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Surgical options for chronic patellar tendon rupture in total knee arthroplasty

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Abstract
Purpose The purpose of this study was to compare mid-term results of three different reconstructive techniques for chronic patellar tendon disruption after total knee arthroplasty (TKA). Several surgical techniques have been proposed, but to date it is still unclear which is the best solution. The hypothesis was that allografts provide better functional results than autografts in restoring a correct joint function.
Methods Twenty-one reconstructions were performed in twenty-one patients (three groups of seven patients) with chronic patellar tendon lesion following TKA. Group I underwent reconstruction with an Achilles tendon allograft with a calcaneal block, Group II with an autograft of the quadriceps tendon reinforced by the semitendinosus tendon and Group III with a full extensor mechanism allograft consisting of the tibial tubercle, patellar tendon, patella, and quadriceps tendon. Preoperatively and at each follow-up, the value of the extensor lag and the Knee Score (KS) were recorded.
Results The mean extensor lag decreased from 50° ± 19.4° to 3° ± 1.6°. The KSS improved from 44.7 ± 20.5 to 78.9 ± 13.6 points. The comparison between the groups showed statistically significant differences in the mean postoperative KS between Groups I (average score of 87.7 ± 14.3 points) and II (average score of 70 ± 4.1 points), but not between Groups I and III (average score of 78.9 ± 14.6 points) or between Groups II and III. Differences in the postoperative extensor lag were not significant between the three groups.
Conclusions The present study may serve surgeons in choosing the best reconstructive strategy for a chronic patellar tendon lesion in TKA. According to the reported results, an Achilles tendon allograft should be considered the gold standard repair. The autograft technique is suitable when the host tissue is competent, particularly when dealing with younger patients or post-infection. A full extensor mechanism allograft may represent a reliable solution when the defect involves the patellar bone or the quadriceps tendon.
Level of evidence IV.

Keywords Patellar tendon · Extensor mechanism · Allograft · Autograft · Reconstruction · Total knee arthroplasty

List of abbreviations

TKA	Total knee arthroplasty
EMA	Extensor mechanism allograft
ATA	Achilles tendon allograft
QSA	Quadriceps tendon and semitendinosus autograft
KS	Knee Score

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Introduction

Extensor mechanism ruptures account for 0.1–2.5% of all complications following total knee arthroplasty (TKA) [22, 25, 28]. Chronic patellar tendon disruptions alone account for less than 1%, but they are highly disabling for the patients, compromising both joint function and implant longevity [11]. The aetiology of the lesion can be traumatic or atraumatic [4, 11]. Traumatic ruptures occur from a direct trauma most of the time, such as a fall [4]. Atraumatic ruptures may occur in degenerated tendons, and often are secondary to immunocompromised conditions such as rheumatoid arthritis, systemic lupus erythematosus, diabetes mellitus or chronic steroid use, to an infection, or to iatrogenic causes [17, 19, 30, 33]. In order to restore a correct joint function, several surgical techniques have been proposed [4, 29]. Primary repair techniques, employed in traumatic non-arthroplasty cases, such as cerclage wires [1], sutures [18] and staples [28] have shown unsatisfactory results in chronic lesions after TKA, with high re-rupture rates or residual extensor lag. Reconstructive procedures with autogenous tissues such as semitendinosus [10] or gracilis tendon [28] have provided suboptimal results showing significant residual extensor lag, but two recent studies reporting good clinical and functional outcomes have aroused a renewed interest on the autograft techniques [26, 31]. Allograft reconstruction using either the Achilles tendon [12] or the entire extensor mechanism [2, 6, 8, 15, 16, 23] has yielded mixed results, and their use is limited primarily by costs, availability, immune reaction, and disease transmission [14]. Nevertheless, it is still unclear which is the gold standard procedure to repair a chronically injured patellar tendon after TKA. The purpose of the present study was to compare mid-term results of three different reconstructive techniques: extensor mechanism allograft (EMA), Achilles tendon allograft (ATA), and the autograft technique with the quadriceps tendon reinforced by the semitendinosus tendon (QSA) [26], in order to provide guidance in choosing the best reconstructive option for a chronic patellar tendon lesion in TKA.

Materials and methods

Twenty-one reconstructions for chronic patellar tendon ruptures after TKA were performed in twenty-one patients by two surgeons (A.B. and A.R.) at two different institution using three different techniques. Patients in group I underwent reconstruction with ATA, those in group II with QSA, and those in group III with EMA. All three groups consisted of seven knees in seven patients (Table 1), who were matched for sex, mean follow-up and number of previous procedures. No patient was lost to follow-up. At the time of the surgical procedure, all the patients in Group I, one patient in Group II and five patients in Group III underwent a simultaneous revision total knee arthroplasty. The Knee Score (KS) [20] and the extensor lag were calculated both pre- and postoperatively at each follow-up. Reconstructions were considered failures in case of extensor lag >20°, KS < 60 points or if a revision or removal of the graft was needed.

Table 1 Baseline findings retrieved in the 21 cases of patellar tendon reconstruction

Findings (21 cases)	Group I	Group II	Group III
Female nr	5	5	5
Median age years	73	57	70
Range	(41–80)	(53–84)	(60–73)
BMI	35.8 ± 6.3	37.9 ± 7.5	36.4 ± 7.1
Previous periprosthetic infection			
Yes nr (%)	2 (28.6)	2 (28.6)	4 (57.1)
No nr (%)	5 (71.4)	5 (71.4)	3 (42.8)
Number of previous TKA (%)			
1	3 (42.8)	3 (42.8)	0 (0)
2	0 (0)	4 (57.1)	3 (42.8)
3	4 (57.1)	0 (0)	5 (71.4)
Follow-up years (range)	4.9 (1.5–7)	4.7 (3–7)	5.7 (3–10)

BMI body mass index

Surgical technique

Extensor mechanism allograft (EMA)

The patella was longitudinally divided in two parts with a sawblade and subperiosteally enucleated. A trough was created in the proximal tibia to allow for a dovetail engagement with the tibial bone block of the graft and the fixation was obtained with 20-gauge cerclage wires and/or 6.5 mm self-threading acetabular screws. Proximally, both the graft and the host quadriceps remnants were tightly tensioned in full extension with non-absorbable #5 Krackow sutures and the overlapping portions of autologous and graft tissues were sutured with non-absorbable #5 and #2 sutures, covering the graft as much as possible with the autologous tissue (Fig. 1).

Achilles tendon allograft (ATA)

The calcaneous bone block was fixed in a trough in the proximal tibia. The tendinous portion of the graft was divided into two branches. The first branch penetrated into a tunnel 7–9 mm in diameter drilled through the patella, then was retrieved extra-articularly through the quadriceps tendon. The second branch was passed medially and

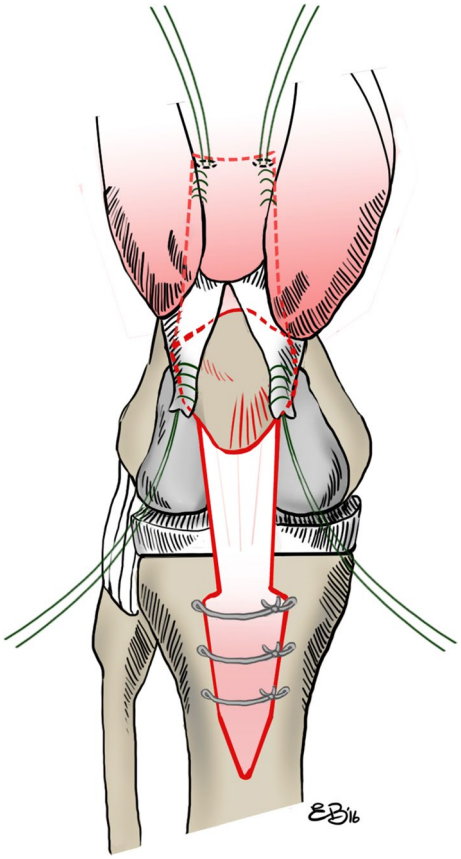

Fig. 1 Full extensor mechanism allograft reconstruction. Distally, the tibial bone block is fixed with three cerclage wires into a trough created in the proximal tibia. Proximally, the graft is passed below the quadriceps (*dashed line*) and its sutures are retrieved through two interruptions performed into the quadriceps tendon

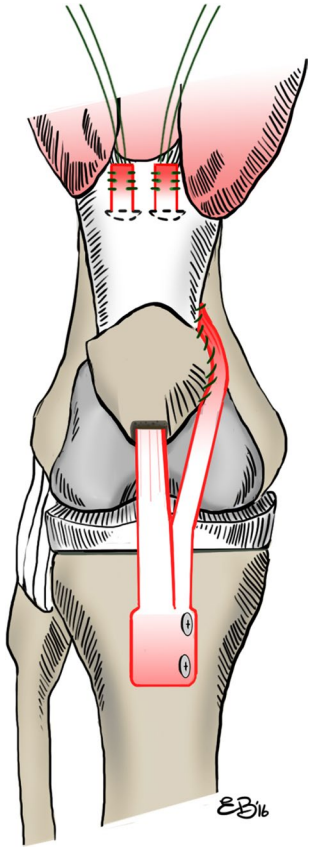

Fig. 2 Achilles tendon allograft reconstruction. The tendon is split in two branches. The first branch penetrates into a patellar tunnel and is retrieved through the quadriceps tendon. The second branch is passed medially, is sutured along the capsulotomy and is retrieved through the quadriceps tendon to be sutured to the first branch

sutured along the capsulotomy or, if the patella was large enough, was passed into a second patellar tunnel, and then was retrieved through the quadriceps tendon and sutured to the first branch with non-absorbable sutures (Fig. 2).

Quadriceps tendon and semitendinosus autograft (QSA)

A quadriceps tendon autograft was harvested with a patellar bone block that was fixed with two 3.5 mm partially threaded cancellous screws in a trough created in the proximal tibia. The semitendinosus tendon was harvested, keeping intact its distal attachment, passed medio-laterally through a drill hole just distal to the tibial tubercle, and then latero-medially through a transverse patellar tunnel. The tendon portion of the quadriceps graft was divided longitudinally in two parts which were fixed to the anterior surface of the patella with two bio-absorbable anchors. With the knee in full extension, the semitendinosus was then pulled distally, sutured along with the quadriceps tendon to the medial and lateral retinaculum with the remnant of the native patellar tendon, and finally sutured onto itself at its attachment (Fig. 3a, b).

Postoperative management

Postoperatively, the knee was immobilized in extension in a long brace for 6–8 weeks. Touchdown weight-bearing was allowed as tolerated. Isometric quadriceps muscle activation was encouraged, but straight leg raising was prohibited for 6 weeks. At 6–8 weeks the brace was removed, full weight-bearing was allowed and knee assisted flexion was started, with a gradual increase by 10°–15° every week and the goal of reaching 90° of flexion by the end of 12 weeks. Active knee flexion was not permitted for 8 weeks postoperatively.

Approval was obtained from the Internal Review Board (IRB) of Istituto Fiorentino di Cura e Assistenza, Florence, Italy, according to the official guidelines of the Declaration of Helsinki, 1996 (ID 166bis/13-10-2015).

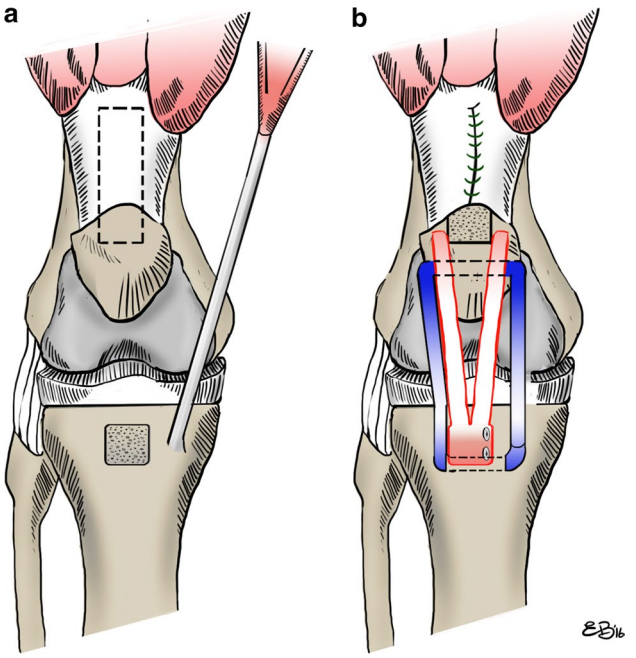

Fig. 3 Quadriceps tendon and semitendinosus autograft reconstruction. A quadriceps tendon autograft is harvested with a patellar bone block; the semitendinosus is harvested keeping its distal insertion intact (**a**). The semitendinosus is passed medio-laterally through a drill hole just distal to the tibial tubercle, then latero-medially through a transverse patellar tunnel, and sutured onto itself at its attachment. The quadriceps tendon autograft is split in two parts and fixed to the anterior surface of the patella (**b**)

Statistical analysis

The sample size of the three groups was due to the size of the smallest one (Group II), which consisted of seven patients. The two matched groups (Groups I and II) were part of a series of 59 allografts reconstructions of the extensor mechanism. Nonparametric analysis was performed for continuous variables. A paired Wilcoxon test was used to compare pre- and postoperative clinical values. The Kruskal–Wallis test was performed to compare the mean values between the groups, followed by a multiple pairwise comparison. $P < 0.05$ was considered significant. The SPSS software program (SPSS, Inc., Chicago, IL, USA) was used for the database and statistics.

Results

Considering all the patients, statistically significant changes ($P < 0.0001$) were observed in the mean extensor lag from 50° ± 19.4° to 3° ± 1.6°, and in the mean KS from 44.6 ± 20.5 to 78.9 ± 13.6 points. The mean KS changed from 34.9 ± 21.3 to 87.7 ± 14.3 in Group I, from 65 ± 3.8 to 70 ± 4.1 in Group II and from 34 ± 14.4 to 78.9 ± 14.6 in Group III. The mean extensor lag varied from 54° ± 17.2° to 2° ± 1.5° in Group I, from 40° ± 14.4° to 5° ± 4.7° in Group II and from 56° ± 23.9° to 1° ± 0.9° in Group III (Table 2). Two cases were considered failures: a re-infection that was treated with graft removal and knee arthrodesis in Group I, and a re-rupture at the level of the tibial tubercle that underwent a second reconstruction with ATA in Group III. Multiple pairwise comparisons showed the difference in the postoperative KS was significant ($P < 0.05$) between Groups I and II, but not between Groups I and III and between Groups II and III.

Discussion

The most important finding of the present study was that overall mid-term results of patellar tendon reconstructions for chronic rupture after TKA are satisfactory when surgical technique and graft choice are optimized. This is in obvious contrast with the unsatisfactory results of the direct repair after patellar tendon lesion in TKA [22, 24, 27]. The series presented in this study showed a significant postoperative improvement in the functionality of the extensor mechanism with an average extensor lag reduced from 50° to only 3° at follow-up.

Table 2 Reported results for the three groups

	Extensor lag (°)		*P* value	Knee Score (points)		*P* value
	Pre-op	Post-op		Pre-op	Post-op	
Group I	54 ± 17.2 (40–90)	2 ± 1.5 (0–10)	0.017*	34.9 ± 21.3 (0–54)	87.7 ± 14.3 (57–98)	0.018*
Group II	40 ± 14.4 (20–60)	5 ± 4.7 (0–15)	0.018*	65 ± 3.8 (60–70)	70 ± 4.1 (65–75)	0.018*
Group III	56 ± 23.9 (30–90)	1 ± 0.9 (0–10)	0.018*	34 ± 14.4 (15–54)	78.9 ± 14.6 (54–93)	0.028*
P value	n.s.	n.s.		0.001**	0.046**	

* Statistically significant at paired Wilcoxon test

** Statistically significant at Kruskal–Wallis test

Average difference in extensor lag at follow-up did not significantly differ in the three studied groups. Regardless of the type of graft, all groups showed less than 5° of extensor lag on average as a final result of the reconstruction. These results are in line with the recent literature of allograft reconstruction after patellar tendon lesion in TKA [13, 21]. Two large series of extensor mechanism reconstructions after TKA using allograft techniques similar to the one here described, reported a superior residual extensor lag, averaging 13° [5, 23]. This could be explained by the inclusion of more extensive lesions including the quadriceps tendon in these two large series [5, 23].

Results of the comparison between autograft and allograft in this series did not find any significant differences in extensor mechanism functionality, being the extensor lag inferior to 5° in all the groups. Autograft reconstructions after TKA has obtained mixed results in the literature. The first paper by Cadambi and Engh described a technique in which the semitendinosus tendon was harvested and looped proximally around or inside the patellar bone. They reported suboptimal results with a significant residual extensor lag in all the patients [10]. More recently, Spoliti et al. with the same technique utilized in nine patients, achieved a good result with an average extensor lag of only 5° at four-year follow-up [31].

The autograft technique (QSA) utilized in the present study has been recently described by one of the authors (AR) [26]. The rationale of the technique is to reinforce the semitendinosus graft, which may be inadequate in most of the patients after TKA, with an augmentation from a quadriceps tendon autograft [26]. It is authors' opinion that the success of this technique is related to the amount of tissue that is solidly fixed to the patellar and tibial insertions. Harvesting a quadriceps tendon after TKA was possible in most of the cases and it provided a sufficiently long and strong tissue band. The autograft solution may be desirable when the patient is relatively young or when history of infection may harm the results of the procedure.

Regarding clinical scores at follow-up, higher KS values were found in the ATA group compared to the QSA and EMA groups. The difference between ATA and QSA could be explained with some matching bias between the groups, being this a retrospective study with the patients operated by two different surgeons. Similarly, the higher number of procedures previously performed in the EMA group, which also included more septic cases, may explain the inferior clinical results of EMA compared to ATA (Table 1).

Complications were found in two cases. One patient in the ATA group had a recurrence of infection after a third-stage re-implantation. One patient, morbidly obese, in the EMA group had a mechanical failure of the graft at the tibial fixation level. None of the patients in the autograft group had septic or mechanical complications. Two complications out of 14 allograft patients represents a rate of 14% which compares favourably to the 38% complication rate recently reported by Brown et al. [5] and by Diaz Ledezma et al. [13], and more similarly to the 22% complication rate reported by Crossett [12] et al. and by Nazarian and Booth [23].

Allografts probably remain the best choice for extensor mechanism reconstruction in patients with poor quality host tissue [3, 6–9, 15, 16, 32]. Considering clinical results and very limited amount of residual extensor lag, ATA may represent the best allograft option for isolated patellar tendon reconstruction. Most of the graft tissue is embedded into host tissues, maximizing the possibility of integration. In addition, ATA has a higher availability at the bone banks, and it does not need to match the side or sex. ATA is preferable in case of intact patella. It represents a less invasive procedure than EMA, as it preserves the patellar bone and the distal quadriceps tendon. EMA is preferable in cases of a severely damaged or comminuted patella or if there is an associated extensive damage of the quadriceps tendon. Reconstruction with EMA presents a number of drawbacks. The first one is related to the graft dimensions. Minimum size for the tibial bone block (at least 6–7 × 3 cm) and quadriceps tendon (at least 7–8 cm) must be respected. In addition, EMA needs to be side, and possibly sex (for patellar dimensions), matched.

Main advantages of allograft are the absence of donor site morbidity and the large amount of tissue available that facilitates fixation to the fibers of the host quadriceps tendons with strong tension in full extension. Conversely, theoretical disadvantages are represented by immune reaction, disease transmission, and poor mechanical properties of the tissue which are nowadays rare and minimized by using fresh-frozen allograft [14].

Strengths of the study should be considered the relatively long follow-up, which reached five years on average, the relative large number of patients included (there are only three larger series described in the literature), the same site of lesions (all limited to the patellar tendon), the maximum tensioning technique in full extension utilized in all the cases, and the same rehabilitation protocol for all the patients.

This study also presents some limitations. The first limitation is due to its retrospective nature and design. Matching three groups of seven patients each with a similar type of lesion is possible for demographic parameters, but difficult for all the previous patient histories. Another limitation is that the autograft and allograft cases were performed by different surgeons in different countries, adding the bias of the operator and of the different type of patient. Lastly, the number of patients is underpowered for statistical calculation between three different groups.

To the authors' knowledge this is the first study comparing three different techniques to reconstruct a chronically injured patellar tendon after TKA. The reported findings may help the surgeon to choose the best graft based on patients' features and previous history.

Conclusions

According to the reported mid-term clinical and functional results, the Achilles tendon allograft should be considered as the gold standard repair of a chronic patellar tendon lesion after TKA. The autograft technique is suitable when the available host tissue is competent, particularly when dealing with younger patients or post-infection with the possibility to harvest a quadriceps tendon flap, and in case of difficulties with bone bank providers. When the extent of the defect is involving the patellar bone or the quadriceps tendon, a full extensor mechanism allograft may represent a reliable solution.

Author's contribution AL participated in the design of the study, collected clinical data, and drafted the manuscript. GB participated in the design of the study and performed the statistical analysis. PPS participated in performing surgery, followed up the patients, and recorded Knee Score. AR performed surgery and participated in the study design and coordination. AV participated in performing surgery, followed up the patients, and recorded Knee Score. AB performed surgery, conceived the study, and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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Ethical approval The internal Institutional Review Board of the IFCA Institute of Florence, met on 13 October 2015, declares that the project titled "Surgical Options for Chronic Patellar Tendon Rupture in Total Knee Arthroplasty" submitted by Dr. Andrea Baldini et al. is compliant with the Helsinki Declaration and ethically correct. Therefore, its execution is allowed (ID 166bis/13-10-2015).

Informed consent Informed consent was obtained from all individual participants included in the study.

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