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ORIGINAL STUDY

Outcome of surgery for chronic patellar tendinopathy: A systematic review

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There is no consensus on how to best surgically treat chronic patellar tendinopathy. This systematic review investigates the surgical treatment for chronic patellar tendinopathy, and the outcomes.

A database search was performed to identify all relevant articles, to which exclusion criteria were then applied. Data was extracted from 24 studies, and the outcomes were then systematically reviewed.

The results showed that the success rate of surgery for patellar tendinopathy is generally over 77%. Return to sports rates are better for proximal tendon patients who undergo bony procedures. Patients return to sports faster if they undergo arthroscopic procedures, and fewer complications are described. Studies that did not involve any procedure on the proximal tendon did not produce a different result to studies where the tendon was operated on. We found no effect of post-operative immobilisation on outcome.

Based on the included studies, surgery gives satisfactory results in the treatment of patellar tendinopathy. There is a lack of high-quality evidence on the effects of surgery and post-operative rehabilitation regime on chronic patellar tendinopathy, as well as lack of objective outcome measures.

Keywords : Patellar tendon ; tendinopathy ; surgery ; systematic review

INTRODUCTION

Patellar tendinopathy is common amongst athletes whose sports involve frequent jumping or weight training *(9,14,26)*. For many athletes, it has been a burden throughout their sport career or even the primary cause to end it[24]. Patellar tendinopathy an overuse syndrome caused by repetitive stresses of the extensor mechanism *(5)*. Overloading the tendon leads to micro-trauma, with micro-lesions appearing through the failure of cross links, resulting in collagen fibres sliding past one another *(24)*. The micro-lesions occur most commonly at the bone-ligament junction at the proximal part of the patellar tendon, although some reports of mid and distal patellar tendinopathy have been published *(11)*. These micro-lesions, if not healed completely

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(6), can lead to localised collagen degeneration and subsequent mucoid degeneration or fibrosis *(20)*.

Evidence has shown that chronic patellar tendinopathy does not involve any inflammation *(13,16),* and treatment is aimed at combating collagen breakdown rather than inflammation *(13)*. The term 'tendinosis' means degeneration of the tendon, and should not be used until an excision biopsy has been examined by a pathologist as the term implies a specific, histopathologically proven condition *(16)*. The term 'jumper's knee' is also regularly used, but this term does not indicate the affected tissue and also includes other peripatellar pain syndromes such as patellofemoral pain syndrome or hoffitis *(24)*. We therefore suggest using the term 'tendinopathy' in clinical situations to describe the combination of pain, swelling, and impaired performance resulting from tendon over-use *(16)*.

There is no consensus as to how successful surgical treatment is, or what surgical technique is best. Most physicians suggest an initial course of conservative treatment, such as exercises, anti-inflammatory medication and injections *(23)*. If these treatments fail, then surgery is usually performed. Open patellar tenotomy is the most widely described, and is the procedure against which others are compared[8]. However it has been hypothesised that arthroscopic tenotomy may provide similar results to open tenotomy, with the added benefit of a quicker return to sport *(2).*

This systematic review will look at the surgical outcomes for chronic patellar tendinopathy and aim to answer these questions.

Does the outcome vary depending on the location of the pathology?

Does the surgical procedure and approach affect the outcome?

Are there any adverse effects of earlier mobilisation post-operatively?

MATERIALS AND METHODS

A systematic review of available literature was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Guidelines. This search was completed on 10th October 2014 using search databases MEDLINE, Google Scholar, Cumulative Index to Nursing and Allied Health Literature (CINHal) and EMBASE to identify all the papers providing surgical outcomes for chronic patellar tendinopathy. The search was restricted to studies in English that concerned surgical outcomes in human patients only. Subject headings used in the search were "tendinopathy," "tendon," "tendon injuries," "patellar ligament," "knee injuries," "tendinitis," and "patella." The key search terms used were "patellar tendon," "tendinosis," and "jumper's knee." Sub-headings used were "surgery," "pathology," and "physiology." The search results were sorted through to extract those studies that concerned chronic patellar tendinopathy, and the abstracts of these were then screened to identify those which provided surgical outcomes for this condition. To ensure that no papers were missed, the references used in the papers found were assessed for whether they could be included.

A total of 55 papers were collected, and was reduced to 24 when the exclusion criteria were applied *(1,2,4,6,7,10-12,15,17-19,21,22,24-33)*. Papers were excluded if 1) there were fewer than 10 subjects in the study, as this may compromise the reliability of the study, 2) the subjects were followed up for, on average, less than 12 months, as this provides a reasonable amount of time to observe the outcomes of surgery, 3) they included complete tendon ruptures, as these may have had a different aetiology, 4) subjects had undergone additional surgery for a different condition, as this could distort the surgical outcomes for patellar tendinopathy.

Data extracted from the papers included demographic data, location and number of tendons involved, number of patients, follow-up, duration of symptoms and pre-operative imaging (Table I). Table II outlines the surgical procedure and the post-operative rehabilitation. Table III contains data on complications, outcome scores, return to sports rates and durations, and post-operative imaging.

RESULTS

The 24 studies included in our review ranged from 1986 to 2014. Twenty-two studies were level IV prospective, retrospective or observational stu-

dies, and two studies were randomised controlled trials. The study by Bahr et al (2006) compared open surgical treatment with eccentric strength training, and Willberg et al (2011) compared arthroscopic surgical treatment with sclerosing polidocanol injections. Relevant data for the surgical cases was extracted and used in our systematic review. Although one study *(19)* did not provide any information on gender, the male to female ratio in the remaining 23 studies was 4.6:1. The average age of patients for the study on distal tendon involvement *(28)* was 24 years (range 12-32 years). For the remaining studies the average age was 26.9 years (range 15-59 years). The patients were followed up for a mean duration of 44.4 months (range 6-180 months). Most studies had a follow-up ranging from 86% to 100%. Maffulli et al (1999) had a follow-up rate of 62%, Pascarella et al (2014) had a follow-up rate of 45% at 10 years, and Fritscay et al (1993) did not state their follow-up rate. Twenty studies gave duration of symptoms before surgery and this averaged at 23 months (range 4-240 months). Apart from one study *(25)*, all other imaged their patients pre-operatively. These included radiographs (eight studies), ultrasound scans (USS) (14 studies), Magnetic Resonance Imaging (MRI) (12 studies), colour duplex imaging (two studies), and a Computerised Tomography (CT) scan (one study).

The surgical approach and procedure varied. Ten studies had no complications, five studies did not mention complications, and two did not specify the number of patients with the listed complications. The remaining seven studies listed 46 complications. There were a number of post-operative outcome measures used including Victorian Institute of Sport tendon study group Assessment (VISA) (six studies), Visual Analogue Score (VAS), modified jumper's knee classification according to Blazina, and modified Kelly classification (five studies each), Lysolm score (three studies), and Kujala score (two studies). Scores used once included the Tegner score, Roles and Maudsley classification, subjective scores and classifications designed by individual authors and detailed in the papers. A consistant outcome measure recorded in all but one paper was percentage return to sports to a previous level, and 14 studies stated duration. Follow-up imaging was only performed in seven studies. Only one study reported appearances as almost normal *(7)*, and only one study reported a correlation between USS appearance and clinical outcome *(30)*. The study by Coleman et al (2000) showed that the appearance of the tendon on USS remained abnormal in over 70% of cases at follow-up, and sonographic appearances did not correlate with clinical outcome.

Does the outcome vary depending on the location of the pathology?

Twenty studies solely dealt with proximal tendons (732 tendons, 688 patients), three studies *(17,19,30)* contained a varying combinations of locations (117 tendons, 112 patients), and one study *(28)* included only distal tendons (24 tendons, 23 patients). Although it was not possible to isolate the results for different locations from these individual studies, one study *(30)* did state in their results that patients with insertional tendinopathy fared significantly less well than patients with tendinopathy of the main body.

The weighted average of return to sports at a previous level rate was 77.1 % (range 15.8-92.5%) for the proximal tendon studies, 79.4% (range 66-91%) for the combined studies, and 100% for the single study on distal tendons. There was no statistically significant difference between the proximal tendon and the combined tendon studies (p=0.31). No valid surgical comparison could be made with the single study on distal tendons. There was also no significant difference in the weighted average time taken for return to sports at a previous level for the proximal tendon studies (4.9 months, range 1-18 months) and the combined studies (6.1 months, range 1.5-12 months) (p=0.32).

Does the surgical procedure and approach affect the outcome in the proximal tendon?

Procedure on the tendon:

Although 21 studies included procedures performed on the tendon, three arthroscopic studies did not involve any procedure on the tendon. Lurbach

et al (2008) performed a bony resection of the lower pole of the patella, Willberg et al (2011) debrided the infrapatellar fat pad, and Maier et al (2014) debrided the synovium and the infrapatellar fat pad. Results on return to sports were not provided for the last study.

There was no significant difference between the weighted average of return to sports at a previous level rate for the studies where tendon procedures were performed (76.5 %, range 45-92.5%), and the two studies where no tendon work was done (83.6%, range 77-95%) (p=0.19). There was also no significant difference in the weighted average time taken for return to sports at a previous level for the studies where tendon procedures performed (5.1 months, range 1-18 months) and the studies where no tendon work was done (4.4 months, range 1.5-12 months) (p=0.21).

Performing a bony procedure:

A bony procedure was always performed in seven studies on the proximal tendon, and involved debridement, resection or denervation of the inferior patella pole. Bony procedures were also performed selectively in seven studies if there were osteophytes, bony erosions, bone marrow oedema, or lesions present at the bone-tendon junction. Bony procedures were not performed in five studies on the proximal tendons.

The weighted average of return to sports at a previous level rate was 84.9 % (range 77-95%) for studies where bony procedures were always performed, and 68.7% (range 45-89%) for the studies where bony procedures were not performed. This difference was statistically significant (p=0.04). There was however no significant difference in the weighted average time taken for return to sports at a previous level for the studies always involving a bony procedure (3.9 months, range 1.5-12 months) and those never involving it (7 months, range 2-18 months) (p=0.12).

Open or arthroscopic approach:

Fifteen studies used an open procedure and six studies used an arthroscopic procedure. Two studies *(2,4)* used both open and arthroscopic procedures. It was not possible to determine if Peer et al (2003) used an open or arthroscopic procedure. Coleman et al (2000) compared the outcomes in 29 open patellar tenotomies and 25 arthroscopic patellar tenotomies and found no significant differences in outcome. The open procedure generally involved a longitudinal tenotomy and debridement of abnormal tissue including calcifications, cysts and nodules. Longitudinal cuts to stimulate tendon repair, and synovectomies were performed in selected cases, as was the use of USS to detect the area of abnormality. The arthroscopic procedure was generally performed through the anterolateral portal and involved shaving of the abnormal tendon and the dorsal soft tissue including the synovium and infrapatellar fat pad.

There was no significant difference between the weighted average of return to sports at a previous level rate for the arthroscopic studies (79.7 %, range 46-95%), and the open studies (76.6%, range 15.8-92.5%) (p=0.35). There was however a significant difference in the weighted average time taken for return to sports at a previous level with the time for arthroscopic studies (3.8 months, range 1-18 months) being significantly lower than open studies (5.5 months, range 2-12 months) (p=0.04). The five arthroscopic studies that stated the number of complications described only one, whereas the nine studies describing the open procedures detailed seven complications.

Are there any adverse effects of earlier mobilisation post-operatively?

The post-operative rehabilitation regime ranged from long leg cast immobilisation for up to eight weeks to no immobilisation.

For the proximal tendons, there was no significant difference between the weighted average of return to sports at a previous level rate for the studies where no immobilisation was used (78.3 %, range 45-95%), and where the limb was splinted (81.4%, range 58-92.5%) (p = 0.36). There was also no significant difference in the weighted average time taken for return to sports at a previous level for the studies without immobilisation (5.2 months, range 1-18 months) and with (4.5 months, range 2-12 months) (p = 0.32).

DISCUSSION

For patellar tendinopathy, a six- to seven-fold greater extent of proximal tendon involvement, an average age in the mid- to late-twenties, and the four- to five-fold greater incidence in males correspond with our experience.

Pre-operative radiographs, USS and MRI scans were often normal. Radiographs identified ostephytes, calcification and degenerative changes. USS identified hypoechoic areas typically on the dorsal aspect of the tendon, widening of tendon, paratendonitis, and features of degeneration including irregular fibres, calcifications, cysts, nodules and paratendonitis. MRI scans identified hypodense areas, again typically on the dorsal aspect, thickening, partial tears and necrosis of tendon, and features of degeneration including cysts, nodules. It was useful for identifying increased signal in bone and associated pathologies e.g. bursitis. Colour Doppler identified increased vascularisation on the dorsal aspect, both inside and outside, of the tendon including the vessels entering the infrapatellar fat pad. At least three of the studies included in the review involved bone and soft tissue debridement adjacent to the tendon, but not of the tendon itself. The CT scan did not contribute to the other investigations.

In our review, the average return to sports at previous level rates were 77% for proximal tendinopathy (19 studies), 79% for various combinations (three studies), and 100% for distal tendinopathy (one study). Our results are comparable to those of a previous systematic review carried out in 2007 that included only 10 studies *(9)*. They reported a success rate of 87.47%, and return to sports rate of 71.28%. A more suitable outcome measure, used in 25% of our studies, is the VISA score. It measures the pain and disability in patellar tendinopathy from 0 (maximal disability and pain) to 100 (asymptomatic) *(12)*. The condition of the patient can be measured using this score both pre- and post-operatively, and takes into account the severity of clinical symptoms as well as how the patient performs on tests of function and their level of sporting participation *(3)*.

Sarimo et al (2007) included only distal tendons and included patients as young as 12 years old. They did not include any formal outcome measures but did state that all of their patients returned to sports by 2.8 months with no or some symptoms. The three studies on combinations of patellar tendinopathy locations showed that surgery gave satisfactory results. As there is a lack of studies on the surgical treatment of mid and distal patellar tendinopathy, only the proximal tendinopathy was assessed further. Although proximal, mid, and distal patellar tendinopathy may have different aetiologies, it appears that they all respond to surgery. The return to sport rates for proximal tendinopathy and the tendinopathies in other locations were similar.

Willberg et al (2011) compared arthroscopic surgical treatment with colour doppler-guided sclerosing polidocanol injections. Twenty-six patellar tendons underwent ultrasound and colour Doppler-guided arthroscopic shaving and had a significantly lower VAS score at rest and during activity, less pain and were more satisfied with the treatment result compared with the patients in the sclerosing injection group. They also returned to sports faster. Two further studies did not perform any intervention on the tendon. Lurbach et al (2008) performed an arthroscopic bony resection of the lower pole of the patella. Twenty patients were evaluated at 24 months after surgery and showed significant improvements in the Lysholm, Tegner and Kujala scores, and the VAS for pain, function, and satisfaction. Maier et al (2014) evaluated the mid- and long-term efficacy of the arthroscopic debridement of the synovium and the infrapatellar fat pad in 35 competitive athletes followed-up for a minimum of 24 months. The VISA and Blazina scores, subjective knee function, pain VAS improved significantly. Ninety-seven percent of patients obtained excellent or good functional outcomes with a mean follow-up of 4.4 years, and 76.7% of the athletes were able to perform sports at previous levels without any symptoms by 4.4 months. These three studies suggest that arthroscopic debridement of structures other than the tendon produces good results and is a viable alternative to tendon debridement.

The return to sports results were significantly better for the seven studies where bony procedures were performed than in the five studies where bony procedures were not performed. This is supported

by a previous study that have suggested a success rate of 92% where patella tip resection or drilling was performed compared with 71% where no bony procedures were performed *(3)*. Our analysis only included studies on proximal tendinopathy and may not be valid for mid and distal tendinopathy.

Two studies *(2,4)* used both open and arthroscopic procedures. Coleman et al (2000) compared the outcomes in 29 open patellar tenotomies and 25 arthroscopic patellar tenotomies. There were no significant differences in the outcome measures but they suggested that arthroscopic surgery may give a quicker return to sport time. Curuculo et al (2009) performed a retrospective multicenter study including 64 patients, 10 of whom underwent arthroscopy. Again, there was no difference in outcome but the authors suggested that it took longer after an open procedure to return to sports. Arthroscopic surgery is associated with minimal complications, and reduced postoperative pain and stiffness. We found that arthroscopy was associated with a significantly faster return to sports and fewer complications.

The post-operative rehabilitation regime ranged from long leg cast immobilisation for up to eight weeks to no immobilisation, but did not appear to affect the success of the procedure. No study explained the rationale or provided any evidence for a more restricted rehabilitation regime.

CONCLUSION

This systematic review has shown that surgical treatment generally provides good success rates for patellar tendinopathy. More evidence for the treatment of mid and distal patellar tendinopathy is needed. We have shown that a bony procedure is associated with better return to sports rate for proximal tendons, but this may not apply to mid and distal tendinopathy. Although we have shown that arthroscopic procedures are associated with a faster return to sports and fewer complications, we encourage further studies to assess whether arthroscopic procedures give better results than open procedures. Interestingly, studies that did not involve any procedure on the tendon did not produce any different results to studies where the tendon was operated on. More work on the pathogenesis of this condition will hopefully improve our understanding and management of this condition.

There is a lack of high-quality evidence on the effects of surgery and post-operative rehabilitation regime on chronic patellar tendinopathy, as well as lack of objective outcome measures. Only two of the 24 studies in our review were randomised controlled trials. The retrospective case series introduce the possibility of recall bias and the loss of key information. The association between clinical and radiological outcome also needs to be better defined.

Table I. — Demographic data for the included studies included in the review
RCT: Randomised Controlled Trial, USS: Ultra-Sound Scan, MRI: Magnetic Resonance Imaging

Authors	Study design	Location	Number of tendons	Number of patients	Age (years)	Gender (male : female)	Time of follow-up (months)	Percent follow-up	Duration of symptoms (months)	Imaging and findings
Bahr et al (2006)[1]	Level I, therapeutic RCT	Proximal	20	20	30 (19-49)	17:3	12	100	35 (6-120)	MRI: Thickening and increased signal intensity
Lorbach et al (2008)[15]	Level IV, therapeutic case series	Proximal	20	20	28.1 (17-43)	18:2	24	100	25 (12-48)	Radiographs: Traction osteophytes. MRI: Hypodense areas at posterior proximal tendon
Willberg et al (2007)[32]	Level IV, prospective case series	Proximal	15	15	30 (18-49)	12:3	13	100	27 (9-78)	USS: localised widening, irregular fibre structure, focal hypoechoic areas in dorsal proximal tendon. Colour Doppler: neovascularisation inside and outside dorsal proximal tendon. Vessels entering from fat pad posterior to tendon.
Ferretti et al (2002)[6]	Level IV, retrospective case series	Proximal	33	27	26.9 (18-31)	24:3	96 (60-132)	87	33 (13-96)	USS (8 knees), MRI (4 knees), both (10 knees) (none in 11 knees): Degeneration of tendon near inferior pole of patella
Karlsson et al (1992)[11]	Level IV, retrospective case series	Proximal	91	81	24 (18-38)	61:20	(12-24)	100	-	USS: Cone-shaped, focal hypoechoic lesion in centre of proximal tendon at the tip of patella. Length of lesion on longitudinal scan exceeded 5mm
Shelbourne et al (2006)[29]	Level IV, prospective case series	Proximal	22	16	19.7 (16-25)	10:6	50 (18-84)	88	(12-84)	MRI: Thickened patellar tendon with necrosis and often partial tearing of posterior half with compensatory enlargement of anterior half
Peers et al (2003)[24]	Level IV, retrospective case series	Proximal	14	14	27.4 ± 6.8	11:3	26.3 (16-48)	86	12.9 (6-21)	USS: Hypoechoic degenerative region within thickened proximal tendon in all patients, and small intratendinous calcifications in half
Coleman et al (2000)[2]	Level IV, retrospective case series	Proximal	29 Open	25	27 ± 8	22:3	45.6 ± 15.6	93	18 (Median)	USS
			25 Arthroscopic	23	25 ± 6	17:6	51.6 ± 15.6	93	20 (Median)	

Authors	Study design	Location	Number of tendons	Number of patients	Age (years)	Gender (male : female)	Time of follow-up (months)	Percent follow-up	Duration of symptoms (months)	Imaging and findings
Khan et al (1999)[12]	Level IV, prospective and retrospective case series	Proximal	15 Prospective	13	31 (20-42)	13:0	24	100	36 (9-96)	USS: Focal hypoechoic area with increase tendon diameter in all, particularly on the deep surface. MRI: region of increased signal intensity
			18 Retrospective	17	27 (18-41)	16:1	46.8 (24-68.4)	100	18 (6-48)	None
Pierets et al (1999)[25]	Level IV, retrospective case series	Proximal	26	26	31 (21-50)	17:9	50.4	100	22.8 (4-96)	None
Verheyden et al (1997)[31]	Level IV, retrospective case series	Proximal	31	29	29 (19-53)	27:2	51 (36-72)	100	16 (6-24)	USS: Tendon thickening , hypoechoic zone or cysts
Popp et al (1997)[26]	Level IV, retrospective case series	Proximal	11	9	20.2 (17-22)	8:1	25.2	100	38.4 (24-72)	MRI: Focal thickening in proximal third (all cases), middle third (5 cases), medial (10 cases) and central (1 case) tendon
Fritschy et al (1993)[7]	Level IV, prospective case series	Proximal	21	21	26	19:2	(12-84)	-	-	USS: Irreversible lesions compatible with stage 3 patellar tendinitis
Karlsson et al (1991)[10]	Level IV, retrospective case series	Proximal	86	86	25 (15-51)	72:6	60 (24-180)	91	-	USS
Orava et al (1986)[21]	Level IV, retrospective case series	Proximal	34	34	26.1 (17-39)	28:6	54 (6-96)	100	20.4	Radiographs: 12 normal, 7 tendon thickening, 1 area of degeneration suspected. USS: 1 normal, 3 clear focus, 7 tendon thickening.
Maffulli et al (1999)[17]	Level IV, retrospective case series	Middle or Whole	45	45	25.3 (16-46)	36:9	42 (27-74)	62	20 (15-62)	USS, MRI, CT: 37 cases with area of degeneration, 8 cases with whole tendon thickened
Sarimo et al (2007)[28]	Level IV, retrospective case series	Distal	24	23	24 (12-32)	19:4	42 (6-96)	100	-	Radiographs: Normal. USS: Hypoechoic lesion in distal tendon. MRI: Bone edema tibial tubercle in 3 out of 7 cases

Authors	Study design	Location	Number of tendons	Number of patients	Age (years)	Gender (male : female)	Time of follow-up (months)	Percent follow-up	Duration of symptoms (months)	Imaging and findings
Curuculo et al (2009)[4]	Level IV, retrospective case series	Proximal	64	64	30 (17-59)	55:9	22 (6-116)	100	36 (2-240)	Radiographs: Normal (52%), calcification inferior pole patella (44%). USS in 12 cases: Hypervascularisation at tendon insertion (50%), nodule (25%), cyst (12%). MRI in 55 cases: Hypervascularisation (18%), nodule (46%), cyst (9%), partial thickness tear (18%), bursitis (9%).
Martens et al (1982)[19]	Level IV, retrospective case series	Mixture	34	29	23.4 (15-32)	-	At least 24	100	17 (6-24)	Radiographs
Testa et al (1999)[30]	Level IV, prospective case series	Proximal or Middle	38 (21 Proximal, 17 Middle)	38	31.6 (18-57)	29:9	28.1 (24-67)	89	21.8 (11-57)	Ultrasonography: Paratendonitis (13 cases), intratendinous focal lesion (22 cases), tendon thickened over at least 2cm but no intratendinous focal lesion (9 cases), normal (7 cases)
Maier et al (2014)[18]	level IV, prospective case series	Proximal	35	35	27.6 (SD7.4)	27:3	53 (SD 36)	86	at least 6 months	Radiographs, USS, MRI: Hyperintensity or thickening, or both, of poorly defined proximal tendon
Pascarella et al (2011)[22]	level IV, prospective case series	Proximal	73	64	24.6 (16-35)	40:24	36, 60 (43 cases), 120 (29 cases)	100 (3 years), 67 (5 years), 45 (10 years)	6.4 (5-8)	USS: Hypoechoic regions corresponding to tendon tenderness. MRI: Increased tendon volume and altered signal near lower pole patella.
Santander et al (2012)[27]	Level IV, observational study	Proximal	23	23	29	22:1	58 (12-121)	100	12 (6-24)	Radiographs, MRI: Proximal tendon pathology
Willberg et al (2011)[33]	Level 1 RCT (relevant surgical data extracted)	Proximal	26	26	27 (17-36)	24:2	20 (8-60)	96	24 (6-60)	USS: Structural tendon changes. Colour Doppler: High blood flow on dorsal proximal tendon.

Table II. — Surgery and post-operative rehabilitation for the studies included in the review

Authors	Surgical procedure	Paratenon	Bony procedure	Open/arthroscopic surgery	Post-operative rehabilitation
Bahr et al (2006)[1]	Longitudinal split tenotomy and debridement of tendon by a wedge-shaped full-thickness excision	Paratenon split, then closed	No	Open	Gradual increase in movement during rehabilitation programme, for 6 weeks. No immobilisation.
Lorbach et al (2008)[15]	No debridement of tendon	No	Resection of lower patellar pole	Arthroscopic	Avoidance of extreme flexion with weight bearing for 6 weeks.
Willberg et al (2007)[32]	Arthroscopic shaving of soft tissues dorsal to proximal tendon, and area of tendinosis	Not mentioned	If osteophytes present	Arthroscopic	Increase in training for 2 weeks, and then return to sport if no marked muscle atrophy. No immobilisation.
Ferretti et al (2002)[6]	Longitudinal splitting of the tendon, excision of any abnormal tissue	Paratenon split, then closed	Resection and drilling of the inferior pole of patella	Open	Knee brace applied in full extension for 4 weeks
Karlsson et al (1992)[11]	Longitudinal excision of the damaged tissue	Paratenon split, then left open	Bony curettage if lesion at bone-ligament junction or erosion of the distal patellar tip (4 cases)	Open	Immobilised in a long leg cast for 4 weeks
Shelbourne et al (2006)[29]	Tendonectomy of the necrotic tissue with multiple longitudinal cuts in remaining tendon	Not mentioned	No	Open	Immediate range of motion, full flexion, and immediate high-repetition, low-resistance quadriceps muscle exercise. No immobilisation.
Peers et al (2003)[24]	Tenotomy of the patellar tendon with resection of degenerative tendon tissue	Not mentioned	Not mentioned	Not mentioned	Initial immobilisation period
Coleman et al (2000)[2]	Open: Proximal tendon split longitudinally over area of greatest pathologic changes as identified clinically and sonographically, and abonormal tissue resected.	Split, then closed	No	Open	Full flexion avoided
	Arthroscopic: Abnormal tissueincluding tendon debrided using a power shaver through the anterolateral portal	Not mentioned	No	Arthroscopic	

Authors	Surgical procedure	Paratenon	Bony procedure	Open/arthroscopic surgery	Post-operative rehabilitation
Khan et al (1999)[12]	Proximal tendon split longitudinally over the area of greatest pathologic involvement as identified clinically and sonographically. Macroscopically abnormal tissue resected.	Paratenon split, then closed	No	Open	Not mentioned
Pierets et al (1999)[25]	"En bloc" resection technique: Proximally based triangular piece of the tendon excised below inferior pole of the patella.	Paratenon split, then closed	Sharp lower patella pole smoothened	Open	Immobilised in a plaster cast for 4.7 weeks (range 3-8 weeks)
	Peignage technique (scarification): Multiple longitudinal incisions in tendon and inflammatory degenerative tissue excised.		No	Open	
Verheyden et al (1997)[31]	Resection of the pathologic tissue in a longitudinal strip	Paratenon split, then closed	No	Open	4 weeks for the first 4 cases in a long-leg cast, no immobilisation for the other cases
Popp et al (1997)[26]	Longitudinal tenotomy and abnormal tissue debrided	Paratenon split, then closed	Scarification performed at inferior pole of the patella	Open	Gradual increase in training for 12 weeks. Noimmobilisation.
Fritschy et al (1993)[7]	Bony fragment mobilised from apex of patella and underlying central third of full-thickness tendon excised to tibial tuberosity.	Paratenon split, then closed	Yes	Open	No immobilisation.
Karlsson et al (1991)[10]	Resection of the abnormal tissue performed longitundinally, and calcifications of tendon removed (2 cases)	Paratenon split, then left open	Bony curettage performed if lesion at bone-tendon interface	Open	Immobilised in a knee plaster cast for 4 weeks
Orava et al (1986)[21]	Necrotic focus excised (62%)	Thick adherent paratenon divided and excised (47%)	Bony exostosis excised from the lower pole of patella and several holes drilled (6%)	Open	No immobilisation.
Maffulli et al (1999)[17]	Focal lesion (37 cases): Longitudinal tenotomy and abnormal tissue excised. No focal lesions (8 cases): Multiple longitudinal tenotomies.	Paratenon stripped, then left open	No	Open	No immobilisation.
Sarimo et al (2007)[28]	Tendon split longitudinally over lesion and necrotic tissue excised	Paratenon split, then closed	Drilling of the tibial tubercle if bone edema on MRI (3 cases)	Open	Avoidance of extreme flexion of more than 90 degrees until 3 weeks after surgery

Authors	Surgical procedure	Paratenon	Bony procedure	Open/arthroscopic surgery	Post-operative rehabilitation
Curuculo et al (2009)[4]	Open cases (54 cases): Longitudinal tenotomies (51), bursectomy (23), synovectomy (33). Nodules, cysts and calcifications resected when found.	Not mentioned	In 39/54 cases	Open	Post-operative immobilisation in extension with a splint was prescribed in 80% of cases, lasting for an average of 23 days (0-45 days)
	Arthroscopy (10 cases): bursectomy (10), tendon debridement (4)	Not mentioned	In 2/10 cases	Arthroscopic	
Martens et al (1982)[19]	Longitudinal split with resection of the degenerated or necrotic tissue in tendon near insertion	Paratenon split, then left open	No	Open	Cast for 5 weeks
Testa et al (1999)[30]	Longitudinal tenotomy	Not mentioned	No	Open	Kept elevated for 1 day
Maier et al (2014)[18]	Local synovectomy and resection of infrapatellar fat pad	No	Bony denervation of infeior patella pole	Arthroscopic	No immobilisation.
Pascarella et al (2011)[22]	Debridement of infrapattellar fat pad and abnormal tendon	Not mentioned	Excision of lower pole of patella	Arthroscopic	0-30 degrees CPM for 1 week with increased weight bearing
Santander et al (2012)[27]	Debridement of infrapatellar fat pad and <5mm tendon	Paratenon split, then left open	Debridement of lower pole of patella	Arthroscopic	No immobilisation.
Willberg et al (2011)[33]	Arthroscopic USS assisted infrapatellar fat pad shaving	No	No	Arthroscopic	No immobilisation.

Table III. — Surgical outcome for the studies included in the review

Authors	Complications	Outcome Scores	Return to sport to previous level	Time to return to sport (months)	Follow-up imaging
Bahr et al (2006)[1]	1 chronic pain	VISA: Pre-op 30 (25-35), post-op 70 (62-78) VAS pain score for standing jump: Pre-op 4.3 (3.3-5.3), post-op 1.3 (1.0-1.7) VAS pain score for counter-movement jump: Pre-op 4.8 (3.8-5.8), post-op 1.7 (0.7-2.7) VAS pain score for leg press: Pre-op 4.1 (2.9-6.2), post-op 1.2 (0.4-2.0) 25% asymptomatic, 60% improved, 10% unchanged, 5% worse	45%	-	None
Lorbach et al (2008)[15]	None	Tegner score: Pre-op 4.4±2.9, post-op 7.95±1.6 Lysolm score: Pre-op 57.1±17.1, post-op 97.3±4.4 Kujala score: Pre-op 53.7±14.7, post-op 95.4±7.8 VAS: Pre-op 2.95 (pain), 4.3 (function), 1.8 (satisfaction); Post-op 8.5 (pain), 9.1 (function), 8.95 (satisfaction) Modified jumper's knee classification according to Blazina: Pre-op 4.4±0.8, post-op 0.6±1.1 45% desired level of activity	95%	-	Radiographs and MRI: Resection of lower patella pole and hypodense areas in proximal posterior aspect in all cases. MRI scans showed recurrent minimal traction osteophytes at the resection area in 19 out of 20 cases.
Willberg et al (2007)[32]	Not mentioned	VAS: Pre-op 80.6 (35-100), post-op 20.7 (0-89) 87% satisfied	87%	2.2 (1-3)	None
Ferretti et al (2002)[6]	1 superficial wound infection	Modified jumper's knee classification according to Blazina: Pre-op 4.21(2-5), post-op 0.72 (0-5) 70% excellent, 15% good, 3% fair, 12% poor	82%	5.5 (2-12)	None
Karlsson et al (1992)[11]	Not mentioned	Kelly classification: Post-op excellent or good in 92.5%, poor in 7.5%	92.5%	-	None
Shelbourne et al (2006)[29]	1 superficial infection 2 hematomas (1 requiring surgical drainage)	Subjective pain score (1-10): Pre-op 8.1 (7-10), post-op 1.8 (1-4) Modified Kelly classification: Post-op 69% excellent, 19% good , 12% fair	87.5%	8.1 (3-12)	None
Peers et al (2003)[24]	Not mentioned	VISA: Post-op 70.7 ± 22.2 VAS: Post-op 8 ± 3 (11 cases) Roles and Maudsley classification: Post-op 33% excellent, 25% good, 25% fair, 17% poor	58%	-	None

Authors	Complications	Outcome Scores	Return to sport to previous level	Time to return to sport (months)	Follow-up imaging
Coleman et al (2000)[2]	Swelling or bruising, dysesthesia of the skin over the incision site, and knee stiffness	VISA: Post-op 88 (22-100) Modified Kelly classification: Post-op 42% excellent, 12% good, 27% fair, 19% poor (Open)	54%	10 (4-12)	USS: 19 open group, 22 arthroscopic group. No significant difference between groups. No correlation between VISA score or time since surgery, and hypoechoic area. Appearance of the tendon abnormal in over 70%.
		VISA: Post-op 77 (38-100) Modified Kelly classification: Post-op 42% excellent, 4% good, 50% fair, 4% poor (Arthroscopic)	46%	6 (2-18)	
Khan et al (1999)[12]	None	VISA: Pre-op 22 (4-60), Post-op 69 (55-100) Conventional criteria: Post-op 47%excellent, 33% good, 20% poor (Prospective)	77%	-	USS: hypoechoic region, none reported as normal, comparison of excellent and poor outcome failed to reveal consistent differences in size or echogenicity of hypoechoic regions, or calcium presence MRI: all abnormal, in 3 cases high-signal regions less obvious than before surgery, and in 7 cases high signal remained over a substantial area. Scans with excellent outcome did not differ qualitatively from poor. Mean cross-sectional area of high-intensity abnormal signal region did not change significantly.
		VISA: Post-op 90 (55-100) Conventional criteria: Post-op 33%excellent, 56% good, 11% poor (Retrospective)	89%	-	USS: 3 of 18 tendons normal, the remainder contained hypoechoic regions (15) or calcifications (9)
Pierets et al (1999)[25]	Shooting pain under the patella, and fatigue and pressure about the knee	Post-op 15.4% pain-fee, 34.6% discomfort with rigorous exercise, 26.9% pain with mild effort, 3.8% unchanged complaints, 19.3% worse	15.8%	6	USS: Thickening of tendon by average 2.65mm (100%), Calcifications (36.4%), Inhomogeneous structure (28.6%). Compared with opposite side, tendon shorter by an average of 5.4mm (57.1%), longer by an average of 3.5mm (28.6%), or length unchanged (14.3%).
Verheyden et al (1997)[31]	None	Own classification: 84% very good, 3% good, 13% poor	87%	4.2	None
Popp et al (1997)[26]	None	Modified jumper's knee classification according to Blazina: Pre-op stage 3, post-op 64% stage 0-1, 27% stage 2, 9% stage 3	91%	-	None
Fritschy et al (1993)[7]	Not mentioned	Post-op 81% cured, 14% pain-free but unable to return to sports at pre-injury level, 5% failed	81%	-	USS: Inflammation resolved, arrangement of fibres homogenous and volume of tendon almost normal

Authors	Complications	Outcome Scores	Return to sport to previous level	Time to return to sport (months)	Follow-up imaging
Karlsson et al (1991)[10]	2 superficial wound infections	Modified jumper's knee classification according to Blazina: Pre-op stage 3 Modified Kelly classification: Post-op 91% excellent or good, 9% fair or poor Lysolm: Post-op 95 (74-100)	91%	3.7	None
Orava et al (1986)[21]	None	Own classification: Pre-op 32% reduced sporting activities, 47% no symptoms normal activities but sports not possible, 21% pain with normal activities, post-op 68% asymptomatic, 26%reduced sporting activity, 6% sports not possible	68%	-	None
Maffulli et al (1999)[17]	6 hematomas (2 superficial wound infections) 5 skin hypersensitivity 3 anterior knee pain whilst kneeling 7 morning knee stiffness in early post-operative period 1 case was operated on twice	Modified jumper's knee classification according to Blazina: Pre-op stage 3 Own classification: Post-op 82% excellent (pain resolved, return to pre-injury sporting level), 11% good (mild discomfort, return to sports at desirable level), 7% poor (discomfort with ADL, given up sports)	82%	7 (1.5-12)	None
Sarimo et al (2007)[28]	None	Own classification: Post-op 88% good (return to prior sports with no residual symptoms), 12% fair (return to prior sports with some residual symptoms)	100%	1.9-2.8	None
Curuculo et al (2009)[4]	1 unhealed wound requiring a second intervention 1 algodystrophy	Modified jumper's knee classification according to Blazina: Pre-op stage 3.65 (3-3B), 0.48 (0-3) 92% had improved patellar pain 77% had improved tendon body pain 92% had improved pain during stretching (etc) (Open)	63%	5.5 (2-12)	None
		Modified jumper's knee classification according to Blazina: Pre-op stage 3.8 (3-3B), post-op 0.8 (0-2) 100% had improved patellar pain 100% had improved tendon body pain 100% had improved pain during stretching (etc) (Arthroscopic)		4 (1-12)	

Authors	Complications	Outcome Scores	Return to sport to previous level	Time to return to sport (months)	Follow-up imaging
Martens et al (1982)[19]	Not mentioned	Modified jumper's knee classification according to Blazina: Pre-op 5 stage 4, 27 stage 3, 2 stage 2 Own classification: Post-op 62% excellent (no residual symptoms), 29% good (continue sports at same level, some pain), 9% poor (residual complaints interfering with sports)	91%	5 (3-8)	None
Testa et al (1999)[30]	3 subcutaneous hematomas, 1 superficial infection, 3 scar hypersensitivity on kneeling, 8 morning knee stiffness in early post-op period	Modified jumper's knee classification according to Blazina: Pre-op stage 3 Own classification: Post-op 42% excellent (pain resolved, return to pre-injury sporting level), 24% good (mild discomfort, return to sports at desirable level), 21% fair (discomfort limiting return to pre-injury level of sports), 13% poor (discomfort with ADL, given up sports)	66%	-	USS: Tendon thicker. In patients with excellent or good results, the tendon was isoechogenic, but In patients with a fair or poor result, areas of hyperechogenicity.
Maier et al (2014)[18]	None	VISA: Pre-op 57.3 (SD 11.4), post-op 95.1 (SD 8.2) VAS Pain: Pre-op 5.7, post-op 0.6 Modified jumper's knee classification according to Blazina: Pre-op 4 (SD 0.8), post-op 0.3 (SD 0.7) Knee function 48.8% to 90.5%.	77%	4.4 (1.5-12)	None
Pascarella et al (2011)[22]	None	Modified jumper's knee classification according to Blazina: Pre-op Stage 2 (38 patients), Stage 3 (26 patients) IKDC: Pre-op 51.6 (SD 2.9), post-op 84.2 (SD 0.1) Lysolm: Pre-op 52.3 (SD 10), post-op 92.3 (SD 7.3) VISA: Pre-op 35.3 SD 2.6), post-op 69.4 (SD 3.3)	88%	3	None
Santander et al (2012)[27]	None	Modified jumper's knee classification according to Blazina: Pre-op Stage 3 Kujala post-op 96 (64-100)	83%	-	None
Willberg et al (2011)[33]	None	VAS: Pre-op 44.6 (rest), 76.5 (activity); post-op 5 (rest), 12.8 (activity) Satisfaction: Post-op 86.8 (SD 20.8)	-	-	None

Pre-op=Pre-operative ; Post-op=Post-operative ; USS=Ultrasound scan ; VAS= Visual Analogue Scale ; VISA= Victorian Institute of Sport Tendon Study Group Assessment ; ADL=Activities of Daily Living ; SD=Standard Deviation

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