 3 methods of surgical treatment for patellar pseudarthrosis associated with proximal retraction of the quadriceps. The best results were found in the group in which patellar trans-skeletal traction was used.

The surgical technique using quadriceps V-Y elongation presents the possibility of loss of the final degrees of knee extension, yielding unsatisfactory clinical results. Moreover, the use of only the fascia lata may not be sufficient for the treatment of chronic lesions and patellar tendon re-ruptures. Thus, we describe a 2-stage surgical technique for the treatment of chronic patellar tendon injuries. This technique is indicated for patients with proximal quadriceps retraction who present with a Caton-Deschamps index, measured on knee radiographs, greater than 2 and in whom the patella does not reduce to its physiological height with digital distal traction (Fig 1). The first surgical stage consists of patellar trans-skeletal traction, and in the second stage, the technique of Kelikian et al.\textsuperscript{20} with our modification is performed.

**Surgical Technique**

**First Stage**

The patient lies in the dorsal decubitus position while under anesthesia. Asepsis is performed with chlorhexidine detergent, and antisepsis, with alcoholic chlorhexidine.

The knee is flexed at 30° with the aid of an image intensifier; a 3.5-mm Steinmann pin with a central thread is passed transversely in the proximal one-third of the patella, from medial to lateral, percutaneously. A stirrup is installed at the 2 ends of the pin, and a trans-skeletal traction device is installed, with 3 kg of traction initially (Fig 2). The patient remains hospitalized with the traction device in the patella, increasing the weight by 0.5 kg/d. Sequential radiologic images with a lateral view of the knee in extension are obtained to estimate distalization of the patella (Fig 3). When we observe that the distance between the anterior tibial tuberosity (ATT) and the distal pole of the patella equals the longest length of the patella, the second surgical stage is performed with reconstruction of the patellar tendon using the technique of Kelikian et al.\textsuperscript{20} with our modification.

**Second Stage**

The patient lies in the dorsal decubitus position while under anesthesia and a femoral nerve block. Asepsis is performed with chlorhexidine detergent, and antisepsis, with alcoholic chlorhexidine.

![Fig 1](image1.png)

(A) Lateral view of left knee with chronic patellar tendon rupture, with great amount of retraction of quadriceps tendon. (B) Anteroposterior view of left knee showing high patella. Dashed red line depicts distance between anterior tibial tuberosity and lower pole of the patella. (C) The Caton-Deschamps index (CD) is 3.07. $L_1$ = patella articular surface. $L_2$ = distance between the lower pole of the patella and upper limit of the tibia.
The Steinmann pin is maintained to facilitate distalization of the patella. We establish longitudinal anterior-medial access, about 10 to 15 cm in length, with extensive exposure of the patellar tendon, patella, and quadriceps tendon.

Initially, the semitendinosus and gracilis tendons are identified, and proximal detachment of the tendons with an open stripper (Arthrex, Naples, FL) is performed. The injured patellar tendon is identified and tagged using a Krackow-type suture with 2 threads of Ethibond (No. 5; Ethicon, Somerville, NJ) in its central portion, leaving 4 equal-length threads. A 4.5-mm cortical tunnel is constructed with a transverse cannula drill, from medial to lateral, in the distal portion of the patella, parallel to the Steinmann pin used for traction. With the 4.5-mm drill bit still inside the patella, 3 parallel longitudinal tunnels are made with Beath pins, leaving a repair wire on the carrying handle at the distal end of each longitudinal drill hole of the patella (Fig 4).

A horizontal bone tunnel in the tibia at the ATT is made with a 6.0-mm cannulated drill. The semitendinosus tendon is transported through the tibial tunnel, ascending to proximal and being passed from lateral to medial in the patellar tunnel, undergoing distalization, and being reinserted into its tibial origin.

Fig 2. (A) Traction pin inserted into proximal third of patella. (B) Intraoperative fluoroscopic image evidencing traction pin inside proximal one-third of patella. (C) Stirrup with traction cable and 3-kg initial weight installed.

Fig 3. (A) Lateral view of left knee on first day of traction. The initial distance between the anterior tibial tuberosity and the inferior pole of the patella (red line) is 7.28 cm. (B) Day 7 of traction. The distance between the anterior tibial tuberosity and the inferior pole of the patella (red line) is 5.23 cm. (C) Day 13 of traction with patella in its physiological position. Red line depicts the distance between the lower pole of the patella and the anterior tibial tuberosity.
Simultaneously, the gracilis tendon is elevated to proximal, is passed from medial to lateral in the patellar tunnel, undergoes distalization, is transported in the tibial tunnel from lateral to medial, and is reinserted together with the semitendinosus tendon at its origin. In fact, we perform the passage of the tendons through the same holes (tibial and patellar) but in opposite directions (Fig 5). To increase fixation and decrease the violin-cord effect of the flexor tendons (in which the tendons become palpable and prominent in the subcutaneous area), medial and lateral fixation with 2 Agrafe 10-mm clamps (Arthrex) is performed. The 4 strands of Ethibond (No. 5) are transported to the proximal pole of the patella and sutured (Fig 6). After
this stage, a 1.2-mm cerclage wire is passed posterior to the quadriceps tendon. The 2 ends of the wire crisscross over the patella and are tensioned. Two twists are then made, and the system with the 2 strands is brought together with the ATT. In this region, a 4.5-mm cortical screw with a washer is introduced, in a perpendicular or oblique direction from distal to proximal to the ATT, and is fixed to the posterior tibial cortex but is left with the neck still protruding. The knee is flexed at 30°, the length of the knee is marked on the wires up to the screw, and 2 more twists are made (Fig 7). The ends of the cerclage wire are enclosed

**Fig 6.** The 4 strands of Ethibond (No. 5) sutured in the patellar tendon are transported to the proximal pole of the patella (A) and sutured (B).

**Fig 7.** (A) The semitendinosus and gracilis tendons, already transported to the bone tunnels, are fixed with 2 Agrafe clamps. The 4 strands of Ethibond (No. 5) have been transported to the proximal pole of the patella and sutured. (B) An interference screw can be used in the tibial tunnel, although this is not mandatory. (C) The cerclage wire is passed posterior to the quadriceps tendon, 2 twists are made, and the distal extremities of the cerclage wire are fixed at the level of the anterior tibial tuberosity with a 4.5-mm cortical screw with a washer. (D) Final aspect of surgical procedure.
Fluoroscopy should always be used to insert the traction pin at the lateral aspect of the patella. A small surgical incision (1 cm) must always be performed for insertion of the traction pin. In the preoperative period, it should be assessed whether distalization of the patella to the physiological position occurs with distal traction, realized with the examiner’s own finger; a lateral radiograph should be obtained with the knee in extension in association with digital distal traction for evaluation. An interference screw can be used in the tibial tunnel to increase tendon fixation.

The surgical incision in which the traction pin presents should always be covered with sterile dressing to avoid infection in the pin track.

The traction pin and 4.5-mm drill should be inserted in the proximal one-third and distal one-third, respectively, and the mid patella in the anterior plane to avoid an anterior cortical fracture or articular fracture of the patella.

Care should be taken when using an interference screw in this region of the tibia because it could cut the graft at the moment of insertion; if used, it must be inserted carefully.

Postoperative Rehabilitation

The patient leaves the operating room using a hard brace. Quadriceps isometry exercises start on the second postoperative day. Use of the hard brace allows the patient to perform full weight bearing. Abductor and adductor isometry exercises are initiated in the second postoperative week. After the third week, we remove the brace, and the passive gain of knee flexion begins, focusing on range of motion between 0° and 45°. After the sixth week, active flexion of the knee is allowed, and the patient can flex the knee up to 90°. After the eighth week, full knee flexion is allowed.

Discussion

Rupture of the patellar tendon when not treated acutely can evolve with proximal retraction of the patella, generating a complication in the treatment of this injury. In a review article on extensor mechanism injuries, Pengas et al.\(^2\) reported unfavorable results for chronic injuries of the patellar tendon, especially those in which the patella would be retracted by the quadriceps to proximal.

In a study evaluating the current evidence on the techniques and results of patellar tendon reconstruction, published in 2015, the authors indicated that for the treatment of chronic lesions, autologous grafts are preferred.\(^22\) To treat chronic patellar tendon injuries associated with significant proximal retraction of the quadriceps, Siwek and Rao\(^5\) described a 2-stage surgical technique using surgical trans-skeletal patellar traction in the first stage to achieve distalization of the patella to its physiological level; the second stage consisted of reconstruction of the patellar tendon using the reinsertion of the patellar tendon as reinforcement and using autologous fascia lata graft, acting as an autologous biological reinforcement of the patellar tendon. In their study, Siwek and Rao described 6 cases of patients who remained in traction for between 4 days and 2 weeks. The results were excellent in 2 patients, good in 3 patients, and insufficient in 1 patient who continued to have an insufficient range of motion and quadriceps atrophy. Isiklar et al.\(^23\) used an Ilizarov external fixator for 4 to 6 weeks to achieve distalization of the patella in a case report of 2 patients and reported good results.

Other authors have defended the treatment of chronic lesions of the patellar tendon in only 1 surgical stage using quadriceps elongation. Mandelbaum et al.\(^24\) described a technique using stretching of the quadriceps tendon and Z-shortening of the patellar tendon, performing reconstruction with reinforcement of the gracilis and semitendinosus tendons.

Temponi et al.\(^25\) reported a cases series of 7 patients in whom a modified Dejour technique was performed using the central third of the contralateral quadriceps tendon. Improvements in the International Knee Documentation Committee score and Lysholm score from 45 to 64.5 and from 45.4 to 79, respectively, were obtained, both of which were statistically significant; none of the patients had a preoperative Caton-Deschamps index greater than 2. In 2018, Samagh et al.\(^26\) published a case report describing a technique for reconstruction of the patellar tendon in patients with chronic injuries. In the patient described, the self-reported Caton-Deschamps index was greater than 1.2 and the injury had occurred 5 months earlier. The authors did not report a large amount of proximal...
retraction of the patella, and they were able to achieve distalization of the patella without quadriceps stretching, describing a reconstruction technique using autologous semitendinosus and gracilis grafts. The grafts are bent multiple times, with the final graft measuring 10 to 12 cm long and 8.5 to 10 mm thick. A 2-cm longitudinal tibial bone tunnel is made at the center of the ATT, and a 2-cm longitudinal bone tunnel is made at the distal pole of the patella; the graft is then centrally positioned on the topography of the patellar tendon, being fixed and tensioned with suspension fixation devices.

Harato et al. described a surgical technique in which they use cannulated screws and polyethylene tape, using a device that, when rotating on itself, shortens the polyethylene tape and thus achieves distalization of the patella; at the same time, they reconstruct the patellar tendon with a Leeds-Keio artificial ligament. According to the authors, the technique should be used in cases in which the patella does not show a great amount of retraction. If a patient presents with chronic and coarse proximal retraction, Harato et al. recommend the use of trans-skeletal traction before performing their technique.

In 2019, we published the case report of a patient with patellar pseudarthrosis with 9 years of evolution, presenting a distance between the fragments of the patella of 9 cm. We performed patellar trans-skeletal traction, decreasing this distance to 1.2 cm, and performed patellar osteosynthesis in a conventional manner, presenting an excellent functional clinical result with an active range of motion of 0° to 90°. The use of our 2-stage technique ensures distalization of the patella with less need for release, quadricepsplasty, or subperiosteal detachment, facilitating the second surgical stage. Pearls and pitfalls of this surgical technique are listed in Table 1, and advantages and disadvantages are shown in Table 2.

Reconstruction of the patellar tendon using the gracilis and semitendinosus passing through the same tunnel in the patella and tibia (at the level of the ATT), associated with reinforcement with cerclage wire, allows early rehabilitation, with a more rapid movement gain. The technique presented for chronic lesions of the patellar tendon in 2 stages using trans-skeletal patellar traction and reconstruction using the technique of Kelikian et al. with our modification is simple, is reproducible, and presents satisfactory clinical results.

Table 2. Advantages and Disadvantages

| Advantage                          | Disadvantage                          |
|------------------------------------|---------------------------------------|
| Preoperative traction period       | A longer hospitalization time is required. |
| Modified technique of Kelikian et al. | Two surgical procedures are necessary. |
| Better fixation of the tendon grafts can be achieved. | There is a risk of patellar fracture. |
| It is possible to achieve distalization of the patella without performing quadricepsplasty or V-Y stretching of the quadriceps tendon. | |

References

1. Capogna B, Strauss E, Konda S, et al. Distal patellar tendon avulsion in association with high-energy trauma: A case series and review of the literature. *Knee* 2017;24:468-476.
2. Pengas IP, Assiotis A, Khan W, et al. Adult native knee extensor mechanism ruptures. *Injury* 2016;47:2065-2070.
3. Ibounig T, Simons TA. Etiology, diagnosis and treatment of tendinous knee extensor mechanism injuries. *Scand J Surg* 2016;105:67-72.
4. McGregory JE. Disruption of the extensor mechanism of the knee. *J Emerg Med* 2003;24:163-168.
5. Siwek CW, Rao JP. Ruptures of the extensor mechanism of the knee joint. *J Bone Joint Surg Am* 1981;63:932-937.
6. Ramsey RH, Muller GE. Quadriceps tendon rupture: A diagnostic trap. *Clin Orthop Relat Res* 1970;70:161-164.
7. Andrikoula S, Tokis A, Vasiliadis HS, et al. The extensor mechanism of the knee joint: An anatomical study. *Knee Surg Sports Traumatol Arthrosc* 2006;14:214-220.
8. Waligora AC, Johanson NA, Hirsch BE. Clinical anatomy of the quadriceps femoris and extensor apparatus of the knee. *Clin Orthop Relat Res* 2009;467:3297-3306.
9. Albuquerque RP, Prado J, Hara R, et al. Epidemiological study on tendon ruptures of the knee extensor mechanism at a level 1 hospital. *Rev Bras Ortop* 2012;47:719-723 [in Spanish].
10. Zernicke RF, Garhammer J, Jobe FW. Human patellar-tendon rupture. *J Bone Joint Surg Am* 1977;59:179-183.
11. Kellersmann R, Blattert TR, Weckbach A. Bilateral patellar tendon rupture without predisposing systemic disease or steroid use: A case report and review of the literature. *Arch Orthop Trauma Surg* 2005;125:127-133.
12. Kelly DW, Carter VS, Jobe FW, Kerlan RK. Patellar and quadriceps tendon ruptures—Jumper’s knee. *Am J Sports Med* 1984;12:375-380.
13. Maffulli N, Wong J. Rupture of the Achilles and patellar tendons. *Clin Sports Med* 2003;22:761-776.
14. Phillips K, Costantino TG. Diagnosis of patellar tendon rupture by emergency ultrasound. J Emerg Med 2014;47:204-206.

15. Chloros GD, Razavi A, Cheatham SA. Complete avulsion of the patellar tendon from the tibial tubercle in an adult without predisposing factors. J Orthop Sci 2014;19:351-353.

16. Grelsamer RP, Meadows S. The modified Insall-Salvati ratio for assessment of patellar height. Clin Orthop Relat Res 1992;(282):170-176.

17. Bhargava SP, Hynes MC, Dowell JK. Traumatic patella tendon rupture: Early mobilisation following surgical repair. Injury 2004;35:76-79.

18. Ecker ML, Lotke PA, Glazer RM. Late reconstruction of the patellar tendon. J Bone Joint Surg Am 1979;61:884-886.

19. Garg P, Satyakam K, Garg A, et al. Patellar nonunions: Comparison of various surgical methods of treatment. Indian J Orthop 2012;46:304-311.

20. Kelikian H, Riashi E, Gleason J. Restoration of quadriceps function in neglected tear of the patellar tendon. Surg Gynecol Obstet 1957;104:200-204.

21. Frutos CFA, Camargo OPA, Severino NR, et al. Protection device on the repair of ruptures of knee extensor mechanism. Rev Bras Ortop 2009;44:57-60 [in Spanish].

22. Gilmore JH, Clayton-Smith ZJ, Aguilar M, et al. Reconstruction techniques and clinical results of patellar tendon ruptures: Evidence today. Knee 2015;22:148-155.

23. Isiklar ZU, Varner KE, Lindsey RW, Bocell JR, Linnter DM. Late reconstruction of patellar ligament ruptures using ilizarov external fixation. Clin Orthop Relat Res 1996;322:174-178.

24. Mandelbaum BR, Bartolozzi A, Carney B. A systematic approach to reconstruction of neglected tears of the patellar tendon: A case report. Clin Orthop Relat Res 1988;235:268-271.

25. Temponi EF, Camelo N, Tuteja S, et al. Reconstruction of chronic patellar tendon rupture with contralateral bone-tendon-bone autograft. Knee Surg Sports Traumatol Arthrose 2017;25:2468-2473.

26. Samagh SP, Huyke FA, Buchler L, et al. Treatment of a neglected patellar tendon rupture with a modified surgical technique: Ipsilateral semitendinosus autograft reconstruction with suture tape augmentation. Case Rep Orthop 2018;2018:2037638.

27. Sanchez G, Ferrari MB, Sanchez A, et al. Proximal patellar tendon repair: Internal brace technique with unicortical buttons and suture tape. Arthrosc Tech 2017;6:e491-e497.

28. Ovigue J, Graveleau N, Bouguennec N, et al. Patellar tendon reconstruction using hamstring tendon and adjustable suspensory cortical fixation. Arthrosc Tech 2019;8:e679-e683.

29. Harato K, Kobayashi S, Udagawa K, et al. Surgical technique to bring down the patellar height and to reconstruct the tendon for chronic patellar tendon rupture. Arthrosc Tech 2017;6:e1897-e1901.

30. Faria JLR, Portella DMS, Titonelli VE, et al. Patellar transskeletal traction for the treatment of chronic patellar pseudoarthrosis. Case Rep Orthop 2019;2019:5915701.