Extensor Mechanism Reconstruction for Chronic Patellar Tendon Tears

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Objectives: Reconstruction for a chronic patellar tendon rupture in a native knee is an uncommon surgical procedure. Although there have been case series investigating patient-reported outcomes, there is no systematic review of these studies to date. The purpose of this review is to synthesize the literature on this procedure to better understand its outcomes, complications, and surgical technique options.

Methods: A systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to identify studies that reported outcomes and techniques of patellar tendon reconstruction for chronic disruption in native knees. Searches were conducted through MEDLINE using PubMed, Cochrane Database of Systematic Reviews, and clinicaltrials.gov.

Results: Ten studies with 103 patients and 105 knees were included. Results for nonnative (arthroplasty) knees were excluded. The mean patient age was 40.3 years, and the mean postsurgical follow-up time was 53.8 months. Of the 105 knees, 75% received a hamstring tendon graft, whereas 13% received a bone-tendon-bone graft and 7% received a whole extensor mechanism allograft. The mean preoperative range of motion was 113.8°, which improved to 126.0° postoperatively. The mean preoperative Lysholm score was 58.6, which improved to 86.0 postoperatively; 100% of patients returned to their normal work activities and 76% returned to their prior level of physical activity. There were no major complications reported in any of the included studies.

Conclusions: Chronic patellar tendon disruption in a native knee is an uncommon injury that can result in significant limitations for patients. Although more research is needed to better elucidate which graft is best, outcomes after patellar tendon reconstruction for chronic tears appear to be satisfactory with current techniques.

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Patellar tendon rupture of the native knee can be caused by traumatic or nontraumatic etiologies, and the underlying injuries can include an isolated tendon rupture or a patella fracture.[1,2] The majority are diagnosed and treated acutely because this injury typically is disabling.[1] As a result of poor access to care, financial constraints, or misdiagnosis, a portion of these injuries are not identified acutely and may become a chronic issue, however. In the chronic setting, patients may present with difficulty bearing weight on the affected leg, weakness with extension that manifests as difficulty rising from a chair or climbing stairs or chronic knee pain.[3–5] One can diagnose a chronic tendon rupture with a lateral knee radiograph exhibiting patella alta,[6] whereas advanced imaging with magnetic resonance imaging or ultrasound can demonstrate chronicity and degree of tendon retraction.[6,7]

Acute patellar tendon ruptures are relatively straightforward to surgically repair, with reliable outcomes.[8] In contrast, chronic disruptions present a challenge for surgeons because of retraction, scar formation, and limited data on effective surgical techniques.[9] A variety of techniques have been proposed to reconstruct chronic patellar tendon tears, including contralateral bone-tendon-bone autograft (BTB), hamstring tendon, and Achilles tendon allografts.[4,5,10]

To date, our understanding of clinical outcomes following extensor mechanism reconstruction for chronic patellar tendon

Key Points

- Chronic patellar tendon ruptures are an uncommon condition and there is to date little consensus on the best strategy for their management.
- Ten pertinent studies, the majority of which were level IV evidence, that included more than 100 patients were found in the literature.
- Patients who underwent reconstructive procedures for chronic patellar tendon disruption tended to improve postoperatively both in terms of range of motion and function, with no apparent difference in hamstring versus bone-tendon-bone grafting.
- Few complications are reported in the literature following these reconstructions, and the ones that are reported are largely minor in nature.

tears has been limited to small case series in the literature. As a result, data comparing the various techniques are sparse. Although extensor mechanism reconstruction for chronic tears has been systematically reviewed in the setting of total knee arthroplasty (TKA),[11] a review of extensor mechanism reconstruction for these injuries in the native knee has yet to be published. The objective of this study was to review clinical outcomes, reconstruction techniques, and complications arising after extensor mechanism reconstruction in the setting of chronic patellar tendon rupture in the knee. We hypothesized that extensor mechanism reconstruction for chronic patellar tendon tears provides satisfactory outcomes with minimal complications.

Methods

Protocol and Registration

A review protocol for this systematic review was registered with and may be viewed through PROSPERO (https://www.crd.york.ac.uk/prospero; ID: CRD42018103495). The date of submission was July 8, 2018 and the date of registration was August 16, 2018.

Eligibility Criteria

Studies were included if they reported the results of patellar tendon reconstruction after chronic disruption in a native knee. To be included in this systematic review, studies must have reported at least one clinical outcome score postoperatively and been written in English. Reviews, editorials, technique guides, and case reports of three patients or fewer were excluded. Studies of nonnative knees (eg, patellar tendon reconstruction following TKA) or those involving acute disruption of the patellar tendon also were excluded. This systematic review was carried out following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[12]

Information Sources and Search

Searches were conducted using MEDLINE through PubMed, Embase, Scopus, the Cochrane Database of Systematic Reviews, and clinicaltrials.gov. These online databases were searched in May 2020. The search algorithm input into PubMed was "'extensor mechanism reconstruction' OR 'patellar tendon repair' OR 'quadriceps tendon repair' OR (chronic AND tendon AND rupture)." The search term for the Cochrane Database of Systematic Reviews and clinicaltrials.gov was "extensor mechanism reconstruction."

Study Selection

Two authors independently reviewed the initial studies populated by the aforementioned search criteria, first by title, then using abstracts, to determine eligibility per the inclusion and exclusion criteria. Nonrelevant results, duplicate studies, and studies that did not meet inclusion criteria were excluded. Full texts of the remaining studies were subsequently reviewed for inclusion.

Discrepancies in the first two rounds of exclusion by title and abstract were settled by mutual consensus. There were no discrepancies in the final round of exclusion by full text. References in the final set of included studies were reviewed to identify additional studies for inclusion. Data collection was independently executed by the investigators from all of the studies and compared to confirm accuracy.

Data Items

Data extracted from each study included the following: surgical approach and technique, sample characteristics, sample size, concomitant pathology, preoperative and postoperative scores, follow-up duration, and surgical complications.

Risk of Bias

The risk of bias in each study was independently assessed by two authors using the Methodological Index for Non-randomized Studies (MINORS) criteria.[13] This tool grades studies based on a clearly stated aim, consecutive patients, prospective data collection, appropriate endpoints, unbiased assessment of the endpoint, appropriate follow-up, loss of follow-up <5%, and prospective study size calculation. Comparative studies also included the following: adequate control group, contemporary groups, baseline equivalence between groups, and adequate statistical analysis.

Summary Measures

The principal summary measure was the difference in means between preoperative and postoperative outcome scores. These means were weighted according to the sample size of each study.

Synthesis of Results

The data synthesized from each study were preoperative and postoperative outcome scores reported as means within each study. Weighted means for each score were calculated based upon the number of patients from each study. In addition, measurements and outcome scores were expressed as percentage ideal, which is the pooled mean for a given outcome divided by the maximum possible score for that particular outcome metric.

Results

Study Selection

The Cochrane Database of Systematic Reviews reported no results for extensor mechanism reconstruction. The PubMed search produced 1807 results. After title review, 158 studies were included for abstract review. From these abstracts, 42 were identified as eligible for full-text review. Following full-text review, eight papers were identified for final inclusion. Subsequent review of the references of these papers yielded two

additional studies for inclusion, bringing the final number to 10 publications[3–5,10,14–19] (Fig.).

Study Characteristics

The 10 studies were published between 2013 and 2019 and encompassed a total of 105 knees from 103 patients[3–5,10,14–19] (Table 1). Two studies[14,18] were level III studies and the remaining eight were level IV studies.[3–5,10,15–17,19] The average risk of bias using the MINORS criteria was 9.3 for the nine noncomparative studies, as opposed to 18.5 in the lone comparative study.[14]

All of the study patients had a chronic patellar tendon disruption. The mean age for the included patient population was 40.3 years (range 18–87). Of the seven studies reporting sex, 80.9% of the patients were male and 19.1% were female.[3–5,10,17–19] The mean follow-up length was 53.8 months (range 12–144 months).

Seven studies investigated the use of hamstring tendon grafts.[3,4,10,14,16,17,19] Two studies used contralateral BTB autografts.[5,15] Fiquet et al used a whole extensor mechanism allograft.[18] In addition to hamstring grafts, one study investigated multiple graft options, including hamstring and gracilis autografts, Achilles tendon allografts, or tibialis anterior tendon allografts.[10] Further interstudy differences are present in surgical approaches, with nine of the 10 studies applying an open approach through a longitudinal, midline incision, whereas the other used a percutaneous approach.[16]

In the seven studies using hamstring autografts, the graft was most commonly passed through two transverse tunnels, one in the patella and one at the level of the tibial tubercle. The hamstring graft was passed and anchored in a variety of ways: in a figure-eight pattern in four studies;[3,4,10,17] in a percutaneous-approach circular pattern by Jain et al;[16] and using vertical tunnels with a button to anchor the proximal portion of the hamstring graft in the patella and two side holes exiting the distal vertical tunnel to pass the suture to anchor the graft distally.[19] Three studies[3,10,14] mention McLaughlin cerclage wires, and the authors of two of these studies elected to remove the wires at either 6[14] or 9 weeks.[3]

For the BTB graft studies, Temponi et al employed contralateral BTB autografts in their study.[5] Kovačev et al did not detail their surgical technique, but they did state that they used BTB autografts for chronic tears when possible and BTB allografts when an autograft was not an option.[15]

Fiquet et al used an extensor mechanism allograft consisting of an anterior tibial tubercle, a whole patellar tendon, a whole patella, and a quadriceps tendon.[18] They cut the allograft in the shape of an hourglass and made a corresponding trough in the native patella for allograft placement. The graft was secured by metal wires in the patella and compressive screws in the anterior tibial tubercle and the quadriceps tendon was then tensioned and attached to the native quadriceps tendon with Fiberwire (Arthrex, Naples, FL).

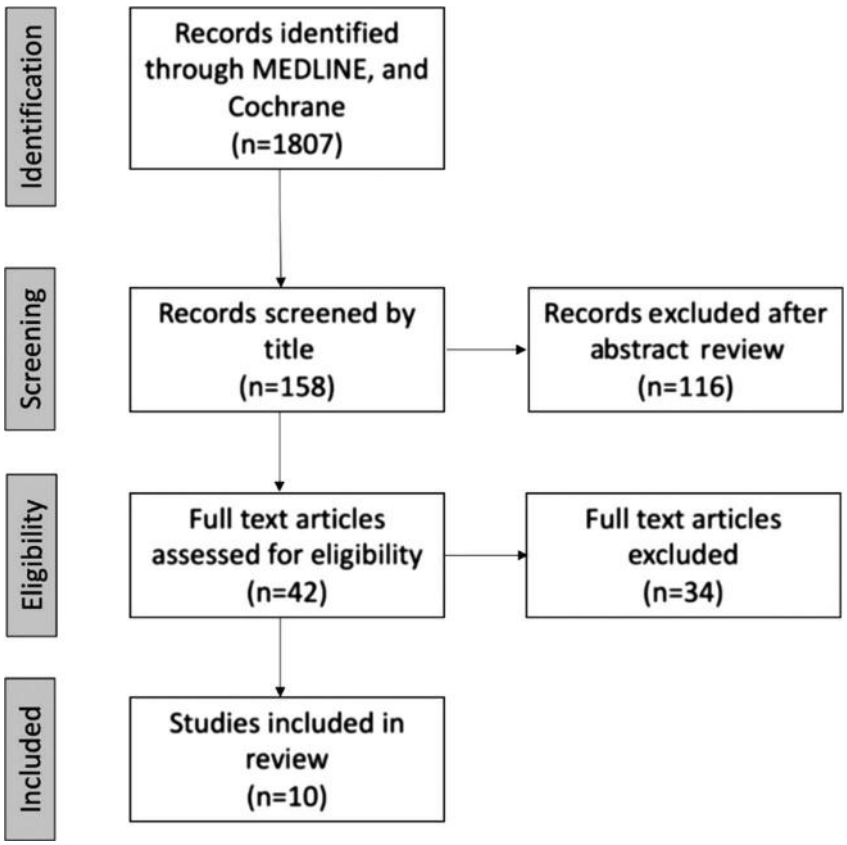

Fig. Literature selection algorithm.

Table 1. Publications reporting outcomes after patellar tendon reconstruction for chronic ruptures

Graft type	Author	Year	Journal	Level of evidence	Technique	No. knees	Outcome scores	Follow-up, mo
Hamstring	Abdou[3]	2014	*Archives of Orthopaedic and Trauma Surgery*	IV	Hamstring autograft	17	Lysholm score, ROM	24
	Belhaj et al[14]	2017	*Annals of Physical and Rehabilitation Medicine*	III	Hamstring autograft	8	KSS Knee Score, KSS Function Score, VAS, ROM	75
	Jabalameli et al[10]	2018	*Trauma Monthly*	IV	Semitendinosus and gracilis autograft (6) semitendinosus autograft (2), Achilles allograft (1) tibialis anterior allograft (1), direct repair (2)	12	ROM, extensor lag, IKDC Score, Cincinnati score, Insall-Salvati ratio	74.4
	Jain et al[16]	2014	*The Knee*	IV	Hamstring autograft	9	Insall-Salvati ratio, Lysholm score, ROM	54
	Maffulli et al[17]	2013	*Journal of Bone & Joint Surgery*	IV	Hamstring autograft	19	Cincinnati score, Kujala score, Insall-Salvati ratio, extensor lag, ROM	70
	Sundararajan et al[4]	2013	*International Orthopaedics*	IV	Hamstring autograft	7	IKDC score, Insall-Salvati ratio, Lysholm score, Kujala score, ROM	40.7
	Valianatos et al[19]	2019	*Journal of Knee Surgery*	IV	Hamstring autograft	11	Lysholm score, extensor lag	72
BTB	Kovačev et al[15]	2015	*Medicinski Pregled*	IV	Contralateral BTB autograft, BTB allograft	7	Lysholm score	48
	Temponi et al[5]	2017	*Knee Surgery, Sports Traumatology, Arthroscopy*	IV	Contralateral BTB allograft	7	Lysholm score, IKDC score, Tegner Activity Level, CD Index, ROM	41.3
Extensor mechanism	Fiquet et al[18]	2018	*International Orthopaedics*	III	Extensor mechanism allograft	8	Extensor lag, KSS Knee Score, ROM	39

BTB, bone-tendon-bone; CD Index, Caton-Deschamps Index; IKDC, International Knee Documentation Committee; KSS, Knee Society Score; ROM, range of motion; VAS, Visual Analog Scale.

A total of 14 outcome measurements were recorded from the 10 studies. The most common outcome metrics reported were the Lysholm score[3–5,15,16,19] and range of motion (ROM),[3–5,10,14,16,17] with each documented in six studies. The Insall-Salvati ratio,[4,10,16,17] which assesses radiographic patellar height, and extensor lag were reported in four studies[4,10,17,18] and the International Knee Documentation Committee Score was reported in three studies.[4,5,10]

Synthesis of Results

All of the studies reported improvements in outcome measures postoperatively. The overall results are summarized in Table 2 and further subdivided into results from hamstring and BTB grafts in Table 3.

The mean Lysholm score improved from 58.6 preoperatively to 86.0 postoperatively. A similar rate of improvement was found when categorized by surgical technique: 62.0 to 87.6 with hamstring grafts and 45.4 to 73.0 with BTB grafts. The mean preoperative ROM was 113.8° of flexion, which increased to 126° postoperatively. Hamstring grafts demonstrated an improvement in flexion from 107.7° to 127.4° postoperatively, and one study[5] reported BTB ROM postoperatively at 127°. The average Insall-Salvati ratio improved from 1.77 preoperatively to near the "normal" nonpathologic range of 0.8 to 1.2, with an average postoperative ratio of 1.26. Finally, the mean extensor lag was 31.6° preoperatively compared with 1.8° postoperatively. In studies reporting return to work, 100% of patients were able to do so,[4,17] whereas 76% returned to the prior level of physical activity.[3,4,17]

Complication data were reported across six studies (71 knees from 69 patients).[3–5,10,16,17] The remaining studies did not report complications.[14,15,18,19] No major complications or failures were reported. Eight patients experienced persistent anterior knee pain,[3,17] five reported persistent hypoesthesia over the anterior portion of the knee,[17] and one reported hypoesthesia over the anterior tibial tubercle.[17]

Discussion

This systematic review is the first to comprehensively evaluate outcomes after extensor mechanism reconstruction for chronic patellar tendon disruptions. The current literature describes satisfactory results, demonstrating improvement in postoperative outcomes after extensor mechanism reconstruction in the setting of chronic patellar tendon disruption.

Our summative results demonstrate significant improvement in all of the outcomes, both radiographic and patient reported, and there were no major complications reported by any study. The

Table 2. Overall outcome measurements following patellar tendon reconstruction

Outcome measure	No. studies	No. knees	Mean preoperative score	Percentage ideal	Mean postoperative score	Percentage ideal
Degrees of flexion	6	68	113.8°	78.6	126.0°	86.9
Lysholm score	6	58	58.6	58.6	86.0	86.0
IKDC score	3	26	35.3	35.3	79.7	79.7
Insall-Salvati ratio	4	47	1.77	(ideal 0.8–1.2)	1.26	(ideal 0.8–1.2)
Cincinnati score	2	31	36.6	36.6	85.2	85.2
Kujala score	2	26	42	42	84.6	84.6
Visual Analog Scale	1	8	5.5	45%	2.63	73.7%
KSS Knee Score	2	16	34.55	34.55	77.07	77.07
KSS Function Score	2	16	31.57	31.57	85.28	85.28
Tegner Activity Level	1	7	1	10	4	40
CD Index	1	7	1.5	(ideal 0.6–1.3)	1.2	(ideal 0.6–1.3)
Extensor lag	4	48	31.6°	—	1.8°	—
Thigh girth differential	2	21	—	—	2.09 cm	(ideal 0)

CD Index, Caton-Deschamps Index; IKDC, International Knee Documentation Committee; KSS, Knee Society Score.

average ROM improved by 12°, Lysholm scores improved by 27 points, and radiographic outcomes such as the Insall-Salvati ratio improved by 29%. No studies reported on strength postoperatively. Although an improvement in the Insall-Salvati ratio is merely a radiographic outcome, the improvement in Lysholm score and ROM demonstrates patient-perceived improvements in activity level.

Historically, patellar tendon reconstruction for chronic tears has proven to be more difficult because of tendon retraction, atrophy of the quadriceps muscle, and contractures.[20–22] These problems are not present in acute patellar tendon ruptures and are more likely to contribute to complications and inadequate fixation. In the present review, patients experienced significant preoperative limitations that were exhibited through poor ROM and functional outcome. The patients, however, did regain a significant degree of knee function and activity level. A similar conclusion was reached by Haskel and colleagues, who demonstrated that patients with patellar tendon repair had excellent return to work (96%), play (89%), and return to play at the same level or better (80%).[23] Their review, however, did not specify tendon

Table 3. Functional outcomes following patellar tendon reconstruction, by graft type

Outcome measured	Graft type	No. studies	No. knees	Mean preoperative score	Percentage ideal	Mean postoperative score	Percentage ideal
ROM	H	4	28 preoperative; 43 postoperative	107.7°	71.8	127.4°	84.9
	BTB	1	7	NR		127°	84.7
Lysholm score	H	4	28 preoperative; 44 postoperative	62.0	62	87.6	88
	BTB	2	7 preoperative; 14 postoperative	45.4 (7)	45.4	73 (14)	73
IKDC score	H	1	7	46.8	47	86.8	87
	BTB	1	7	45.5	45.5	64.5	64.5
Insall-Salvati ratio	H	3	35	1.77		1.33	
Cincinnati score	H	1	19	44.5	45	84	84
Kujala score	H	2	19 preoperative; 26 postoperative	42	42	84.6	85
Visual Analog Scale	H	1	8	5.5	45	2.6	74
KSS Knee Score	H	1	8	19.5	20	73.1	73
KSS Function Score	H	1	8	26.9	27	78.8	79
Tegner Activity Level	BTB	1	7	1	10	4	40
CD Index	BTB	1	7	1.5	(ideal 0.6–1.3)	1.2	(ideal 0.6–1.3)

Hamstring graft data were collected for 8 knees in the study by Jabalameli et al, but was not separated by data for other procedures; therefore, it was not included in this table. BTB, bone-tendon-bone; CD Index, Caton-Deschamps Index; H, hamstring; IKDC, International Knee Documentation Committee; KSS, Knee Society Score; NR, not reported; ROM, range of motion.

rupture acuity or chronicity, or the tendon grafts used, although many of the referenced articles alluded to traumatic rupture, suggesting acute repair. Regardless, despite functional discrepancies between acute and chronic tendon rupture repair, patient outcomes appear to be markedly improved irrespective of graft type or timing, and the majority of patients can reasonably expect to return to previous activities. Further research is necessary to determine a patient's ability to return fully to their preinjury level of activity after the reconstruction of a chronic patellar tendon disruption.

Although the results of chronic patellar tendon reconstruction are encouraging, these outcomes are generally worse than acute patellar tendon repair.[24] Belhaj and colleagues assessed 25 patients with acute (17) or chronic (8) patellar tears undergoing repair.[14] Postoperatively, the authors found that those with chronic tears had lower postoperative Knee Society Score (KSS) knee (86.6 ± 9.0 vs 73.1 ± 13.9; $P < 0.05$) and function (92.9 ± 13.6 vs 78.8 ± 21.7; $P < 0.05$) scores and ROM ($119.7° \pm 8.0°$ vs $93.8° \pm 13.6°$; $P < 0.001$), and higher visual analog scale scores (1.6 ± 1.1 vs 2.6 ± 1.3; $P < 0.05$).

Comparing the outcomes of the two most commonly used grafts (hamstring tendon and BTB) was challenging given the lack of outcome score standardization and the paucity of patients (14 knees) in studies reporting BTB graft outcomes (Table 3). Despite this, we expressed outcomes as pooled means to allow for easier comparison between graft choices and found that the rate of improvement was similar between the two groups. The patients who received a hamstring tendon autograft had a 26% improvement in Lysholm score (58.6–86.0), a 13% improvement in ROM, and a 25% improvement in Insall-Salvati ratio. Patients receiving a BTB graft demonstrated a 28% improvement in Lysholm score (from 45.4 to 73), but the remaining outcomes scores were reported only in one study, and an adequate comparison for those outcomes between graft types could not be made (Table 3).

The treatment of patellar tendon disruptions secondary to knee arthroplasty is better documented than in native knees.[25] Although it is known that direct repair of these chronic disruptions in the TKA population is fraught with complications, many studies have shown that patients can have satisfactory outcomes after reconstruction following TKA. Specifically, Lamberti et al demonstrated that these patients had improvements in extensor lag from $50° \pm 19.4°$ to $3° \pm 1.6°$ and improvements in KSS from 44.7 ± 20.5 to 78.9 ± 13.6.[26] In addition, Shau et al conducted a systematic review that demonstrated that patients undergoing extensor mechanism reconstruction had an average improvement in KSS from 34.4 ± 14.2 to 90.3 ± 89.7.[11] The patient outcome findings in our review were thus similar to outcomes in chronic patellar tendon reconstruction in the setting of a TKA, although no known study offers a direct comparison.

Of the 71 knees included in the studies that reported complications, 14 knees experienced either persistent anterior knee pain[3,17] or hypoesthesia over the anterior portion of the knee.[17] Because of the relatively small number of patients in this review, we believe that this review may not fully represent the true complication rate after patellar tendon reconstruction. It is likely that there are long-term complications such as re-rupture, which was not mentioned in the included studies. Further research with more patients and longer follow-up is needed to determine late complications associated with reconstruction in the chronic rupture setting.

The major limitations of this study are those inherent to any systematic review and are related to the quality of the included studies. Most papers referenced in our review are case series with small patient populations, because of the rarity of this injury. Only one of the 10 studies is a comparative study.[14] Furthermore, based on the MINORS criteria, the average score of the included noncomparative studies was 9.1 out of a global ideal score of 16, and the single comparative study had a MINORS score of 19 out of a global ideal of 24.[13] Although this may seem to detract from the quality, the data pooling ideally diminishes some of this concern. Given the fact that chronic patellar tendon tears are uncommon injuries and there is no consensus for their treatment, our study was limited in the amount of overlapping data for comparison or meta-analysis. The small case series and cohort studies included in our review have inherent selection bias as a result of their size. Another limitation is the lack of standardized outcome measures reported in the included studies. This made establishing comparisons between graft types among the various studies especially difficult. Because there is no single measurement tool for evaluating extensor mechanism reconstruction outcomes, there is some heterogeneity in the studies included in this systematic review. We reconciled this by normalizing outcome measures by applying a "percentage ideal" to each score when possible. This allowed us to facilitate the comparison of treatment effectiveness, although direct measurements between these normalizations have not been validated.

Conclusions

Chronic patellar tendon disruption in a native knee is an uncommon injury that can result in significant limitations for patients. Although more research is needed to better elucidate which graft is best, outcomes after patellar tendon reconstruction for chronic tears appear to be satisfactory for both hamstring tendon and BTB grafts.

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