

Surgery for unilateral and bilateral patellar tendinopathy: a seven year comparative study

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Abstract

Purpose Open surgery for patellar tendinopathy allows patients with unilateral and bilateral tendinopathy to return to high levels of physical activity.

Materials Two groups of 23 athletes each underwent open surgical exploration for management of patellar tendinopathy. One group suffered from unilateral patellar tendinopathy (unilateral group), and the other group had bilateral (bilateral group) patellar tendinopathy. Maximum voluntary isometric contraction and anthropometric measures were assessed pre-operatively and at an average follow-up of seven years. The Victorian Institute of Sport Assessment (VISA)-P scoring system was also administered; functional outcomes were classified from excellent to poor according to a modification of Kelly's criteria.

Results At the final follow-up, in both groups, VISA-P scores were significantly improved compared with preoperative values, with no intergroup differences. Clinical results were excellent or good in 21 patients in the unilateral and 19 in the bilateral group. Twenty of 23 patients in the unilateral group and 17 of 23 in the bilateral group were still active in sports

($p=0.2$). In the unilateral group, at the last follow-up, thigh volume and strength were significantly improved compared with baseline, with significant difference between operated and nonoperated limbs. In the bilateral group, there were no significant differences in thigh volume and strength between the dominant and nondominant limbs both before and after the index procedure.

Conclusions This procedure is not technically demanding and provides a high rate of good and excellent outcomes in the long term.

Keywords Patellar tendinopathy · Histology · Tenotomy · Functional outcomes · Return to preinjury activity · Athletes

Introduction

Up to 14 % of elite athletes who practice jumping sports (high and long jump, basketball and volleyball) suffer from patellar tendinopathy [1]. The first approach is conservative [1–4], with encouraging results in almost 90 % of patients mildly symptomatic. In unresponsive patients, surgery is indicated [5, 6]; both open and arthroscopic procedures have been successfully proposed, but the best treatment is still unknown [5, 7]. This was a seven year follow-up study comparing clinical, functional and anthropometric outcomes of athletes who had undergone unilateral (unilateral group) vs bilateral (bilateral group) open exploration and multiple tenotomies for management of patellar tendinopathy. Since unilateral patellar tendinopathy is related to identifiable risk factors not found in subjects with bilateral patellar pathology, these conditions may have different clinical evolution. This study was designed to test the hypotheses that: (1) open surgery provides long-term relief of symptoms and allows patients with mono- and bilateral tendinopathy to resume the same level of sport activity as before the onset of symptoms; (2) patients with

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unilateral tendinopathy fare better than those with bilateral tendinopathy.

Methods

All patients were operated on after they had signed a written informed consent and after approval by the local ethics committee. All patients were operated from 1996 to 2008 by a single surgeon and are part of a cohort of 153 patients operated on by this surgeon for such pathology during that period. Only skeletally mature patients aged 18–45 were included, all with a diagnosis of unilateral or bilateral exercise-induced classic jumper's knee, defined as tendinopathy at the interface between the lower pole of the patella and the patellar tendon and proven by clinical and imaging [(high-resolution real-time ultrasonography (US) or magnetic resonance imaging (MRI)] findings and postoperative histological examination. All patients were originally referred to our care after at least a six month history of unilateral or bilateral patellar tendinopathy and failure of conservative management. Patients who had received peritendinous corticosteroid injections were also included. Patients who had undergone previous tendon surgery in either tendon and with additional knee injury (meniscal tears, osteochondral injuries, ligament insufficiency reconstruction), calcific tendinopathy, patellofemoral degenerative joint disease or symptomatic patellar instability, were excluded. Patients were also excluded if one of the following findings was present: a Q angle $> 20^\circ$, a genu valgus $> 7^\circ$, trochlear angle $> 145^\circ$ at the skyline view, patellar dysplasia 4° and 5° according to the Wiberg classification or patella alta (Insall–Salvati index > 1.2). Patients who had taken fluoroquinolones in the two years before symptom onset were excluded. Only patients with bilateral patellar tendinopathy at presentation and with both tendons operated at the same surgical sitting were included. All 23 patients who satisfied the above criteria were matched with a patient with unilateral patellar tendinopathy who practised the same sport. The bilateral patellar tendinopathy group comprised 23 athletes [average age 29.1 years; standard deviation (SD) 11.4, range 18–45], and the unilateral patellar tendinopathy group comprised 23 athletes (average age 24.3 years, SD 8.4, range 18–45).

Clinical assessment

All patients were secondary and tertiary referrals from other health-care professionals. The first author (NM) made the diagnosis in all patients from history, clinical examination and US findings. All patients were classified as affected by stage III tendinopathy according to the Blazina staging system, were involved in sports and complained at clinical examination of anterior knee pain over the area between the lower pole of the patella and the patellar tendon. Pain during isometric contraction of the quadriceps muscle was assessed

against resistance and passive maximum stretching; muscle atrophy was evaluated by measuring the circumference of both thighs 10 cm proximal to the upper pole of the patella. The alignment of the extensor mechanism was assessed clinically and on radiographs (plain and skyline views). US was performed by a certified musculoskeletal radiologist in all instances.

All 46 patients had received one to three injections of corticosteroids per each patellar tendon [unilateral, 1.3; range one to three; bilateral: 1.6 per tendon, range one to three; not significant]. In 35 patients, the injections had been administered under US guidance; in the remaining 11 patients, the corticosteroid injection had been administered posterior to the site of maximal patellar tendon tenderness without any image guidance. Seventeen patients (ten unilateral, seven bilateral, for a total of 24 tendons) had undergone shockwave therapy.

Anthropometry

A full set of anthropometric measurements was taken with the patient naked before each testing session. Weight (nearest 100 g), baseline height (nearest mm), tricipital, bicipital, subscapular and supra-iliac skinfolds bilaterally were measured. The average of measurements each side was used to determine body fat. This was calculated from the mathematical average of skinfold thickness bilaterally using equations developed by Durnin and Womersley [8]. Thigh volume and cross-sectional area of the thigh (muscle and bone) were assessed bilaterally at the level of the second segment before operation and at the latest follow-up [9, 10].

Maximum voluntary isometric contraction

Maximum voluntary isometric contraction (MVC) was measured using a custom-made apparatus [11]. Each patient was introduced to the procedure, and performed the test with the normal limb being tested first in patients with unilateral patellar tendinopathy. In patients with bilateral patellar tendinopathy, the limb with the least painful tendon was tested first. If the two tendons were equally painful, the nondominant limb was tested first. Three attempts were recorded, and the highest was used in all subsequent analyses. Each MVC lasted an average 1.5 ± 0.3 seconds, and a period of rest of 20–30 seconds was allowed between each contraction.

Surgical technique

Under general anaesthesia, the limb was exsanguinated, and a thigh tourniquet was inflated to 300 mmHg. Through a mid-line longitudinal incision, the peritendon was opened

longitudinally and separated from the underlying patellar tendon. After excision of the paratenon, the tendon was exposed and separated from Hoffa's body by blunt dissection. The tendon was palpated to locate any tendinopathic lesion, which usually presented as an area of intratendinous thickening. Three longitudinal tenotomies from the lower patellar pole to the tibial tubercle were made, and the tendinopathic areas of the tendon were excised. The tendon and paratenon were not repaired. The subcutaneous fat was juxtaposed using fine absorbable sutures, and the skin was closed with subcuticular absorbable sutures. A wool and crepe bandage was applied and kept in place for two weeks. Removed tissues were fixed in 10 % buffered formalin and sent for histologic analysis under light microscopy by a pathologist [12, 13]. Each sample was assessed using a semiquantitative grading scale ranging from 0 to 21, which considers fibre structure and arrangement, nuclei rounding, regional variations in cellularity, increased vascularity, decreased collagen stainability and hyalinisation. Each variable was scored from 0 to 3 (0 normal, 1 slightly abnormal, 2 abnormal, 3 markedly abnormal).

Postoperative rehabilitation

Immediate postoperative mobilisation with crutches was recommended, weight-bearing was allowed as tolerated and isometric exercises of the quadriceps muscles were encouraged as soon as patients could tolerate them and then performed five minutes per hour each waking hour. Patients were reviewed two weeks from surgery, when active mobilisation was encouraged. At six weeks, if full active and passive motion had been regained, patients were allowed to start concentric exercises. Eccentric exercises and running were started gradually after 12 weeks, and patients were warned not to return to full sports until at least eight months from operation. Patients were seen again at 6 months and discharged at nine months if asymptomatic and allowed to resume sport at nine months after muscle strength gains had subjectively plateaued.

Follow-up

At the last appointment, at a mean 7.1 ± 2.5 -year follow for group 1 and 6.9 ± 3.1 years for group 2, patients underwent clinical examination by a single independent investigator not involved in preoperative assessment and surgery. Patients who underwent surgery after publication of the Victorian Institute of Sport Assessment (VISA)-P score [14] were asked to complete the questionnaire on their preoperative status retrospectively. At final follow-up, outcomes were classified as excellent, good, fair or poor based on objective and subjective assessments, according to a modification of Kelly et al.'s criteria [15]. Objective measures were range of movement,

quadriceps atrophy and presence of compressive tenderness of the patella. Subjectively, patients are asked to rate the results of the procedure according to the presence of pain and return to sporting activities.

Statistics

Descriptive statistics were calculated. After assessment of the distribution with the Kolmogorov–Smirnov test, unpaired *t* tests and Mann–Whitney *U* tests were respectively used to compare parametric and nonparametric variables. The Mann–Whitney *U* test compared histological scores between groups, and the chi-square test was used to evaluate the difference of return to sport between groups. Mean, SD and 95 % confidence intervals (CI) were calculated. A $P < 0.05$ was regarded as statistically significant. SPSS version 17.0 (SPSS, Chicago, IL, USA) was used to analyse data.

Results

The groups did not differ in demographic features. No patient reported significant knee trauma before symptom onset. All patients were nonsmokers and were free from clinically and serologically detectable metabolic, inflammatory and autoimmune diseases. Symptom duration before the first clinical observation ranged from six to 16 months (average, 8.9 months) in the unilateral group and from six to 19 months (average 9.3 months) in the bilateral group. At preoperative US, all patients had hypoechoic areas in the substance of the tendon and tendon thickening, with evidence of neovascularity at colour and/or power Doppler. At histology, all samples showed a typical picture of tendinopathy, with evidence of neovascularity, mucoid degeneration, haphazard cellularity and different grades of disorganisation of collagen fibres [12]. The histological sum-score averaged 15.3 ± 3.2 in the unilateral group and 18.6 ± 2.9 in the bilateral group. All variables considered were significantly more abnormal in the bilateral group ($P < 0.05$).

Postoperative assessment

At the latest clinical assessment, ROM was significantly improved compared with preoperative status, in the absence of statistically significant intergroup differences: three patients in the unilateral group and four in the bilateral group reported extension deficit. Pain and tenderness over the proximal attachment of the tendon were observed in two patients of the unilateral group and three of the bilateral group. No patient complained of symptoms along the body of the tendon or over the tibial tuberosity. At the final follow-up, in both groups,

VISA-P scores were significantly improved compared with pre-operative values, with no intergroup differences. In the unilateral group, it improved from a preoperative average of 62 to 88 at the last follow-up and from 56 to 82 in the bilateral group. Clinical results were excellent or good in 21 patients of the unilateral and 19 of the bilateral group. All patients returned to ordinary daily and working activities. Patients in the unilateral group resumed sport at 8.5 ± 1.2 months (range 7.5–10) and in the bilateral group at 10.1 ± 1.7 months (range 9.5–13, $p=0.04$). At the final appointment, 20 of 23 patients in the unilateral group and 17 of 23 in the bilateral group were still active at the same level as before symptom onset ($p=0.2$). Of the nine remaining patients, six had changed to low-impact sports; three patients, all in the bilateral group, abandoned sport altogether.

Anthropometric findings

Anthropometric findings are shown in Table 1.

At the last appointment, patients in the bilateral group had greater body mass index (BMI) and greater subcutaneous body fat than patients in the unilateral group. In the unilateral group at the last follow-up, thigh volume in the operated limb ($p=0.03$) was significantly smaller than preoperatively. Thigh volume difference between the operated and nonoperated limbs was statistically significant both before ($p=0.04$) and after ($p=0.03$) the index procedure (Table 2).

In the bilateral group, there were no significant difference in thigh volume between the dominant and nondominant limbs both before and after the index procedure (Table 3).

In the unilateral group at the last follow-up, strength of the operated limb was significantly improved ($p=0.04$) compared with baseline; there were no significant differences between operated and nonoperated limbs both before and after index procedure (Table 4). In the bilateral group, there were no significant differences between the dominant and nondominant limbs both before and after the index procedure (Table 5).

Complications

No patients suffered infections or a clinically identified deep vein thrombosis. Four patients (two in each group) reported numbness around the incision site, but symptoms regressed spontaneously within two months. Three patients experienced a delayed wound closure, but they healed completely within a few months without any sequelae.

Discussion

The main finding of the study is that patients undergoing surgery for unilateral patellar tendinopathy returned to sport

earlier than patients with bilateral patellar tendinopathy. At the last follow-up, in the unilateral group, the thigh volume difference between the operated and nonoperated limbs was statistically significant, and the strength of the operated limb was significantly improved over baseline, with no significant differences between operated and nonoperated limbs. In the bilateral group, there were no significant differences in thigh volume and strength between dominant and nondominant limbs both before and after the index procedure.

Bilateral and unilateral patellar tendinopathy may well have different aetiopathogenesis [16–18]. Although US and MRI scans do not always correlate with pathologic appearance and clinical findings [19–21], the presence of bilateral tendon changes in patients with unilateral symptoms may be a negative prognostic factor for the development of contralateral side tendinopathy in the future.

Many surgical procedures have been proposed for managing patellar tendinopathy when conservative measures fail [22–24]. Arthroscopic debridement and removal of the area of abnormal patellar tendon at the attachment on the patella improves pain, subjective daily function and sports activities, with minimal postoperative complications. In this procedure, the paratenon and surrounding fibrosis are excised, the tendon is separated from Hoffa's body, and multiple full-thickness longitudinal tenotomies are performed along the entire length of the tendon. In this way, the tendon is explored throughout its entirety, and abnormal areas often hidden and difficult to palpate may be completely removed. Differently from other arthroscopic and open techniques, this procedure also involves blunt dissection to free the posterior aspect of the tendon from the adipose tissue of Hoffa's body. Excision of a portion of the tendon can theoretically decrease mechanical properties of the tendon and influence the patient's return to full function and sports, but our patients recovered muscle strength without any long-term functional impairment.

Some authors tried to improve the open approach, possibly by minimising the cutaneous scar either by arthroscopic or percutaneous techniques. Percutaneous tenotomies performed under local anaesthetic and US guidance may be advantageously applied in patients with proximal insertional tendinopathy, but these results are less satisfactory than those observed after open surgery, providing < 60 % good or excellent results [25]. In general, published studies report success rates > 80 % for surgery of end-stage patellar tendinopathy regardless of the surgical technique used, but an association was evidenced between high rates of success and poor methodology of study design, and the large number of different techniques implies that no single technique is superior [23].

In this study, a success rate of 91 % in the unilateral group and 83 % in the bilateral group were reported. Also, 87 % of patients in the unilateral group and 74 % in the bilateral group were still active in sports at the time of latest follow-up ($p=0.2$). Return to full sporting activity was on average by

Table 1 Body mass index (BMI) and body fat

	Unilateral group	Bilateral group
BMI (kg/m ²)	28.4 (4.7); 95 % CI 21.3–36.1	29.1 (4.9); 95 % CI 22.3–35.9
Percent body fat (%)	24.2 (7.2); 95 % CI 15.2–31.8	25.0 (7.9); 95 % CI 16.2–34.1

CI confidence interval

8.5 months for patients undergoing unilateral surgery and 10.1 months ($p=0.04$) for those in the bilateral group. Pascarella et al. [7] emphasised that arthroscopic technique allows early rehabilitation and return to sport. Shorter recovery times, ranging from four [26] to six [27] months, have been observed after open surgery. In another study, patients returned to sport at six months and ten months after arthroscopy and open surgery, respectively, with comparable outcomes between groups, but < 50 % of patients were competitive to the preinjury activity level at four years from the index procedures [28]. In our study, patients took a relatively long time to resume their level of activity, but the exact time of return to full sports activity is difficult to define when dealing with athletes, who expect to gain an excellent result to compete at a high level and to practice daily with infrequent rest. Since the rationale of multiple tenotomies is to stimulate the healing process, it may result in longer time to return to sport, albeit with high rates of good to excellent results in the long term. In addition, we were cautious, as all patients were secondary and tertiary referrals with a relatively long duration of symptoms, a factor that accounts for a higher rate of failure of nonoperative management, a higher rate of surgery and possibly poorer surgical results.

We note that early rehabilitation involving immediate low-load, high-repetition exercises was recommended in order to stimulate tendon healing and accelerate the return to competitive sports [6]. Strengthening the quadriceps muscle group, swimming and gentle eccentric exercises were started early to allow gradual adaptation of the muscle–tendon unit to greater loads; stretching exercises of the quadriceps and hamstring muscles were also encouraged in order to increase flexibility, avoiding excessive eccentric loads or prolonged stretches of the

Table 2 Thigh volume measures in the unilateral group

	Operated limb		Nonoperated limb	
	Preoperative	Latest follow-up	Preoperative	Latest follow-up
Thigh volume (L)	3.75±0.61	3.57±0.8	3.91±0.5	3.94±0.9

Table 3 Thigh volume in the bilateral group

	Dominant limb		Nondominant limb	
	Preoperative	Latest follow-up	Preoperative	Latest follow-up
Thigh volume (L)	3.78±0.71	3.72±0.8	3.81±0.5	3.74±0.5

musculotendinous junction [29]. Patients with unilateral patellar tendinopathy presented significantly higher thigh circumference, greater side-to-side circumference differences and significantly higher thigh strength than those with bilateral tendinopathy. We expected that anthropometric features and strength would be difficult to recover, but we found that proper and intensive rehabilitation improved them. Specifically, in patients with unilateral tendinopathy, the strength of the operated limb recorded at the last follow-up was significantly higher than at baseline. Interestingly, patients with bilateral tendinopathy had greater BMI. This is probably because patients with bilateral tendinopathy are more likely to change or abandon sport activity over time.

Strengths and limitations

A strength of the study is that all patients were managed surgically and postoperatively in a standard fashion and were also part of a larger patient population and selected for a specific characteristic. Although study was not randomised, to our knowledge, it is the first to compare postoperative outcomes in athletes with uni- and bilateral tendinopathy. Longer follow-up studies would better assess the association between pre-operative imaging findings in asymptomatic patients and development of symptoms over time. In addition, genetic and metabolic patterns reasonably predisposing to this condition should be investigated. As the VISA-P questionnaire was developed only after we started the study, it was administered retrospectively to some patients, and this is a partial limitation. Postoperative assessments were not confirmed at imaging but only on clinical and objective

Table 4 Strength measures in the unilateral group

	Operated limb		Non operated limb	
	Preoperative	Latest follow-up	Preoperative	Latest follow-up
Knee extension isometric strength (N)	711±150	735±205	730±188	750±221

Table 5 Strength measures in the bilateral group

	Dominant limb		Nondominant limb	
	Preoperative	Latest follow-up	Preoperative	Latest follow-up
Knee extension isometric strength (N)	691±178	710±205	681±160	700±210

improvements in scoring systems: in this way, we made decisions based on physical examination and clinical acumen without the aid of time-consuming and resource-intensive research protocols.

Conclusion

Open exploration of tendinopathic patellar tendons with excision of the paratenon, multiple longitudinal tenotomies and excision of the tendinopathic area is not technically demanding, is reasonably fast to perform, inexpensive and provides a high rate of good and excellent outcomes in the long term, allowing the majority of patients to remain active at the preinjury level of sport activity at almost seven years from surgery. Given our results, when patients present with bilateral pathology resistant to conservative management, it is recommendable to operate on both sides at the same time.

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