



Revision Patellar Tendon Reconstruction Surgeries With Allograft Achilles: The Codfish Technique

Rodrigo Araujo Goes, M.D., M.Sc., Pedro Alexandre Dias, M.D., M.Sc., Frederico Lage Oliveira, José Rafael Pereira, M.D., M.Sc., Pedro Castelhanito, M.D., M.Sc., Joaquim Soares do Brito, M.D., M.Sc., José Roman Padin, M.D., M.Sc., and José Leonardo Rocha de Faria, M.D., M.Sc., Ph.D.

Abstract: Rupture of the patellar tendon is an uncommon injury that severely compromises knee function, with re-rupture rates varying between 2% and 50% depending on the repair technique. Currently, there is no consensus on the optimal method for revision patellar tendon repair. This Technical Note presents an alternative approach using allograft Achilles tendon augmentation after an initial procedure involving transosseous tunnels with hamstring tendons in the tibia and patella. By using a homologous Achilles tendon graft, this method enhances stability and reduces the risk of re-rupture. Detailed surgical steps and a postoperative rehabilitation protocol are included to optimize patient outcomes, making this a valuable addition to existing surgical approaches for patellar tendon reconstruction.

Patellar tendon ruptures are rare injuries and commonly affect young men between 30 and 40 years of age.¹⁻⁴ The most common location of the tear is close to the tendon's insertion in the patella and less commonly close to the anterior tuberosity of the tibia.⁵ Clinical diagnosis can be made by palpating the gap at the level of the tendon and inability to extend the leg, and radiologically it is possible to confirm the diagnosis by the appearance of a high patella.^{3,4} These are disabling injuries that require early surgical intervention in order to restore knee function.^{2,4-6}

Despite the various techniques described for primary repair of the lesion and/or reconstruction (bone–patellar tendon–bone graft; semitendinosus and gracilis graft, synthetic ligament, and allograft), there is no consensus on which is the best.⁷ The literature reports re-rupture rates ranging from 2% to 50%, depending on the surgical technique used.¹ The authors present a revision surgical technique for reconstruction the patellar tendon using allograft from the Achilles tendon in which transosseous tunnels with ischiotibial allograft are used in the tibia and patella in the initial procedure.

Surgical Technique

Preoperative Evaluation

We use the Caton-Deschamps index to measure the contralateral knee before and after surgery (Fig 1).

Positioning, Assessment Under Anesthesia and Preparation

The patient is anesthetized with spinal anesthesia associated with selective blockade of the adductor canal, positioned in dorsal recumbency, on a conventional table, with a pneumatic tourniquet at the root of the thigh. A padded lateral support and distal support are attached to the operating table to facilitate the positioning of the lower limb when flexed at 30° to 60°. A complete, comparative physical examination is performed for diagnostic confirmation, with

From Centro Hospitalar Universitário Lisboa Norte (CHULN) — Hospital de Santa Maria, Lisboa — Portugal (R.A.G., P.A.D., F.L.O., J.R.Pe., P.C., J.S.d.B., J.R.Pa.); Faculdade de Medicina da Universidade de Lisboa, Lisboa Portugal (R.A.G., J.S.d.B., J.R.Pa.); Divisão de Traumatologia e Ortopedia (DITRO) do Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro — Brasil (R.A.G., J.L.R.d.F.); and Divisão de Ensino e Pesquisa (DIENP) do Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro — Brasil (J.L.R.d.F.).

Received August 2, 2024; accepted October 19, 2024.

Address correspondence to José Leonardo Rocha de Faria, National Institute of Traumatology and Orthopedics of Brazil, 500 Brazil Ave., Rio de Janeiro 20940-070, Brazil. E-mail: drjoseleonardorocha@gmail.com

© 2024 THE AUTHORS. Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/241256

<https://doi.org/10.1016/j.eats.2024.103360>

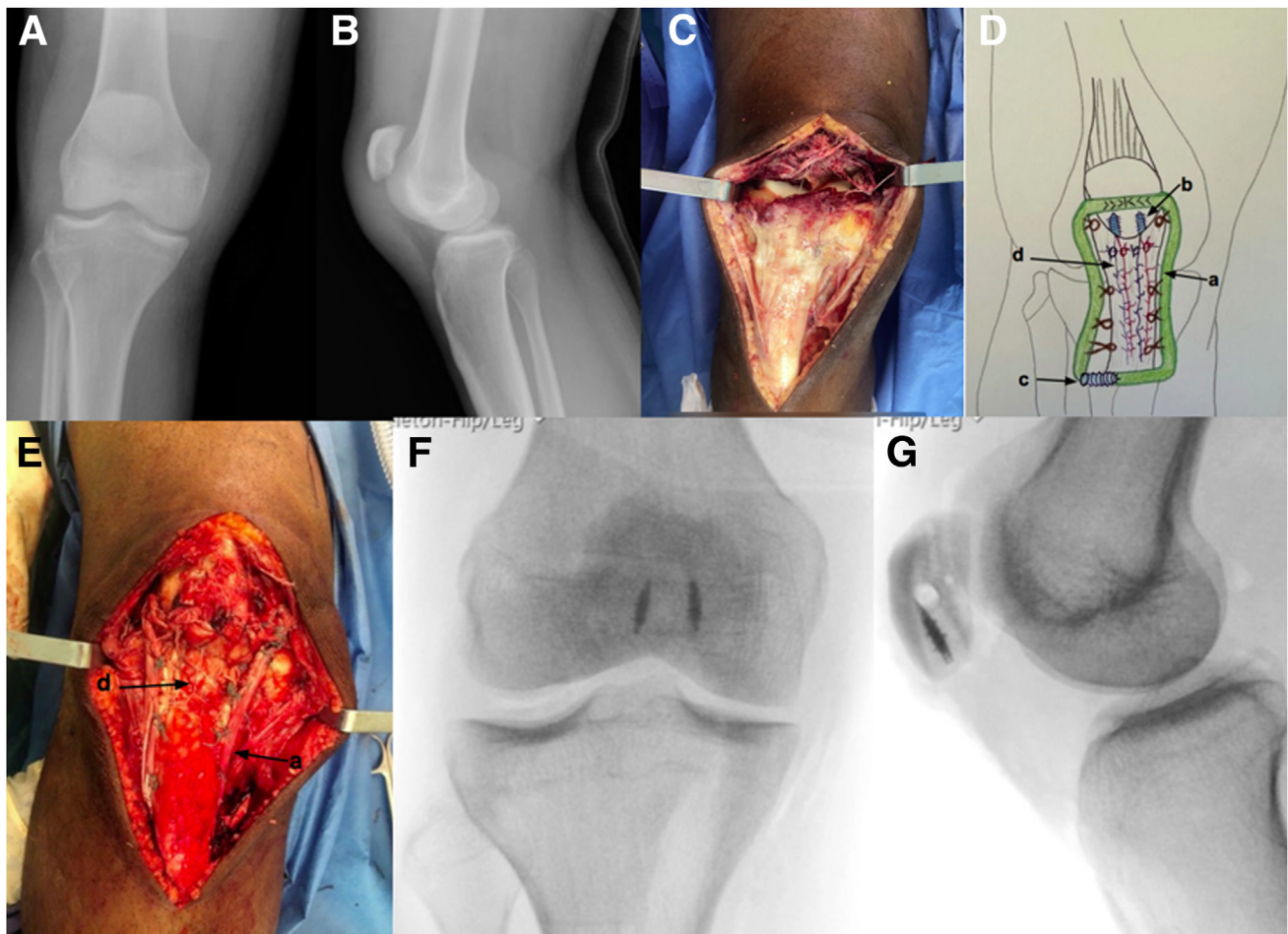


Fig 1. Images from the initial injury and previous surgery on an right knee, which occurred before the current case: AP (A) and lateral (B) views showing the patella alta. (C) Patellar tendon injury and tendon with degenerative changes. (D) Illustration representing the initial technique (a, autologous graft: hamstrings, semitendinosus and gracilis tendons, gathered in an oval figure; b, two 4.5-mm metallic anchors attached to the patella; c, interference screw inside a transverse tibial tunnel, used to secure the graft; d, nonabsorbable sutures attached to metallic anchors). (E) Final intraoperative view. AP (F) and lateral (G) intraoperative views. (AP, anteroposterior.)

visualization and palpation of the infrapatellar gap and the patella alta (Fig 2). Asepsis and antisepsis of the injured limb begins and installation of sterilized surgical drapes.

Preparation of the Homologous Graft

After surgical prepping, the graft is placed in a warm saline solution and laid out in a triangular shape mimicking the form of a dried codfish (Fig 3). It is divided into 3 tendinous parts. Two lateral "strips" with a length of 20 cm each and a diameter of 5 mm, the ends are prepared with a "baseball stitching"-type suture and a central part (Fig 4).

Extensor Apparatus Reconstruction Review

After exsanguination of the limb and with the tourniquet inflated to 150 mm Hg above the patient's

systolic pressure value, an anterior longitudinal incision is performed, from the middle third of the patella to the tibial tuberosity. Debridement of the edges of the lesion is required to properly identify the location of the re-ruptured tendon (Fig 5).

At this time, the previous transverse tunnels are also identified in the patella and in the proximal one third of the tibia. A guidewire is used to identify the patellar and tibial tunnels from the initial surgery and a 5-mm drill to remove the remnants of the tendons. Two 5.5-mm TWINFIX metallic anchors (Smith & Nephew, Andover, MA) are placed, under radiologic control, one lateral and the other intermediate, between the 2 anchors used in the previous procedure (Fig 6). (Tip: before placing the anchors, the 5-mm drill is left in the previous tunnel location in order to confirm the lower limit of the patellar tunnel, so

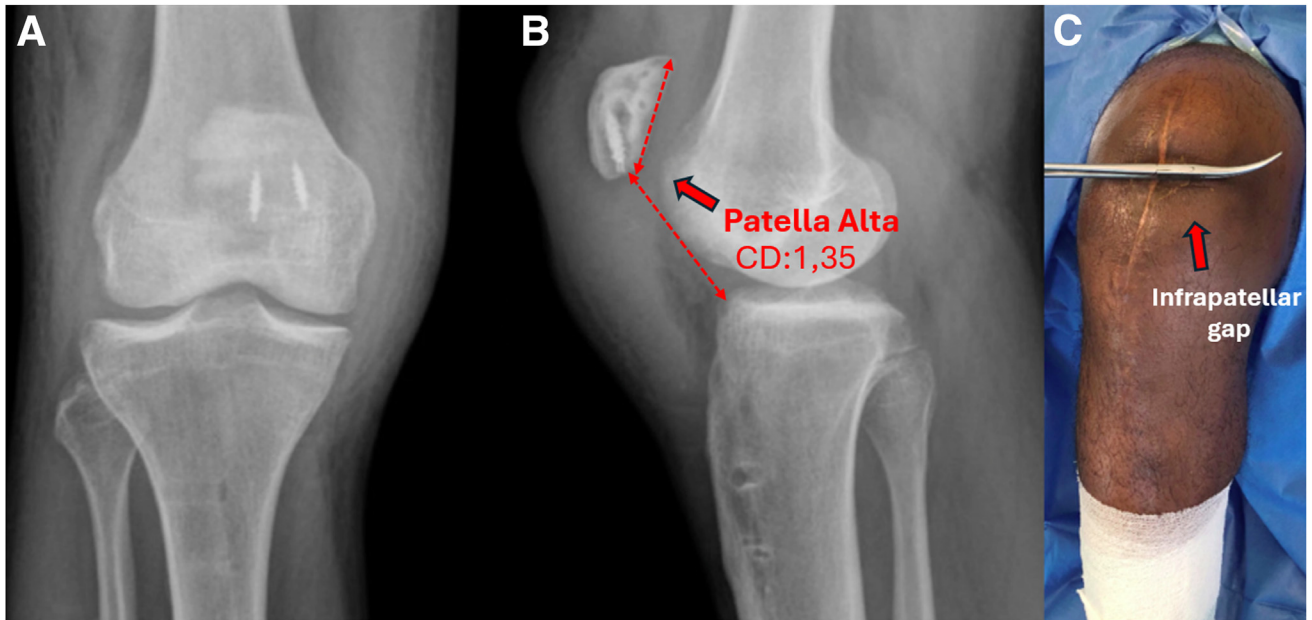


Fig 2. Re-rupture. (A) Anteroposterior view. (B) Lateral view, confirming reconstruction failure and patella alta (red arrow) (Caton-Deschamps [CD]: 1.35). (C) palpation of the infrapatellar gap (red arrow) confirming the second patellar tendon injury.

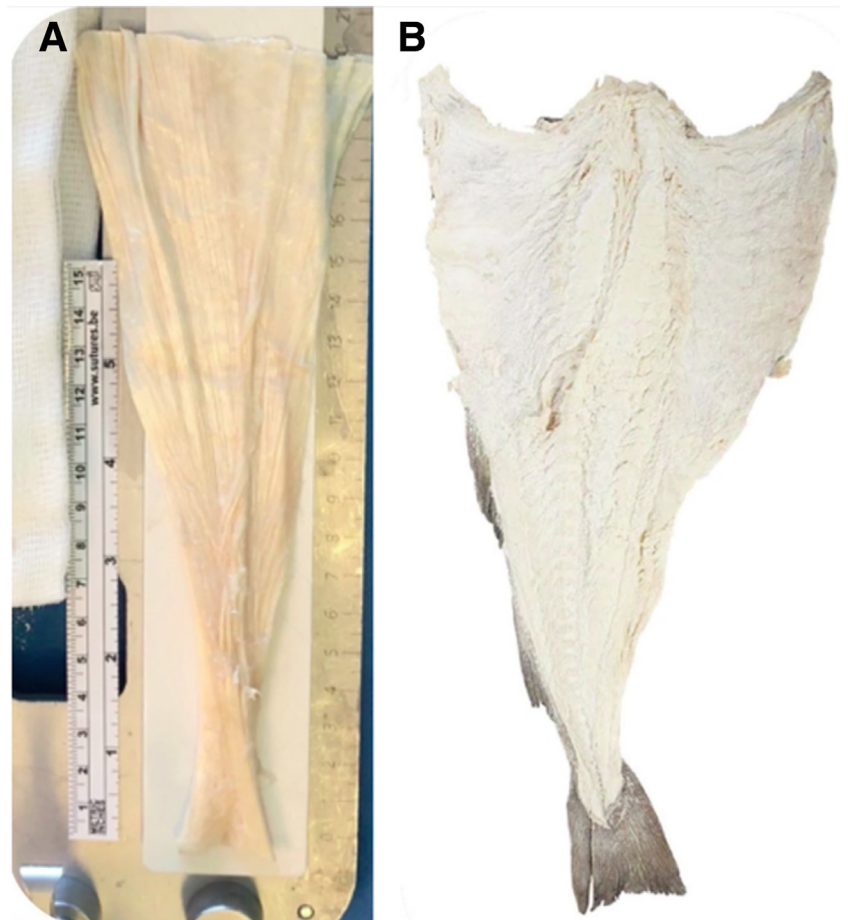


Fig 3. (A) homologous Achilles graft laid out in a triangular shape. (B) The graft mimics the form of a dried codfish.

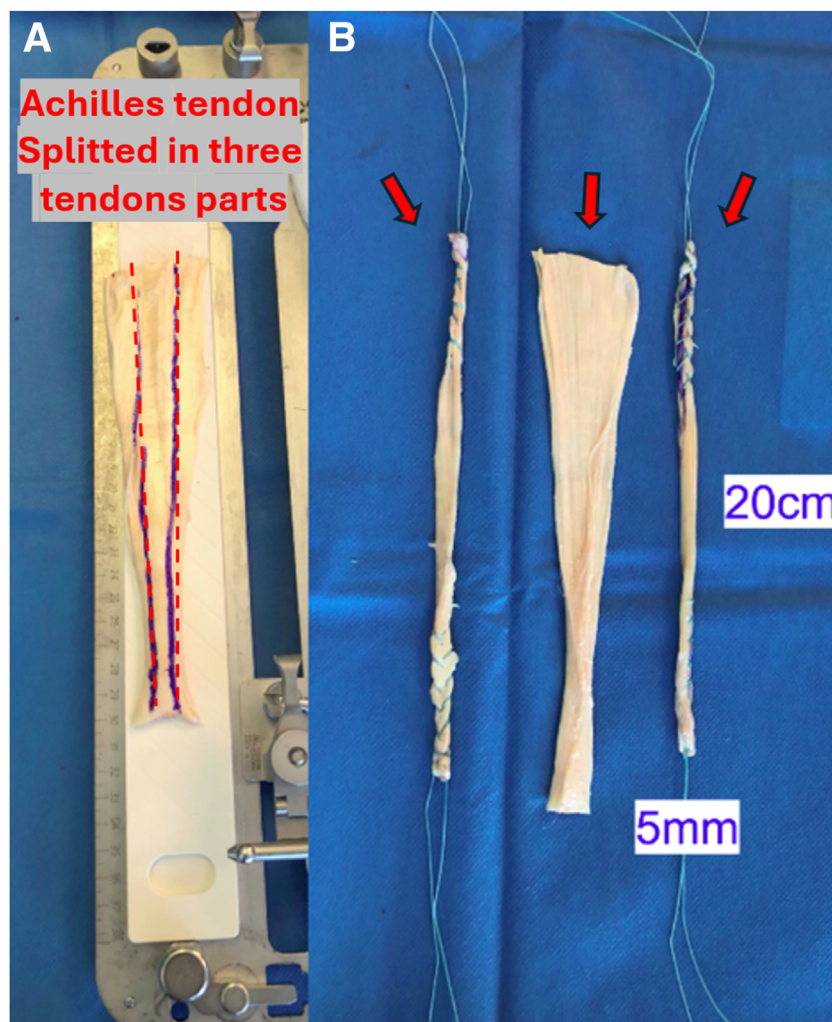


Fig 4. Preparation of the homologous graft of the Achilles tendon. (A) It is divided into 3 tendinous parts (red dotted lines). (B) Two lateral "strips" with a length of 20 cm each and a diameter of 5 mm (red arrows) are shown; the ends are prepared with a "base-ball"-type suture and a central part.

the anchor doesn't penetrate the tunnel.) The stability of the anchors is checked (Fig 7).

Transport sutures are then left behind, one in each tunnel. The wider end of the codfish-type homologous graft is placed over the tibial tuberosity and fixed with 2 braided sutures (Smith & Nephew) for correct positioning. The placement of the nonabsorbable sutures of the anchor, are made in 2 stages, the first being through the patellar tendon in a Krakow type, from proximal to distal and posterior to anterior (Fig 8). (Tip: confirm the type of anchor thread.)

After the first passage of the sutures, the codfish-type homologous graft is then laid on the patellar tendon (Fig 9A) and the second passage of the nonabsorbable anchor sutures is performed. Through the patellar tendon and the graft, Krakow type, from distal to proximal (Fig 9B) Note: Total of 4 suture threads (Fig 9C). The 4 sutures are being pulled at each passage, and the lesion gap is minimized, when

successive suture knots are performed. The knee must be positioned in full extension and neutral rotation.

Passage of Grafts, Fixation, and Protective Cerclage

Each of the lateral "strips" of the homologous tendinous graft is passed through the tibial tunnel with the aid of transport sutures (Fig 10). In the tibial tunnel, an absorbable interference screw (Smith & Nephew), under with a diameter of 7 mm is used. The conventional metal wire of 1.8-mm cerclage, in zero format (so as not to press the codfish graft) is passed through a cannulated screw, in the proximal tibia (tip: to avoid direct contact of the wire with the bone and possible failure of the system) and under the quadriceps tendon (suprapatellar (we did not do it through the patella as it was already weakened by tunnels and 4 anchors), juxtaosseous, at the upper pole of the patella. The 2 "strips" of the grafts are pulled proximally through the patellar tunnel and



Fig 5. Intraoperative confirmation of the rupture and debridement of the lesion edges.

sutured on the contralateral side with nonabsorbable sutures and fixed in the proximal tibia with an interference screw (Fig 11).

The knee must be positioned at 30° flexion and neutral rotation. The codfish graft is secured with nonabsorbable sutures at the patella and quadriceps tendon (Fig 12 A and B). The excess codfish graft is cut. The cerclage wire is pulled and tensioned with the knee positioned at 90° flexion and neutral rotation, serving as a form of protection for the previously performed reconstruction (Fig 13).

The stability of the grafts is tested with flexion-extension range of motion 0° to 90°. Final anteroposterior and lateral radiographs are obtained for confirmation (Fig 14).

Hemostasis is reviewed, the wound is sutured by layers and the skin closed with staples. Occlusive dressing and inguinal-malleolar knee immobilizer as protection is used. Two months after surgery, the cerclage is removed (Fig 15). Eight months after surgery, the patient is fully recovered (Fig 16).

Discussion

The article introduces an alternative approach to address re-rupture of the patellar tendon (Video 1). This technique presents an interesting option for use in revision surgeries of patellar tendon ruptures.

Intrasubstance tendon ruptures are usually treated with primary end-to-tend repair and ruptures near the tendon insertion by the use of nonabsorbable transosseous sutures^{1,8,9} or anchors.^{3,4,6} Up to 50% of primary repairs may fail,¹ and this re-rupture may occur as the result of technical failure, associated with weak vascularization of the tendon subject to high loads,^{1,10} poor tendon quality, or a single event with high load, requiring more advanced repair techniques.¹¹

Ettinger, et al.¹² concluded that anchor repair decreases the gap and increases failure resistance after repetitive cyclic loading. Later, Ode et al.⁹ have proven biomechanically that the use of cortical button is superior to the use of transosseous sutures and anchors. To reduce the risk of re-rupture and allow a faster return to activity with early mobilization, several techniques of reinforcement (augmentation) of the repair have emerged, with grafts of semitendinosus tendon, gracilis, Achilles, or synthetic graft.^{3-6,8,9,11} The use of homologous graft with Achilles tendon showed good results when used as a "salvage" procedure, in particular situations such as chronic tendon ruptures, lack of sufficient tissue for repair or in cases of re-rupture.¹³

Pavão et al.⁵ in 2022, in order to treat a chronic rupture of the patellar tendon, used an autologous graft

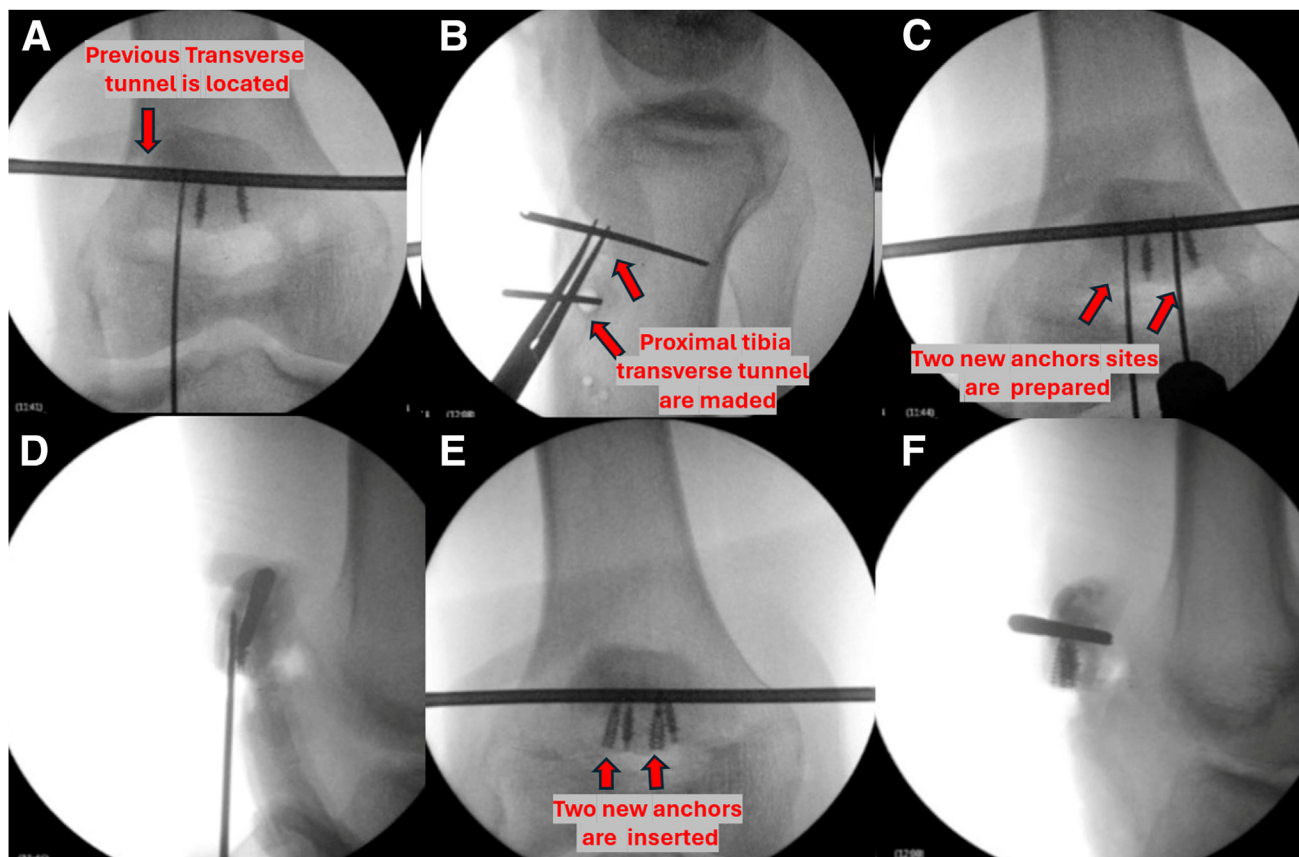


Fig 6. Intraoperative control radiographs. (A) Transverse tunnels from the original surgery are located (red arrow), in the patella and debrided using a cannulated 5-mm drill bit (keeping it in situ to avoid further damage). (B) Proximal tibial transverse tunnel (red arrows). (C) and (D) Two 5.5-mm metallic anchors in the patella, one lateral and another intermediate, between the 2 anchors from the original procedure. Confirmatory AP (E) and lateral (F) radiographs are taken to assess the position of the anchors.

from the semitendinosus tendon passing through a tunnel in the patella and tibia in an X shape. Rocha de Faria et al.¹⁴ modified a technique for treating chronic patellar tendon ruptures with quadriceps tendon shortening, employing skeletal traction in the initial

phase, followed by reinforcement with semitendinosus and gracilis through transosseous tunnels in the patella and tibia. Achilles graft reconstruction is based on the use of an Achilles allograft with preserved calcaneus bone insertion, inserted through an osteostomy into the

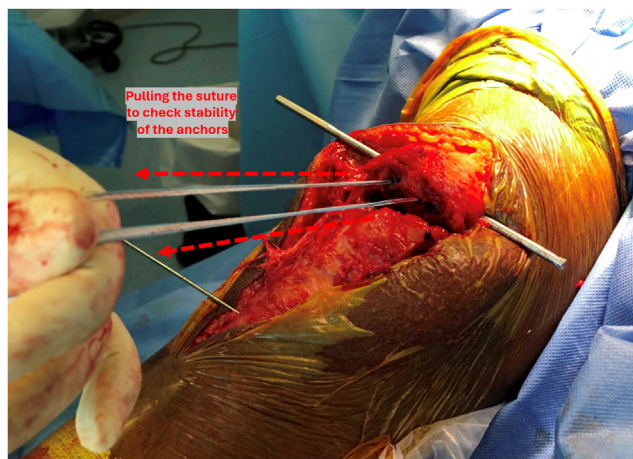


Fig 7. Pulling the suture to check stability of the anchors.

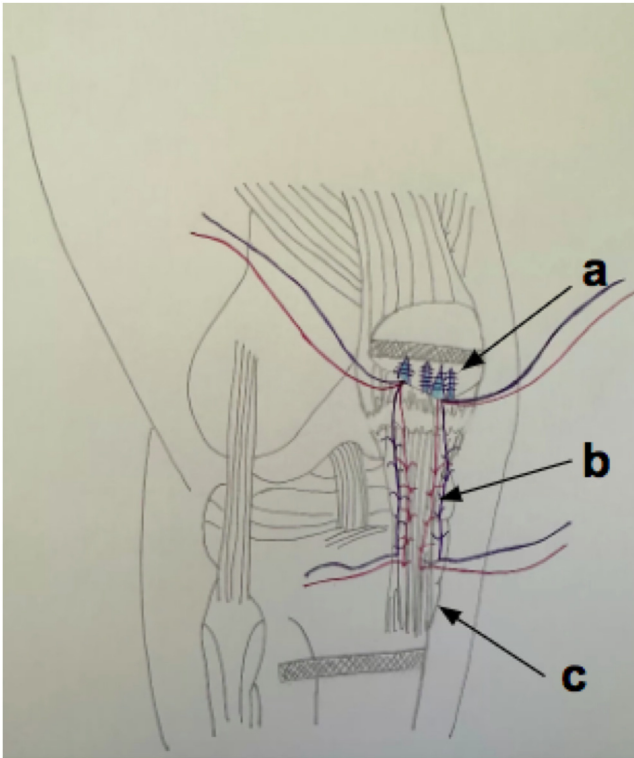


Fig 8. Illustration: placement of the anchors' nonabsorbable sutures: through the original patellar tendon using a Krakow suture, from proximal to distal and posterior to anterior. (a, anchors; b, nonabsorbable sutures; c, patellar tendon).

tibial tuberosity and secured with a screw, the graft is sutured and pulled through longitudinal tunnels in the patella, then it is sutured to the quadriceps tendon and

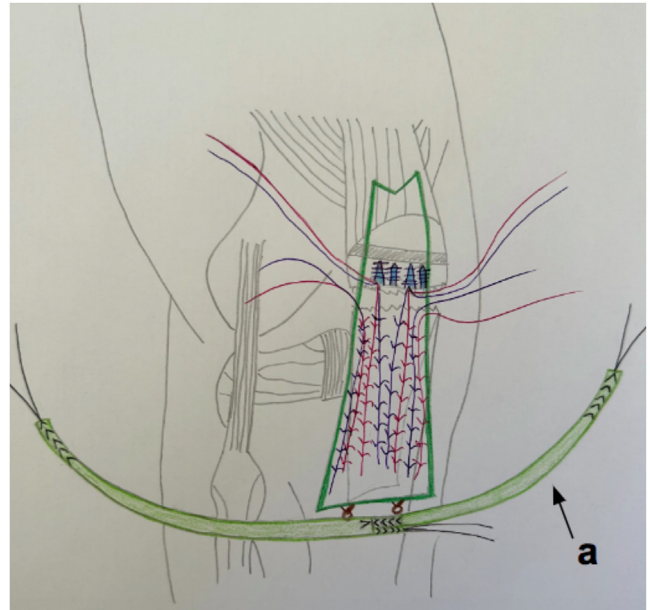


Fig 10. Each of the lateral "strips" of the homologous tendinous graft (a) passing through the tibial tunnel, with the aid of transport sutures.

folded again distally, with the remainder sutured to the native patellar tendon working as a double reconstruction graft.¹³

The surgical technique steps are summarized in Table 1. The advantages and disadvantages of this technique are described in Table 2, and the pearls, pitfalls, risks, and contraindications are reported in Tables 3 and 4. The presented technique offers a

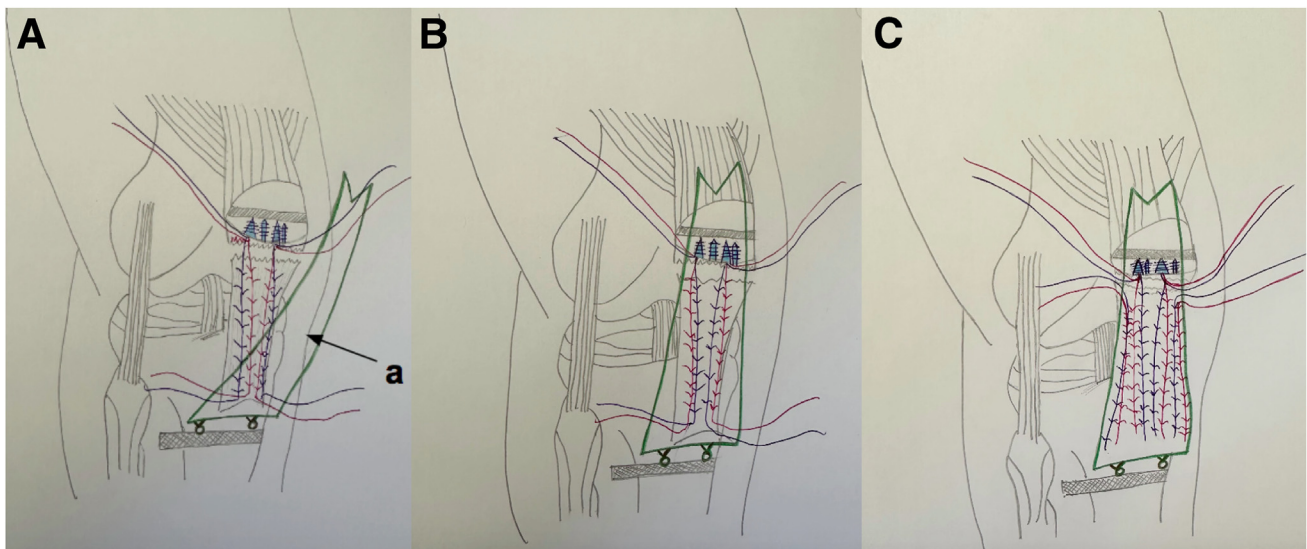


Fig 9. The 3 stages of the Achilles homologous graft. (A) The codfish-type homologous graft is laid on the patellar tendon just proximal to the tibial tuberosity (a, codfish-type homologous graft). (B) Second stage of the placement of the non-absorbable sutures of the anchor: through the patellar tendon and the graft, Krakow suture, from distal to proximal. (C) Final stage: traction is applied to the sutures in order to close the gap between the 2 patellar tendon ends.

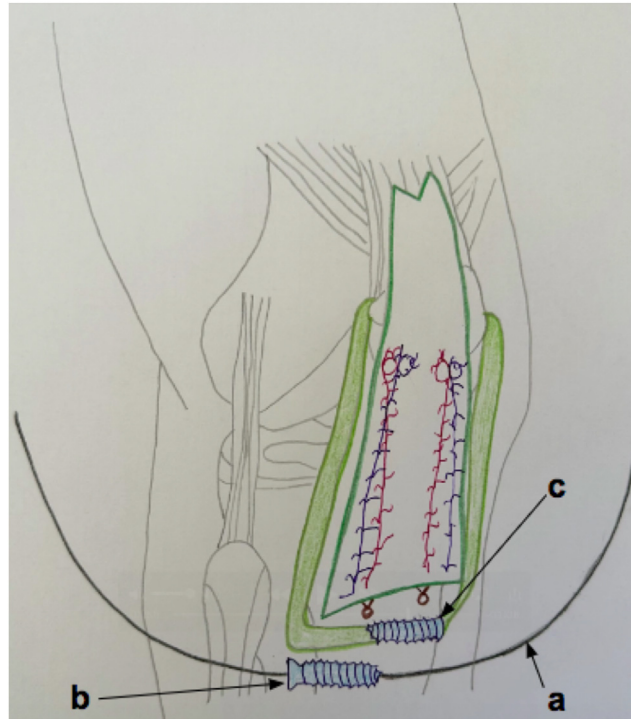


Fig 11. Fixation of the grafts and protective cerclage. Illustration representing the passage of the 2 “strips” of the grafts being pulled proximally through the patellar tunnel and fixation with an interference screw (c) in the proximal. A suture is added to reinforce the entrance of the tunnel. The conventional cerclage wire (a) is passed through a cannulated screw (b), in the proximal tibia.

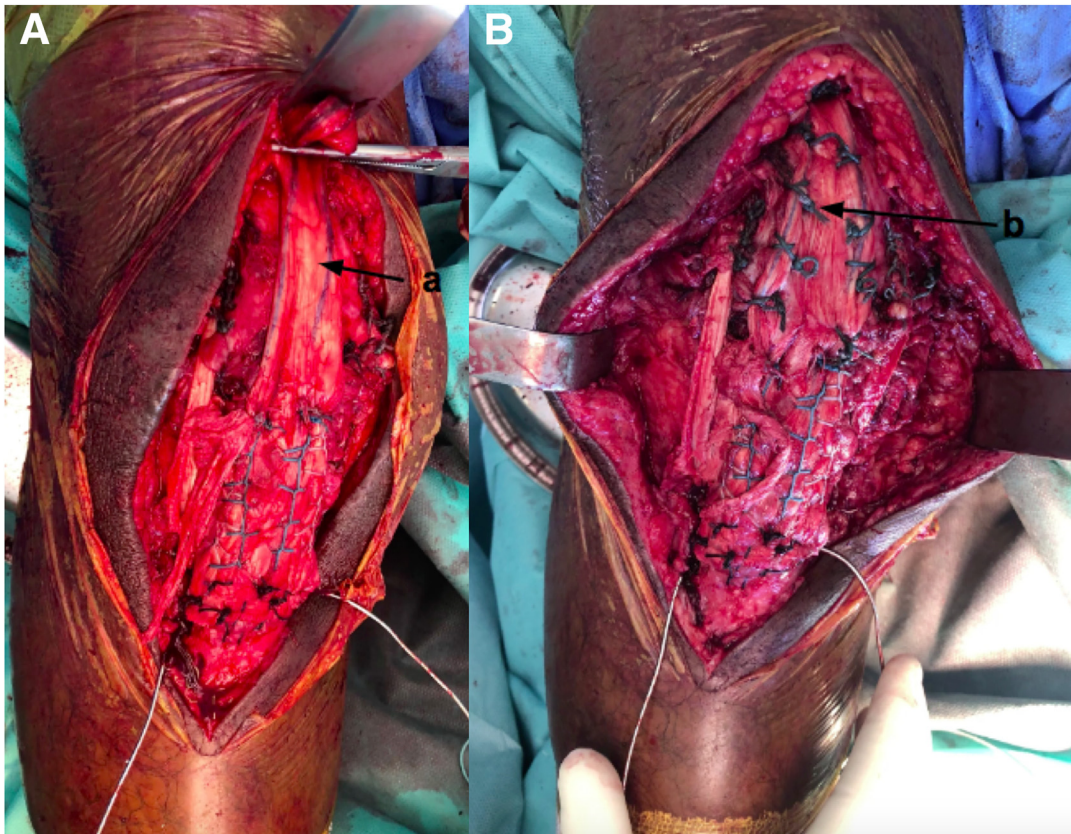


Fig 12. Intraoperative view. (A) The codfish graft is being secured using a nonabsorbable suture to the patella and the remnants of the original quadriceps tendon (a). (B) the excess of the homologous graft covering the quadriceps tendon is secured with nonabsorbable sutures (b). In this stage the cerclage is not yet tightened.

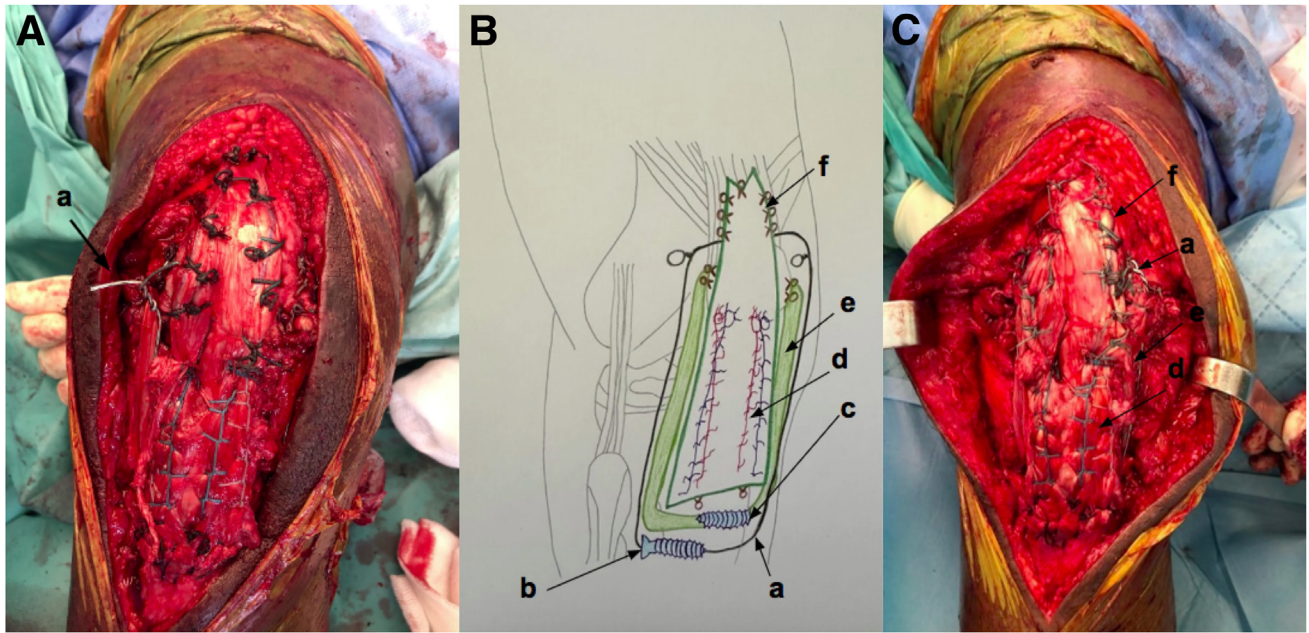


Fig 13. (A) Intraoperative view of the cerclage wire tensioned with the knee positioned at 90° flexion and neutral rotation. Illustration (B) and intraoperative view (C) demonstrating the final assembly (a, cerclage wire; b, cannulated screw; c, interference screw; d, nonabsorbable sutures of the 5.5 mm anchors; e, the 2 lateral "strips" as part of the homologous graft of the Achilles tendon; f, sutures of the homologous graft to the quadriceps tendon).

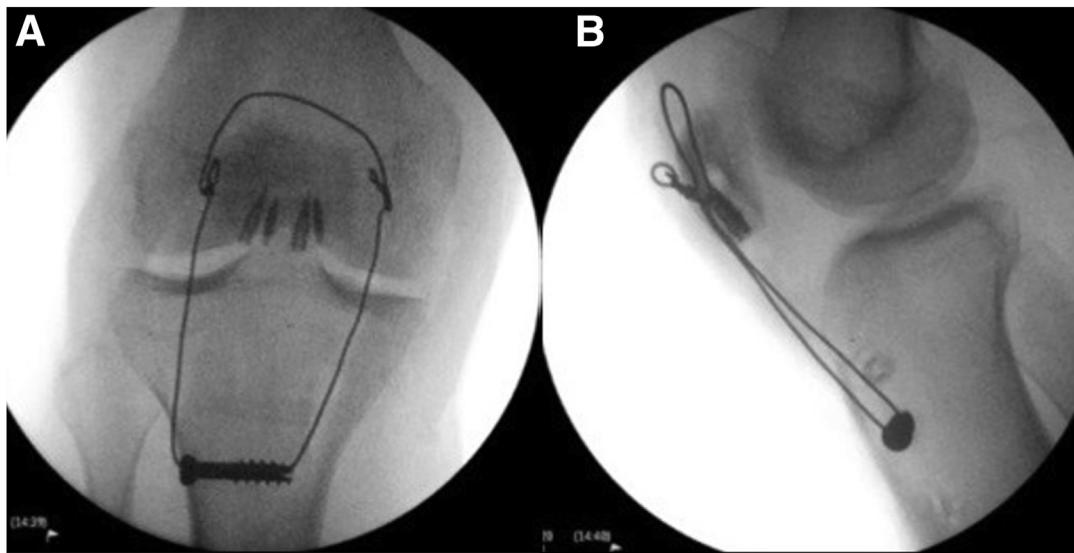


Fig 14. Final intraoperative radiographs of the right knee: AP(A) and lateral (B) views. The patellar height was restored.

promising alternative for treating chronic patellar tendon ruptures, especially in revision cases. By using a homologous Achilles tendon graft, this method enhances stability and reduces the risk of re-rupture. The

detailed surgical steps and postoperative rehabilitation protocol aim to optimize patient outcomes, making this a valuable addition to the existing surgical approaches for patellar tendon reconstruction.



Fig 15. Two months postoperative radiograph of the right knee, anteroposterior view, after the removal of the cerclage wire and cannulated screw.



Fig 16. An 8-month follow-up examination of the right knee. (A) Standing. (B) Full extension of the right knee and extensor apparatus functioning at full strength. (C) Squatting.

Table 1. Step-by-Step Revision Patellar Tendon Technique

Step 1	Measure the Caton-Deschamps index in the contralateral knee pre- and postoperatively.
Step 2	The patient is administered anesthesia and positioned in dorsal recumbency with an inflated pneumatic cuff.
Step 3	Extensive anterior longitudinal incision, from the middle one third of the patella to the tibial tuberosity (TT).
Step 4	Identification of the plans, the tendon re-rupture and the previous transverse tunnels (patella and proximal one third of the tibia).
Step 5	Preparation of the Achilles allograft tendon, divided into 3 parts as 2 lateral "strips" (20 cm each and 5 mm diameter) and a central part (codfish-type).
Step 6	Place two 5.5-mm metallic anchors, under radiologic control.
Step 7	Drill (5 mm) the patellar and tibial tunnels and transport sutures are then left behind, one in each tunnel.
Step 8	The codfish-type graft is placed over the TT and sutured.
Step 9	Passage of the nonabsorbable sutures of the anchor through the patellar tendon, Krakow type, from proximal to distal direction and from posterior to anterior.
Step 10	The codfish-type homologous graft is then laid on the patellar tendon and the second passage of the nonabsorbable anchor sutures is performed: through the patellar tendon and the graft, Krakow type, from distal to proximal.
Step 11	Successive suture knots are performed. The knee must be positioned in full extension and neutral rotation.
Step 12	The anterior borders of the lesion are regularized and sutured.
Step 13	The tendons are passed through the tibial and patellar tunnels, in the shape of a zero, and fixed with an absorbable interference screw (7 mm) into the tibial tunnel.
Step 14	The conventional metal cerclage, in the shape of a zero is passed through a cannulated screw, in the proximal tibia and under the quadriceps tendon.
Step 15	The 2 "strips" of the grafts are pulled proximally through the patellar tunnel and sutured on the contralateral side, with the knee positioned at 30° of flexion and neutral rotation.
Step 16	The codfish graft is sutured at the patella and quadriceps tendon, and the excess codfish graft is cut.
Step 17	The cerclage wire is tractioned and tensioned according to the knee positioned at 90° of flexion and neutral rotation.
Step 18	Stability is tested with flexion-extension 0°-90°, radiographic control, review hemostasis, sutured in layers and the skin closed with staples. Occlusive dressing and inguinal-malleolar knee immobilizer.
Step 19	Two months postoperatively, the cerclage is removed.

Table 2. Advantages and Disadvantages of Revision Patellar Tendon Technique

Advantages
• This technique may be used when there is tissue loss to the native patellar tendon. • Augmenting with Achilles graft enhances the structural integrity since it is biomechanically robust. • There's no need to harvest hamstring tendons if they have already been harvested in a previous surgery. • Use of a limited amount of hardware is necessary for this technique. • This technique can be modified for primary patellar tendon repair. • No age restrictions.
Disadvantages
• Accessing the allograft may pose logistical challenges. • Team proficiency with homologous grafts and experience in transplant centers. • Inserting 2 anchors into the patella requires one of sufficient length and width. • 4- Potential complications include patellar fractures or tibial bone bridge collapse.

Table 3. Pearls and Pitfalls of Revision Patellar Tendon Technique

Pearls
• The Caton-Deschamps index should be measured and recorded before surgery. • It is necessary to perform a careful debridement of any fibrous tissue. • Before placing the anchors, the drill remains in the previous tunnel location in order to confirm the lower limit of the patellar tunnel, so the anchor doesn't penetrate the tunnel. • The cerclage metal wire is passed through a cannulated screw, in the proximal tibia to avoid direct contact with the bone and possible failure of the system.
Pitfalls
• Failing to carefully measure the graft for the correct height may result in insufficient tissue to tension the assembly adequately. • Failure to drill the previous tunnels may make it difficult for the graft to pass through. • Risk of fracture while drilling through the tunnels. • Risk of patellar cartilage injury. • Risk of re-rupture of the patellar tendon and the codfish allograft. • Risk of interference of patellar tunnel with anchors. • Risk of absorption of Achilles allograft. • Risk of suture failure.

Table 4. Contraindications of Revision Patellar Tendon Technique

Contraindications

- History of infection at the surgical site.
- Presence of extensive scar tissue or adhesions making surgical access difficult.
- Noncompliance with postoperative recommendations.
- Nonavailable homologous graft.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J.L.R.d.F. reports consulting or advisory, speaking and lecture fees, and travel reimbursement from Sintegra Surgical Sciences and editorial boards, RBO. All other author (R.A.G., P.A.D., F.L.O., J.R.Pe., P.C., J.S.d.B., J.R.Pa.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Haber D, Ruzbarsky J, Arner J, et al. Revision patellar tendon repair with anchors, allograft augmentation, and suspensory fixation. *Arthrosc Tech* 2020;9:e1845-e1849.
2. Nguyen M, Hsu W. Performance-based outcomes following patellar tendon repair in professional athletes. *Phys Sportsmed* 2020;48:110-115.
3. Pengasa I, Assiotisb A, Khanc W, et al. Adult native knee extensor mechanism rupture. *Injury* 2016;47:2065-2070.
4. Saragaglia D, Pison A, Duval Rubens-. Acute and old ruptures of the extensor apparatus of the knee in adults (excluding knee replacement). *Orthop Traumatol Surg Res* 2013;99:S67-S76 (suppl 1).
5. Pavão D, Vivacqua T, Werneck F, et al. Treatment of distal patellar tendon chronic rupture: The X-wave technique. *Arthrosc Tech* 2022;11:e1373-e1380.
6. Strother C, LaPrade M, Lucas K, et al. A strategy for repair, augmentation, and reconstruction of knee extensor mechanism disruption—a retrospective review. *Orthop J Sports Med* 2021;18:23259671211046625.
7. Ovigie J, Graveleau N, Bouguennec N. Patellar tendon reconstruction using hamstring tendon and adjustable suspensory cortical fixation. *Arthrosc Tech* 2019;8:e679-e683.
8. Black J, Ricci W, Gardner M, et al. Novel augmentation technique for patellar tendon repair improves strength and decreases gap formation: A cadaveric study. *Clin Orthop Relat Res* 2016;474:2611-2618.
9. Ode G, Piasecki D, Habet N, et al. Cortical button fixation a better patellar tendon repair? *Am J Sports Med* 2016;44:2622-2628.
10. Sanchez G, Ferrari M, Sanchez A, et al. Proximal patellar tendon repair: Internal brace technique with unicortical buttons and suture tape. *Arthrosc Tech* 2017;6:e491-e497.
11. Moretti L, Vicenti G, Abate A, Pesce V, et al. Patellar tendon rerupture in a footballer: Our personal surgical technique and review of the literature. *Injury* 2014;45:452-456.
12. Max Ettinger M, Dratzidis A, Hurschler C, et al. Biomechanical properties of suture anchor repair compared with transosseous sutures in patellar tendon ruptures—a cadaveric study. *J Knee Surg* 2019;32:825-832.
13. Karas V, Sherman S, Hussey K, et al. Allograft reconstruction for extensor mechanism injuries. *J Bone Joint Surg Am* 2015;97:279-283.
14. Rocha de Faria JL, Carvalho M, Marques A, et al. Surgical treatment for chronic rupture of the patellar tendon performed in 2 stages. *Arthrosc Tech* 2020;9:e159-e166.