Systematic Review

Clinical Outcomes are Similar Between Graft Types Used in Chronic Patellar Tendon Reconstruction: A Systematic Review

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Purpose: To compare clinical outcomes between graft types and techniques used to repair chronic patellar tendon injuries to help surgeons make evidence-based decisions. **Methods:** Medline, Embase, and Cochrane libraries were searched through January 2021, according to Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. Inclusion criteria were surgical treatment of chronic patellar tendon injury (defined as >6 weeks old), article available in English, and human subjects, minimum 1-year follow-up, and level of evidence I-IV. Studies describing chronic patellar tendon ruptures in the setting of total knee arthroplasty were excluded. Study quality was assessed using the Joanna Briggs Institute Critical Appraisal tools for case reports and case series. **Results:** A total of 642 studies were identified through the initial search with 9 studies meeting all inclusion criteria. All studies included were case series encompassing 96 patients with follow-up ranging from 21 months to 7.2 years. Reconstruction techniques included the use of semitendinosus and/or gracilis tendon(s), Achilles tendon, bone-patellar tendon-bone (BTB), or direct repair. The most common graft choice was semitendinosus and/or gracilis tendon(s). Each reconstruction method yielded improvement in respect to range of motion (ROM), extensor lag, quadriceps strength, and patient-reported outcome measures (PROMs). Commonly reported complications were pain and numbness with only one reported instance of graft failure. **Conclusions:** In this study, we found that all reconstructive methods described in the literature can produce satisfactory outcomes with improved function, strength, and minimal complications after chronic patellar tendon ruptures. Because of study heterogeneity and low levels of evidence, consensus cannot be reached on a single superior reconstruction method. **Level of Evidence:** Level IV, systematic review of level IV studies.

Introduction

Patellar tendon ruptures are injuries usually seen following trauma and present with pain, a palpable tendon gap, and the inability to achieve or maintain knee extension against gravity.[1] Surgical treatment is the gold standard for these injuries as nonoperative management leads to patellar tendon retraction and scarring, loss of normal knee biomechanics, and poor long-term function.[1,2] Primary patellar tendon repair is typically indicated for acute ruptures; however, the surgical technique used for treating chronic patellar tendon rupture depends on the length of time between injury and surgery, as well as the quality of the remaining tissue.[2]

Chronic patellar tendon ruptures, usually defined as injuries greater than 6 weeks old, are complicated by proximal patellar migration and compromised tendon tissue, which usually makes primary repair difficult or impossible.[2] Patients typically present with extensor weakness and varying degrees of extensor lag that significantly compromises function. Therefore, chronic patellar tendon ruptures usually require the use of autografts, allografts, or synthetic material to reconstruct the tendon, restore patellar height, and achieve active knee extension.[1] Techniques previously described include a variety of graft reconstructions

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(synthetic, allograft, and autograft), with or without augmentation, and primary repair with augmentation. Although many different graft types and techniques have been described, there is no consensus on which provides the best clinical outcomes. A previous systematic review from 2015 found that reconstruction of the patellar tendon with autogenous grafts was the best treatment option for chronic patellar tendon tears due to lower failure rate and lower complication rate when compared to primary repair alone.[2] However, this study did not primarily look at chronic patellar tendon injuries, and this study is now outdated with numerous studies on chronic patellar tendon injuries added to the literature since 2015.

The purpose of this study was to compare clinical outcomes between graft types and techniques used to repair chronic patellar tendon injuries to help surgeons make evidence-based decisions. We hypothesized that autologous grafts would produce the best outcomes for chronic patellar tendon reconstruction.

Methods

Medline, Embase, and Cochrane libraries were searched according to Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. The following search term was developed for Medline and was adjusted as necessary for other databases: chronic patellar tendon rupture or chronic patellar tendon injury or "Patellar Ligament/injuries"[Mesh]) and (reconstruction or repair or treatment or "Transplants"[Mesh] or "Reconstructive Surgical Procedures"[Mesh] or "Rupture/surgery"[Mesh] OR "Patellar Ligament/surgery"[Mesh]) not (anterior cruciate ligament, or ACL) not tendinopathy.

Covidence software was used in study screening and data extraction. Two authors independently screened studies for inclusion. Studies that met the following criteria were included: 1) surgical treatment of chronic (>6 weeks) patellar tendon injury, 2) available in English language, 3) human subjects, 4) clinical outcomes described, 5) minimum 1 year follow-up, and 6) level of evidence I-IV. Studies that met the following criteria were excluded: 1) acute patellar tendon rupture, 2) non-English language, 3) nonhuman studies, 4) clinical outcomes not described, and 5) chronic patellar tendon ruptures in the setting of a total knee arthroplasty. Disagreements were resolved through discussion with all authors. Full text screening and data extraction were then independently performed by two authors. A standardized form within the Covidence software was used to extract data, including publication title, authors, year published, journal, patient demographics, technique for restoring patellar height, graft type and fixation technique, augmentation technique, suture type and configuration, follow-up time, range of motion (ROM), patient-recorded outcome measures (PROM), extensor lag, complications, and any additional indicators of patient function.

Two authors independently assessed risk of bias of included studies using the Joanna Briggs Institute Critical Appraisal tools for case reports and case series. Disagreements were settled by consensus.

Results

There were 642 studies identified from our initial search. Forty-eight studies were sent for data extraction after the screening process (Fig 1).[3-50] Two studies were excluded because of insufficient reporting of patient demographics and outcomes,[18,33] two studies were excluded due to inadequate follow-up,[6,16] and 35 studies were excluded due to being level V evidence,[4,5,7,9-13,15,17-20,22,24,25,27-31,33-42,44,46-50] leaving 9 studies for inclusion in our review.[3,8,14,21,23,26,32,43,45] All of the included studies were case series.

Hamstrings Tendon

Six studies reported the use of semitendinosus and/or gracilis tendon(s) grafts on 69 patients (Appendix Tables 1-3),[3,14,21,23,32,43] all of which were autografts. Forty-nine patients were male, 11 were female, and 9 patients did not have a sex stated. The age of patellar tendon injury ranged from 17 weeks to 16.4 months. Follow-up time ranged from 21 months to 7.2 years. Graft fixation to the tibia was achieved with transosseous tunnels.[3,14,21,32,43] Graft fixation to the patella was achieved with transosseous tunnels in all studies. Augmentation methods included stainless-steel wire.[3]

Range of motion was reported qualitatively as comparable to contralateral[3] and numerically with mean 1-128°.[14,21,23,32,43] Mean extensor lag was 1.5°.[21,43] Quadriceps strength was reported qualitatively as comparable to contralateral.[23] Thigh girth was reported numerically as mean 1.5-cm difference compared to contralateral.[23] Lysholm score improved by 25 points[3] in the study that reported preoperative score. The mean postoperative Lysholm score was 90.6.[3,23,43] International Knee Documentation Committee (IKDC) score improved by mean 50.5 points.[21,43] Visual analog scale improved by 1.6 points.[14] Cincinnati Knee Rating System (CKRS) improved by mean 50.8 points.[21,32] Kujala score improved by 39 points.[32] Complications reported are listed in Appendix Table 4.

Achilles Tendon

One study reported the use of Achilles tendon allograft on 11 patients (Appendix Tables 5 and 6).[26] Eight patients were male, and three were female. Mean follow-up time was 56 months. Graft bone block fixation to the tibia was achieved with screws.[26]

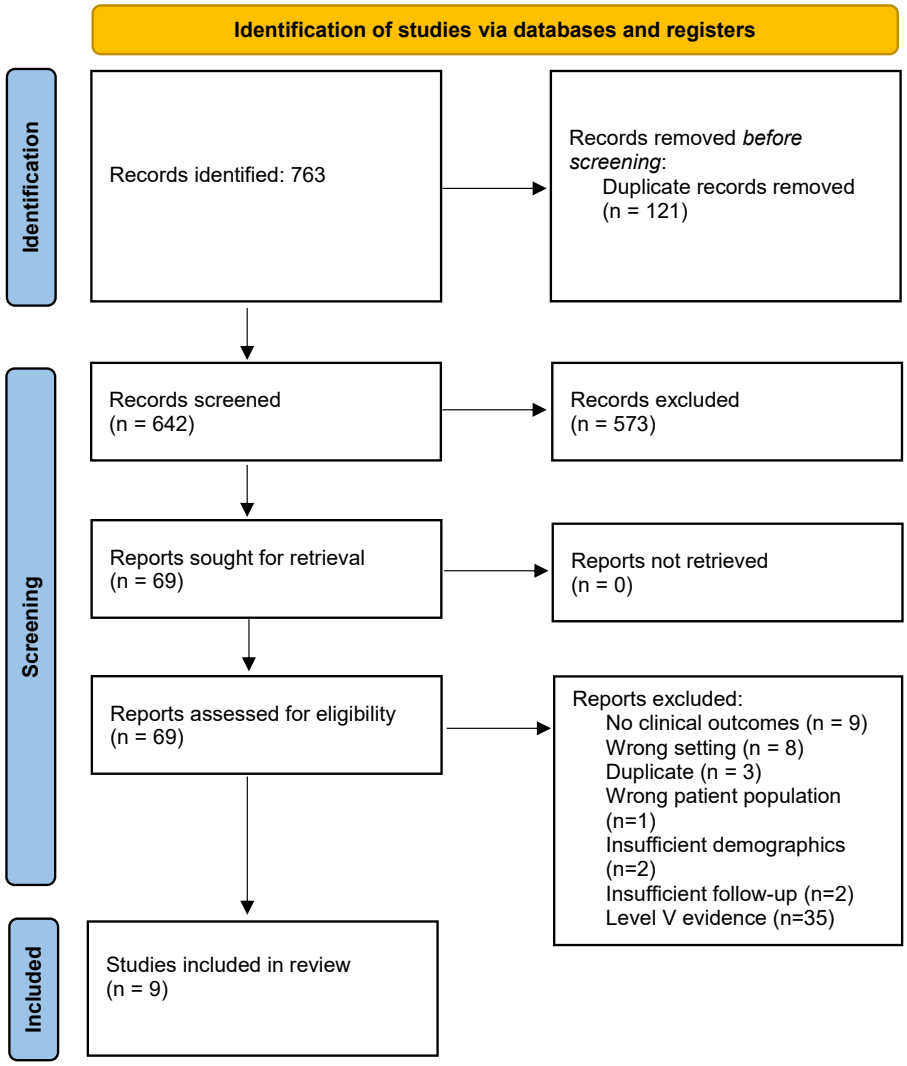

Fig 1. PRISMA Flowchart of search results and study selection procedure.

Proximally, graft fixation was achieved with transosseous tunnels in the patella.[26]

Range of motion was mean 1-122°.[26] Mean extensor lag was 2°.[26] Thigh girth was mean 1.5-cm difference compared to contralateral.[26]

Bone-Patellar Tendon-Bone

Two studies reported the use of bone-patellar tendon-bone (BTB) graft on 10 patients (Appendix Tables 7 and 9).[26,45] One study used autografts from the contralateral knee,[45] while the other study used allografts.[26] All of the patients were male. Mean age of patellar tendon injury was 16.3 months in the study that reported it.[45] Follow-up time ranged from 41.3 months to 67 months. Graft bone block fixation to the tibia was achieved using screws in all studies. Proximally, graft fixation was achieved by screws to fix the proximal bone block to the patella[45] and K-wires to fix the proximal bone block to the patella.[26] Augmentation methods included cerclage wire.[26,45]

Mean ROM was 4-124°.[26,45] Mean extensor lag was 2.5°.[26,45] Quadriceps strength was reported numerically as 3.07/5.[45] Thigh girth was mean 2.4cm different compared to contralateral.[26,45] Lysholm score improved by 33.6 points.[45] International Knee Documentation Committee score improved by a mean 19 points.[45] Tegner activity score improved by a 3 points.[45]

Direct Repair

Two studies reported the use of direct patellar tendon repair on six patients (Appendix Tables 10 and Appendix Tables 11)[8,21] All patients were male. Mean age of injury was 3.5 months. Mean follow-up time was 2.5 years. Both studies augmented the repair with wire.[8,21]

Mean flexion was 116.3°.[8,21] Mean extensor lag was 0°.[8,21] International Knee Documentation Committee score improved by 69 points, and Cincinnati Knee Rating System improved by 65.5 points.[21] One study reported two patients experienced wire breakage that did not require removal.[21]

Discussion

In this systematic review, the literature shows that all described methods of repairing chronic patellar tendon ruptures lead to improved clinical outcomes with low failure rate. However, there is significant heterogeneity in outcome reporting between studies making comparison between the different methods of repair difficult.

The most commonly reported outcome after treatment for chronic patellar tendon rupture was ROM, which was reported in all of the included studies. ROM was comparable between the different reconstruction techniques studied in this review. Studies that used hamstring(s) tendon grafts recorded the greatest mean ROM of 1-128°, and studies that used direct repair recorded the lowest mean ROM of 116.3°. The greatest mean ROM from this review is greater than the highest mean ROM of −11-110° from two studies using hamstring(s) tendon grafts found by Gilmore et al.'s review.[2]

Studies using direct repair reported the lowest mean extensor lag of 0°. Only two studies reported patients' postoperative quadriceps strength with one study using hamstring tendon(s) grafts reporting quadriceps strength to comparable to contralateral,[26] while one study using BTB graft reported mean quadriceps strength as 3.07/5.[45] This result is in accordance with Pengas et al.'s review on knee extensor mechanism injuries, which noted residual loss of quadriceps strength as an expected outcome after chronic tears.[1]

Patient-reported outcome measures improved from preoperative levels in all chronic patellar tendon rupture studies that reported them. Lysholm and IKDC scores were the most reported patient-recorded outcome measure (PROM) appearing in 4 out of 12 studies each. Temponi et al.'s patients treated with BTB graft achieved the greatest improvement in Lysholm score from their preoperative state with an improvement of 33.6 points.[45] Jabalameli et al.'s patients treated with hamstring(s) tendon grafts achieved the greatest improvement in IKDC score from their preoperative state with an improvement of 61 points.[21] Gilmore et al.'s review found the Hospital for Special Surgery Knee Score to be the most common PROM reported in studies on chronic patellar tendon repair and found a study using a synthetic ligament to have the highest score.[2] However, this previous review included patients with previous total knee arthroplasty, explaining their absence from our review.

Complications after chronic patellar tendon reconstruction were common with an overall complication rate of 47%. Studies using autogenous hamstring(s) tendon grafts reported the most complications with persistent knee pain being the most common complication. Additionally, only superficial infections and failure of a graft were reported in patients treated with an autogenous hamstring(s) tendon graft.[14] This is in conflict with the findings of Gilmore et al.'s review, which reported no instances of failure in studies using autogenous grafts for chronic patellar tendon reconstruction and a complication rate of only 6%.[2] Wire breakage was a commonly reported complication in studies that used wire for augmentation of the graft. However, there were only a few cases in which this was symptomatic and required removal.[21] No complications were reported in studies that used Achilles tendon or BTB grafts.

Interestingly, two studies treated chronic injury of the patellar tendon using direct repair with no major complications, which differed from previous reports on this repair method.[2] Direct repair of chronic patellar tendon injuries is typically rare because of contracture of the quadriceps and lack of viable tissue. This result shows that direct repair and augmentation with cerclage wire is a viable option for treating chronic patellar tendon ruptures in cases where contracture is not severe and viable tissue remains.

Limitations

This study has several limitations. With only case series included, our review constitutes level IV evidence. This is due to a lack of high-level evidence for chronic patellar tendon injuries. Second, outcomes included in this review were heterogeneous. This not only made comparison between studies difficult, but also prohibited any sort of meta-analysis of the data. Finally, the small sample size of this study challenges the reliability of results.

Conclusion

In this study, we found that all reconstructive methods described in the literature can produce satisfactory outcomes with improved function, strength, and minimal complications after chronic patellar tendon ruptures. Because of study heterogeneity and low levels of evidence, consensus cannot be reached on a single superior reconstruction method.

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Appendix Table 1. Demographic and Surgery Information for Studies Using Both Autologous and Allogenic Hamstring Tendon(s) Grafts

Author(s)	Number of Patients	Age	Sex	Age of Injury	Follow-Up Time	Graft Type	Augmentation	Graft Fixation
Maffulli et al.[32]	19	46	16 Male, 3 Female	3.8 months	5.8 years	Autograft		Transosseous tunnels in tibia and patella with interference screw in tibial tunnel
Jabalameli et al.[21]	6	37	5 Male, 1 Female	16.4 months	7.2 months	Autograft	Fiberwire and wire	Transosseous tunnels in tibia and patella
Abdou[3]	17	30	14 Male, 3 Female		21 months	Autograft	Stainless steel wire	Transosseous tunnels in tibia and patella
Jain et al.[23]	9	31.5		17 weeks	4.5 years	Autograft		Transosseous tunnels in tibia and patella
Sundararajan et al[43]	7	41.8	6 Males, 1 Female	9 months	40.7 months	Autograft		Transosseous tunnels in tibia and patella
Friedman et al.[14]	11	46.6	8 Male, 3 Female	8 months	54.9 months	Autograft		Transosseous tunnels in tibia and patella with suture anchor

Appendix Table 2. Functional Outcomes Reported for Studies Using Both Autologous and Allogenic Hamstring Tendon(s) Grafts

Author(s)	Range of Motion (°)	Extensor Lag (°)	Quadriceps Strength	Thigh Girth (ΔCm)	Insall-Salvati Ratio	Canton-Deschamps Index
Maffulli et al.[32]	132 flexion				1.5	
Jabalameli et al.[21]	3-118	3			1.06	
Abdou[3]						
Jain et al.[23]	0-149				1.17	
Sundararajan et al.[43]	125 Flexion	0	4.7/5	0.5	1.08	
Friedman et al.[14]	0-117					0.98

Appendix Table 3. Patient-Reported Outcome Measures for Studies Using Both Autologous and Allogenic Hamstring Tendon(s) Grafts

Author(s)	Preoperative Lysolhm Score	Lysholm Score	KOOS	Preoperative IKDC	IKDC	Preoperative VAS	VAS	Preoperative CKRS	CKRS	Preoperative Kujala Score	Kujala Score	PROMIS
Maffulli et al.[32]								44.5	84	42	81	
Jabalameli et al.[21]				23.7	84.7			26.4	88.4			
Abdou[3]	60	85										
Jain et al.[23]		94.4										
Sundararajan et al.[43]		92.4		46.8	86.8						94.5	
Friedman et al.[14]			64.1 Pain, 55.8 Symptoms, 61.5 ADL, 27.8 Sports, 34.1 QOL			4.3	2.7					46.9 ± 8.7 Mental health score, 42.0 ± 9.8 Physical health score

CKRS, Cincinnati Knee Rating System; IKDC, International Knee Documentation Committee score; KOOS, Knee injury and osteoarthritis outcome score; KSS, Knee society score; PROMIS, Patient-Reported Outcomes Measurement Information System; SF-36, 36-item Short Form Health Survey Questionnaire; VAS, visual analogue scale.

Appendix Table 4. Complications for Studies Using Both Autologous and Allogenic Hamstring Tendon(s) Grafts

Author(s)	Complications
Maffulli et al.[32]	9 degenerative changes of patellofemoral joint, 1 lateral aspect of patella partially breached, 1 anterior aspect of tibial tuberosity was partially detached, 5 hypoesthesia and numbness over anterior aspect of knee, 3 persistent anterior knee pain
Abdou[3]	12 patients with pain, 3 patients with swelling
Jabalameli et al.[12]	6 wire breakages with 2 requiring removal
Sundararajan et al.[43]	knee tightness and numbness
Friedman et al.[14]	1 persistent contracture, 1 superficial infection, 1 failed reconstruction

Appendix Table 5. Demographic and Surgery Information for Studies Using Achilles Tendon Graft

Author(s)	Number of Patients	Age (years)	Sex	Age of Injury	Follow-Up Time	Graft Type	Augmentation	Graft Fixation
Karas et al.[26]	11	38	8 Male, 3 Female		42 months	Allograft		Bone block was fixed to tibia with AO screws. Achilles tendon passed through transosseous tunnel patella and sutured at superior pole.

Appendix Table 6. Functional Outcomes Reported for Studies Using Achilles Tendon Graft

Author(s)	Range of Motion (°)	Extensor Lag (°)	Thigh Girth (ΔCm)
Karas et al.[26]	1-122	2	1.5

Appendix Table 7. Demographic and Surgery Information for Studies Using BTB Graft

Author(s)	Number of Patients	Age	Sex	Age of Injury	Follow -up Time	Graft Type	Augmentation	Graft Fixation
Temponi et al.[45]	7	33	Male	16.3 months	41.3 months	Autograft	Cerclage wire	Bone blocks were fixed to tibia and patella with screws.
Karas et al.[26]	3	50	Male		67 months	Allograft	Cerclage wire	Bone block was fixed to patella with K-wires. Bone block was fixed into tibial tubercle with AO screws.

Appendix Table 8. Functional Outcomes Reported for Studies Using BTB Graft

Author(s)	Range of Motion (°)	Extensor Lag (°)	Quadriceps Strength	Thigh Girth (ΔCm)	Canton-Deschamps Index
Temponi et al.[45]	1-127	1	3.07	3.6	1.2
Karas et al.[26]	6-121	6		1.2	

Appendix Table 9. Patient-Reported Outcome Measures for Studies Using BTB Graft

Author(s)	Preoperative Lysholm Score	Lysholm Score	Preoperative Tegner Activity Score	Tegner Activity Score	Preoperative IKDC	IKDC
Temponi et al.[45]	45.4	79	1	4	45.5	64.5

IKDC, International Knee Documentation Committee score.

Appendix Table 10. Demographic and Surgery Information for Studies Using Direct Repair

Author(s)	Number of Patients	Age	Sex	Age of Injury	Follow-Up Time	Graft Type	Augmentation
Casey, Jr., and Tietjens[8]	4	29	Male		2 years	Direct repair	1.5-mm wire
Mahmoud Jabalameli et al.[21]	2	24	2 Male	3.5 months	3 years	Direct repair	No. 2 FiberWire

Appendix Table 11. Functional Outcomes and Patient-Reported Outcome Measures Reported for Studies Using Direct Repair

Author(s)	Range of Motion (°)	Extensor Lag (°)	Insall-Salvati Ratio	Preoperative IKDC	IKDC	Preoperative CKRS	CKRS
Casey, Jr., and Tietjens[8]	112.5	0					
Mahmoud Jabalameli et al.[21]	120	0	0.93	13.8	82.8	18	83.5

CKRS, Cincinnati Knee Rating; IKDC, International Knee Documentation Committee score. System.