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Surgical repair of chronic patellar tendon rupture in total knee replacement with ipsilateral hamstring tendons

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Abstract
Purpose Patellar tendon rupture is a serious complication of total knee arthroplasty (TKA). Its reconstruction in patients with chronic ruptures is technically demanding. This article reports the results of surgical reconstruction of neglected patellar tendon rupture in TKA using autologous hamstring tendons.
Methods Nine TKA patients (six women and three men) (mean age at index surgery 68 years) with chronic patellar tendon tears underwent reconstruction with ipsilateral hamstrings tendon, leaving the distal insertion in situ. The clinical diagnosis was supported by imaging (anterior–posterior and 30° flexion lateral radiographs). Insall–Salvati index, range of motion, and leg extension test were recorded preoperatively and at last follow-up. The modified Cincinnati rating system and the Kujala score were administered. The patients sustained the patellar tendon tear an average of 8 weeks before the procedure.
Results At final follow-up of 4 years (range 2–8 years), the median of extension lag was 5° (range 0°–15°; DS = 5). The median of post-operative Insall–Salvati index was 1.4 (range 1.3–1.8; SD = 0.15; $p = 0.002$) compared to the preoperative index of 1.7 (range 1.5–2.2; SD = 0.23). The mean modified Cincinnati and Kujala scores significantly increased compared with the preoperative ones ($p < 0.01$). At final follow-up, all patients were able to walk without brace or aids, and they were satisfied with the procedure.
Conclusion Based on our retrospective study of nine patients, reconstruction of neglected patellar tendon rupture in TKA with autologous hamstring tendons is feasible and safe, and provides good functional recovery.
Level of evidence Case series, Level IV.

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Keywords Patellar tendon rupture · Extensor mechanism insufficiency · Hamstring tendon autograft reconstruction · Chronic rupture · Total knee arthroplasty

Introduction

Extensor mechanism disruption after a total knee arthroplasty (TKA) is uncommon, ranging from 0.17 to 2.5 % [1, 30, 38, 41]. A tendon tear can occur during TKA, in the immediate post-operative period, or later. The aetiology is complex and multifactorial, and the risk factors include prior knee procedures, surgical technique, and prosthetic design.

Patellar tendon rupture is a devastating complication, and its management challenging: The patella retracts by 2 weeks, and the status of the surrounding soft tissues makes primary repair increasingly more difficult [8]. Also, surgeons may have to deal with bone loss, stiffness, scars from previous surgery, and infection. Primary repair is a suitable option for acute or partial tendon ruptures, but poor results have been reported in chronic tendon injuries [36]. Tendon augmentations strengthen the construct and allow earlier motion. Autologous semitendinosus and gracilis tendon grafts [3, 6], contralateral bone–patellar tendon–bone [32], medial gastrocnemius transposition with partial achilles tendon transfer [9], reconstruction with extensor allograft [28, 39], Achilles tendon allograft [10], and synthetic sutures [21] have also been used. However, given the lack of prospective randomized trial and the small size of published studies, a gold standard procedure is still lacking.

The present investigation reports that the results of a retrospective study documenting the functional outcomes of nine patients who underwent autologous ipsilateral hamstring tendon graft reconstruction of chronic patellar tendon ruptures after TKA have been reported. The hypothesis was that this procedure provides a strong reconstruction respecting the native tissues, without any additional surgery for hardware removal, allowing early mobilization and a high rate of return to pre-injury activities.

Materials and methods

We reviewed retrospectively the data on nine patients (six men, three women) who underwent autologous ipsilateral hamstring tendon graft reconstruction of chronic ruptures to the patellar tendon after TKA, in the period 2002–2011 years. All ruptures occurred after the primary surgery. Both surgical and study procedures were performed after the patients had signed a written consent and after approval by the local Internal Review Board (IRB—San Camillo-Forlanini Hospital, Rome).

Inclusion and exclusion criteria

Inclusion criteria were clinical and imaging evidence of post-traumatic patella tendon rupture greater than 6 weeks in patients with TKA. Exclusion criteria were secondary co-morbidities predisposing to tendon rupture such as chronic renal failure, rheumatological and endocrine disorders, osteoporosis, and diabetes. We excluded six patients with chronic patellar tendon rupture from our cohort (three patients with rheumatoid arthritis, two with diabetes mellitus, and one with chronic renal failure).

Patient characteristics

The mean age of patients was 68 years (range 63–74 years). Patients sustained the patellar tendon tear 8 ± 3 weeks before the procedure (range 6–13 weeks). The last follow-up was at an average of 4 ± 3 years (range 2–8 years, SD 3.6) from the index surgery. None of the patients had a history of previous patellar tendon rupture before the index injury, and no patient received previous reconstruction.

The primary TKA surgery was performed by different surgeons. All patients showed an anterior longitudinal scar, and the standard medial parapatellar approach had been used. No patellar replacement had been performed. All patients received the same post-operative rehabilitation programme. Continuous passive knee motion was begun the day after surgery. Mobilization with crutches and isometric exercises were initiated in the second post-operative day. None of the patients did report any post-operative complications.

Patient assessment

All patients were secondary and tertiary referrals to the senior author (NM) who performed all clinical examinations. Patients presented quadriceps wasting, and a palpable gap without any tension below the patella. Measurement of the range of motion (ROM) of the knee was undertaken with patients positioned supine on an examining table using a standard universal goniometer with scales marked in 1° increments according to the recommendation of the American Academy of Orthopaedic Surgeons [4]. All patients underwent standard weight-bearing anterior–posterior and lateral radiographs confirmed the high position of the patella (Fig. 1), and the Insall–Salvati index [23] was measured on 30° flexion lateral plain radiographs. The results of the leg extension test were recorded [20]. The modified Cincinnati rating system [29] and the Kujala [27] score were also administered.

Surgical technique

Under general anaesthesia and with the patient supine, the knee was prepped and draped in the usual sterile fashion.

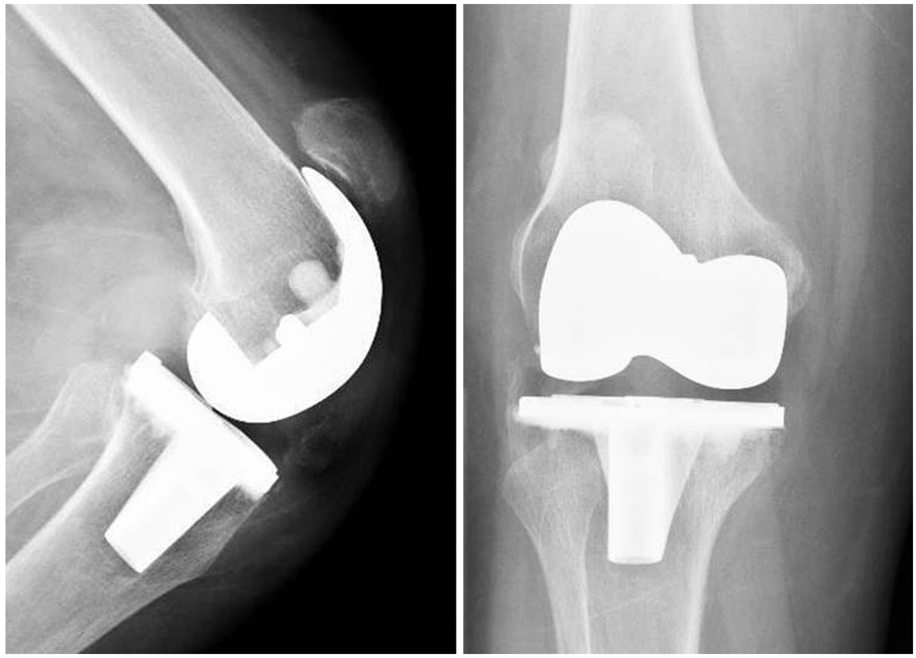

Fig. 1 Preoperative radiographs

We used the original TKA incision to expose the patella and the torn patellar tendon. With the knee flexed to 90°, we proceeded to remove the surrounding fibrotic and scar tissues. Then, through the same incision, we proceeded to dissect the fascia and identify the pes anserinus. The tendons of gracilis and semitendinosus were freed of surrounding tissues and vincula. They were harvested using a tendon stripper and taking care to follow the anatomical course of the tendons. Once the proximal tendon edge had been harvested, the proximal ends were prepared using Number 1 Vicryl (Ethicon, Edinburgh, Scotland) whip stitches. The tendons were not detached from the tibia (Fig. 2). With the knee extended, the patella was mobilized. A transverse tunnel in the mid portion of the patella with a cannulated burr over a Kirschner wire was drilled, and another transverse tunnel was drilled 2 cm posterior to the tibial tuberosity. Both tunnels were drilled lateral to medial, and they were usually 7 mm of diameter. A guide wire and a suture were used to pass the tendon graft through the patellar tunnel from lateral to medial (Fig. 3). The graft was crossed over in a figure of eight fashion, the graft was passed in the same way through the tunnel behind the tibial tuberosity. Traction was applied to the patella to try and relocate it as close as possible to its physiological position, without attempting to release the quadriceps tendon or further dissect the peri-patellar tissues. The graft was sutured to the patella tunnel exit holes with absorbable tendon to periosteum sutures, and a bio-absorbable 7-mm-diameter interference screw was used in the tibial tunnel (Fig. 4). The subcutaneous fat was juxtaposed using fine absorbable sutures, and the skin closed with subcuticular absorbable sutures.

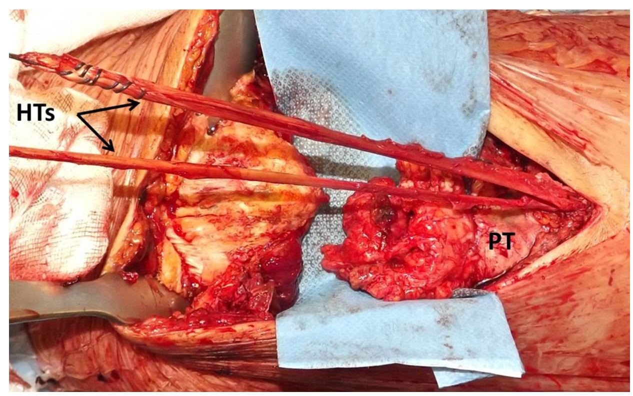

Fig. 2 Hamstring tendons are harvested, living their tibial insertion in situ. *HTs* hamstring tendons, *PT* patellar tendon

Post-operatively, all patients underwent standard plain anterior–posterior and lateral radiographs while supine (Fig. 5). The leg was immobilized in full extension using a synthetic cylinder cast. All patients received intravenous controlled analgesia for 48 h after surgery [19].

Post-operative rehabilitation

Post-operative mobilization with crutches was initiated as soon as possible, and weight-bearing allowed as tolerated. Active ankle flexion–extension mobilization was started immediately. Isometric exercises of the quadriceps muscles were encouraged as soon as patients could tolerate them. The cast was removed at 2 weeks from surgery, and a removable splint was applied for another 2 weeks. Active mobilization

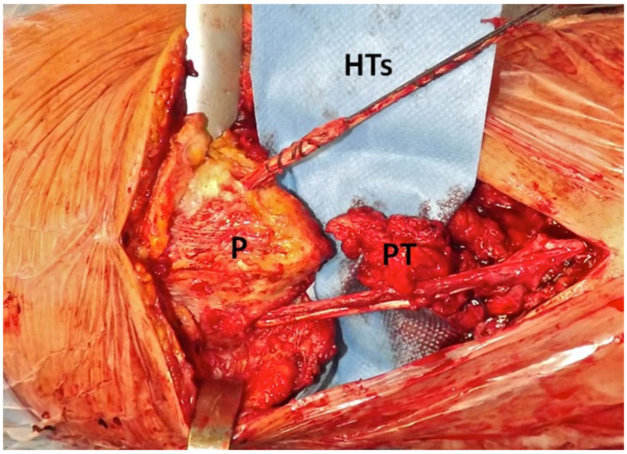

Fig. 3 Tendon graft is passed through the patellar tunnel. *P* patella, *PT* patellar tendon, *HTs* hamstring tendons

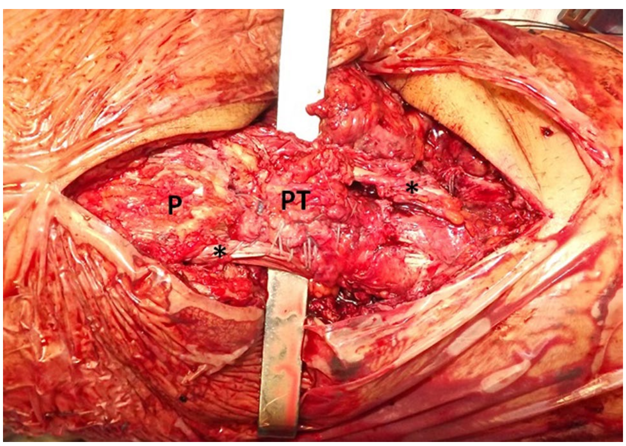

Fig. 4 Graft is crossed over the patella in a figure of eight fashion, and then fixed into the tunnel behind the tibial tuberosity with bioabsorbable 7-mm-diameter interference screw. Traction is applied to the patella to juxtapose tendons stumps. Patellar tendon is sutured, and the graft is sutured to the patella tunnel exit holes with absorbable tendon to periosteum sutures. *PT* patellar tendon, *P* patella, *hamstring tendons

of the knee was started at 4 weeks post-surgery. At 6 weeks, if full active and passive motion were possible, patients started concentric exercises, and continued for 12 weeks.

Follow-up

All patients were followed up post-operatively at 2, 4, 8, 12, and 24 weeks, and then annually. Anteroposterior and lateral radiographs were taken at 4, 12, and 24 weeks, and then annually. At the last examination, the modified Cincinnati rating system and the Kujala score were administered.

We asked patients whether they had returned to working or ordinary daily activities, and to define the satisfaction for the surgical procedure with a self-reported four-stage scoring system classifying their status as very satisfactory, satisfactory, moderately satisfactory, or unsatisfactory.

Statistical analysis

Descriptive statistics are presented as mean (±SD). Student's *t* test for independent samples was used to detect for differences between baseline and follow-up for each variable. We calculated total sample size with G-Power 3.1.3 [18]. When considering the main factors of the present study, a sample size of five showed to be appropriate for a statistical power greater than 0.95. To assess reliability and variability of the measures, we calculated coefficient of variation (CV = SD/mean %). The distribution of the data was assessed with the Kolmogorov–Smirnov test. The statistical significance of improvement between preoperative and post-operative Cincinnati and Kujala scores were tested using the Wilcoxon signed rank test. A p value <0.05 was considered to be statistically significant. Statistical analysis was performed by using SigmaPlot 11.0 software (Systat Software, Tulsa, OK, USA).

Results

Surgical findings

A complete tear of the patellar tendon was found in all patients. The tear occurred in the midsubstance of the patellar tendon in four patients and at the inferior pole of the patella in five patients.

Clinical and functional assessment

Preoperative plain radiographs showed a high riding patella in all patients, and the median of preoperative Insall–Salvati index was 1.7 (range 1.5–2.2; SD = 0.2; CV = 13.24). Passive ROM was at least 115° in all patients, but no patient could fully extend the affected knee actively. The median of preoperative knee active flexion was 105° (range 100°–120°; SD = 6.61; CV = 6.30), and the median of preoperative extension lag was 25° (range 15°–40°; SD = 9.05; CV = 32.59).

At final follow-up, the Insall–Salvati index decreased to a median of 1.4 (range 1.3–1.8; SD = 0.15 CV = 11.01, $p = 0.002$). The median of knee flexion was 100° (range 95°–120°; SD = 8.41; CV = 8.20), and the median of leg extension decreased to 5° (range 0°–15°; DS = 5; CV = 100). Three patients showed no evidence of extensor lag at the last follow-up. The median modified Cincinnati score increased from 42 (range 30–52; SD = 6.7; CV = 16.49) at baseline to 76 (range 64–84; SD = 6.08;

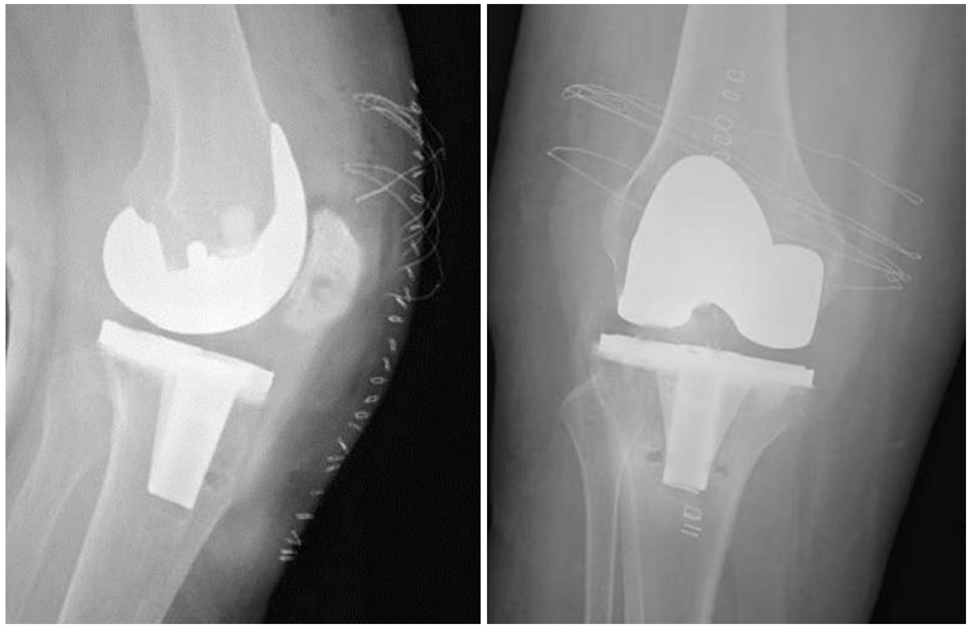

Fig. 5 Post-operative radiographs

CV = 7.93, $p = 0.0001$) post-operatively. The median preoperative Kujala score was 37 (range 30–49; SD = 6.8; CV = 17.41) and increased to 67 (range 61–80; SD = 5.6; CV = 8.25; $p = 0.0015$) at final follow-up.

Return to daily activity and satisfaction

All patients had returned to ordinary daily and working activities. None of the patients perceived the loss of knee flexion at the latest follow-up as interfering with their activities of daily living.

Five patients walked without aids, four with a cane, and no patients walked with crutches. No patients used a brace, and they were all able to ascend and descend stairs without problem.

Four patients were very satisfied with the procedure, three satisfied, and two moderately satisfied. No patient was unsatisfied.

Complications

Two patients reported preoperatively hypoesthesia on the lateral side of the patella tendon and the tibial tuberosity, which was still detectable at final follow-up with no inconvenience for patients. Four patients developed hypoesthesia in the same area after surgery, which resolved in two patients over the course of the post-operative follow-up. Three patients reported anterior knee pain which resolved by 6 months after surgery with physiotherapy. We did not experience any patellar or tibial tuberosity fractures, patellar tendon re-ruptures, or post-operative infections.

Discussion

The main finding of the present study is that chronic tears of the patellar tendons following TKA can safely and reliably be reconstructed using autologous ipsilateral hamstring tendon grafts. Tears of the patellar tendon are uncommon, but serious complications of TKA. The management of chronic ruptures (>6 weeks) of patellar tendon after TKA is demanding [43]. Large gaps are technically demanding to deal with, as the debridement of the scar and degenerated tendon ends do not allow to juxtapose the tendon stumps to each other [2, 10]. Dobbs et al. [12] reported that 23 % of patients who underwent surgical repair of an extensor mechanism rupture needed a re-operation. In these cases, graft augmentation could help to restore the extensor mechanism function.

Different types of grafts can be used for patellar tendon reconstructions [10, 17]. Jaureguito et al. [25] used a medial gastrocnemius muscle flap in six patients, but an average extensor lag of 24° at the final follow-up cannot be considered a satisfying result. Other authors proposed to use of a contra-lateral patellar tendon autograft [11, 44]. Recently, a reconstruction with a Y-shaped, folded back vastus lateralis fascia flap has been successfully proposed in 16 patients, being able to restore quadriceps function, the anatomical position of the patella, and allow early mobilization post-operatively [43]. Extensor mechanism allograft, consisting of the tibial tubercle, patellar tendon, patella, and quadriceps tendons, has recently gained popularity in the literature for reconstruction of chronic patellar tendon ruptures [5, 14, 31, 33, 37]. However, some studies involving more patients and longer follow-up showed high rate

Table 1 Comparison between different studies in the literature

Authors	Year	Country	Number patients	Mean age (years)	Mean F–U (m)	Mean post-op ROM	Mean post-op EL	Aids
Cadami et al. [6]	1992	USA	7	78	30	4°–83°	5°	3 pz
Jarvela et al. [24]	2005	Finland	1	78	12	5°–80°	5°	No
Roidis et al. [40]	2008	Greece	1	73	24	0°–90°	0°	No
The present study	2013	Italy	9	68	47	5°–100°	5°	4

EL extension lag

of failure and complications, such as deep infections, tibial bone block fixation revision, and peri-prosthetic tibia fractures at the site of the tibial bone block [15, 39]. Some authors reported an unacceptable extensor lag of more than 20° in a high percentage of patients [28, 39]. For these reasons, alternatives techniques should be considered.

The use of the autologous semitendinosus tendon to bridge the patellar tendon gap was first described by Kelikian et al. in 1957 [26]. Different authors recently reported reconstruction of patellar tendon injury in TKA with autologous hamstring tendons, with some differences in surgical technique, but they all leave the distal insertion intact with good results [6, 24, 40] (Table 1). Chen et al. [8] used both hamstring tendons combined with a tension-reducing wire. They showed that when the tendon is passed in opposite directions through the tunnels, the force is distributed on both sides of the original patellar tendon, allowing to restore the correct patellar height for maximal range of motion of the knee joint. They treated two patients with good results, a mean ROM at final follow-up of 0°–132°, and no extension lag. All their patients were young and active. Ecker et al. [13] proposed a transfer of the semitendinosus and gracilis tendons supplemented by metal wiring and drilling two separate horizontal tunnels in the patella and tibial tuberosity. We believe that drilling a single tunnel into the patella and tibial tuberosity without cerclage wiring supplementation lowers the risks of fractures and, as potential advantage, requires no hardware removal.

We used ipsilateral hamstring tendons: They are easy to handle, strong, and routinely harvested for tendon and ligament reconstructions [7, 22]. We did not detach them from the tibial attachment and used both the semitendinosus and gracilis tendons to provide a reliably strong construct [34].

The technique reported in the present study offers several advantages. First, the hamstring tendons contain stronger fibres than the distal iliotibial tract, fascia lata, or quadriceps–patellar retinaculum [42] and ensure a strong integration to the tendon bone interface [8]. Harvesting of the tendons is relatively easy, and they are routinely used for other surgical procedures [7, 13]. Their blood supply is at least partially maintained by preserving their distal insertion: This may promote tendon healing. Papachristou et al. [35] compared ACL reconstruction with semitendinosus tendon autograft with or without maintaining the tibial insertion using an animal model. They showed that harvesting the semitendinosus tendon without detachment of the tibial attachment could preserve sufficient of blood supply to keep it viable. Roidis et al. [40] described it as a "biologic technique" which offers a solution and great healing potential.

Reconstruction of chronic tears of the patellar tendon using the ipsi-lateral hamstring gracilis and semitendinosus tendon graft is safe, and clinically and functionally effective. It allows to return to pre-injury daily activities with satisfactory outcomes. The function of the knee joint was satisfactorily restored at final follow-up, despite the extension lag that some patients continued to experience. Patients reported no difficulty in walking and were able to ascend and descend stairs. At the latest follow-up, patients were generally satisfied of the procedure received.

In the present study, cerclage wiring was not used, as it might limit final flexion. We acknowledge that cerclage wiring may allow immediate post-operative mobilization. To improve the stability of the construct, we suture the tendon to the bony entry and exit points of both the tibial and femoral tunnels, and use an interference screw into the tunnel through the tibial tubercle. It is unclear whether restoration of a patellar height comparable to that of the uninjured one exerts any advantages, as it would require more extensive and prolonged surgery.

Rehabilitation should be extensive and supervised by appropriately trained health care professionals throughout the process [16]. We are aware that knee immobilizers are used, but short-term plaster immobilization immediately after the operation was well tolerated, and prevents excessive stresses to the knee. Also, this helps to prevent stiffness and anterior knee pain, both causes of failure. Another issue in rehabilitation is persistent quadriceps weakness after knee injury or surgery, which is frequently reported and may impair functional recovery. Quadriceps strength and endurance are important for normal knee function, and many surgeons believe that deficits prior to surgery influence knee function post-operatively. Many study have been made in order to understand the underlying factor contributing to persistent muscle weakness, in particular after anterior cruciate ligament (ACL) injury, anterior knee pain and TKA [45], but no studies are published about patellar tendon ruptures. Arthrogenic muscle inhibition (AMI) is the most important factor contributing to persistent post-traumatic quadriceps weakness [45]. It is the inability to completely contract a muscle despite no structural damage to the muscle or innervating nerve [46]. The quadriceps activation failure after knee injury may cause persistent weakness, which may compromise the ability to restore normal joint function. However, studies are still contradictory because deficits in preoperative quadriceps strength influence post-operative recovery after ACL reconstruction and TKA at short-term follow-up [47, 48], but activation deficits of the quadriceps is not predictive of quadriceps strength, indicating that the magnitude of recovery of quadriceps strength is not limited by pretreatment activation levels [49]. To confirm these findings, a recent RCT reported no additional benefits of supervised neuromuscular exercise prior to total hip and knee arthroplasty compared to surgery alone at 3 months post-operatively [50]. However, the intervention group experienced a statistically significant short-term benefit in activities of daily living and pain, suggesting earlier post-operative recovery. Based on these recent researches, further studies are needed to understand the role of quadriceps muscles in the recovery after a knee injury.

The relatively small sample size is a limitation of the study, making statistical analysis of the data difficult. Also, the absence of a control group does not allow to draw definitive conclusions. However, we point out that this is an uncommon injury. Status and function of hamstring tendons were not assessed: This is a potential weakness of the study, but it would be justified by the fact that the study population was sedentary. Anthropometric variables and muscle strength were not measured, and this is another weakness of the study. However, this would reflect routine clinical hospital practice. Also, our patients had recovered functionally.

Conclusion

A gold standard procedure for chronic patellar tendon tears after TKA is still lacking because of the lack of level I and the heterogeneity of the studies published in the literature. A feasible and reproducible technique for this challenging injury has been described in the present investigation. It is safe and provides good results and functional recovery, and it allows patients to return to pre-injury daily activities.

However, further studies involving more patients with longer follow-up are needed.

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