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Ultrasound-guided electrocoagulation of neovascularisation for persistent patellar tendinopathy in athletes: a cohort study of 25 patients with a mean follow-up of 5 years from the SANTI Study Group

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ABSTRACT

Background Patellar tendinopathy (PT) is a common condition characterised by persistent patellar tendon pain and dysfunction, particularly in athletes. Neovascularisation is frequently observed in the PT and is associated with increased pain. Ultrasound-guided electrocoagulation of neovascularisation has emerged as a minimally invasive alternative treatment for recalcitrant PT.

Hypothesis/purpose The purpose of this study was to evaluate the clinical outcomes of ultrasound-guided electrocoagulation of neovascularisation in athletes with persistent PT.

Study design Case series; level of evidence, IV.

Methods A retrospective analysis of prospectively collected data was performed on 25 athletes who underwent ultrasound-guided electrocoagulation of neovascularisation for recalcitrant PT. Clinical outcomes including complications, reinterventions and patient-reported outcome measures were recorded. Comparisons between variables were assessed using χ^2 test or Fisher's exact test for categorical variables and Student's t-test or Wilcoxon test for quantitative variables.

Results 25 patients were included in the final analysis. 96% returned to their preoperative activity level at a mean of 3.8 months. At a mean follow-up of 5 years 4% did not receive significant benefit from electrocoagulation therapy. Significant improvements were observed in outcome measures, including the Victorian Institute of Sport Assessment Questionnaire for Patients with Patellar Tendinopathy, Kujala score, modified Blazina score and Visual Analogue Scale for pain.

Conclusion Ultrasound-guided electrocoagulation of neovascularisation for persistent PT in elite athletes resulted in a low complication rate, a high rate and rapid return to sport and a significant improvement in outcome measures.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Surgery is usually offered for patella tendinopathy after failure of medical and physical therapies, but there is variation in the type of surgery performed for the condition. Open surgery has demonstrated inconstant results, carries risk of significant complications and an unreliable rate of return to sport. Arthroscopic debridement is a less invasive surgical option to treat patellar tendinopathy (PT) and has demonstrated positive outcomes and return to sport rates. An alternate treatment modality consisting of ultrasound-guided percutaneous electrocoagulation of the patellar tendon neovessels has been proposed for the treatment of PT. The rational basis for this treatment is clear. However, there are currently no clinical results from the clinical use of this technique.

WHAT THIS STUDY ADDS

⇒ Ultrasound-guided electrocoagulation of neovascularisation offers a less invasive alternative to surgery for the treatment of PT in athletes. The technique allows for earlier rehabilitation, faster recovery and quicker return to sport especially for elite athletes, making it particularly relevant in athletes who need a rapid return to sport. This technique proved effective in that it resulted in statistically significant improvement in all recorded outcomes and only 4% required reoperation for persistent PT.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study reports the results of this technique, which has been shown to be safe, with no specific surgical complications reported. This is the first study to report the results of this technique in a clinical setting.

INTRODUCTION

Patellar tendinopathy (PT) is a condition characterised by persistent pain and dysfunction of the patellar tendon related to mechanical loading and occurs frequently in the athletic population.[1] The prevalence of PT among elite athletes is approximately 20%.[1] The pathology can affect individuals participating in any sport but is more common in basketball and volleyball.[2 3]

Among elite athletes with a clinical diagnosis of PT, most exhibit structural tendon

changes such as tendon thickening, irregular collagen distribution and peritendon neovascularisation.[4–6] The presence of these vessels is proposed to result from the underlying pathological process of chronic inflammation and has been associated with significantly greater pain.[7] This may be due to sensory nerves being coupled with vessels on the dorsal surface of the proximal patellar tendon.[4 8 9]

Non-surgical management consisting of eccentric loading exercise therapy is the first-line treatment for PT. Initial treatment should be prescribed by a physiotherapist with a focus on eccentric squat-based therapy and isokinetic strengthening. If symptoms persist, several other treatments such as the extracorporeal shock wave therapy (ESWT), topical glyceryl trinitrate (GTN), low-energy laser therapy, platelet-rich plasma (PRP) or ultrasound-guided (US-G) sclerosing injections have been described.[10–15] Although non-operative treatment for PT has a success rate of up to 90%, in recalcitrant cases, surgical treatment may be indicated.[16] Open surgery, consisting of patellar tendon debridement, has demonstrated variable results, carries risk of significant complications and an unreliable rate of return to sport.[17–19] Arthroscopic debridement is a less invasive surgical option to treat PT and has demonstrated positive outcomes and return to sport rates.[20 21]

An alternate treatment modality consisting of US-G percutaneous electrocoagulation of the patellar tendon neovessels has been proposed for the treatment of PT.[14] The rationale of this treatment is electrocoagulation of the neovascularisation that feeds the inflammatory process and is coupled with sensory nerves responsible for nociception. This treatment has several proposed advantages over open surgery, including being minimally invasive, allowing early rehabilitation, a more rapid recovery and a faster return to sport, making it particularly attractive for professional athletes with PT. While this treatment has been described, no clinical results using this technique have been reported.

The aim of this study was to report the clinical outcomes after US-G electrocoagulation of neovessels for persistent PT in athletes with a minimum 2-year follow-up. We hypothesised that the described technique for US-G electrocoagulation of neovessels allows an early return to sport, results in improved outcome scores at a minimum of 2-year follow-up and is associated with a low rate of complications.

METHODS

All participants gave informed consent to participate. Patients or the public were not involved in the design and conduct plans of our research. A retrospective analysis of prospectively collected data for consecutive patients who underwent US-G patellar tendon debridement for recalcitrant PT at Centre Orthopédique Santy between June 2013 and June 2020 was conducted. Patients were excluded if prior to or after the procedure they received surgery on the same knee for any reason or had concomitant knee injuries. Patients received US-G electrocoagulation of neovessels if they failed to recover from PT after conservative treatment. Failure of conservative treatment was defined as the absence of significant symptom relief, functional improvement or the ability to resume desired activities despite adherence to a conservative treatment regimen. This regimen included 3 months of physical therapy, ESWT and two PRP injections.

Preoperative MRI was used in all patients to confirm the persistent PT and interpreted by the same senior surgeon (BS-C). MRI showed enhanced signal intensity in T2 sequences near the distal pole of patella with thickening of the tendon at this level (figure 1).

Ultrasound B-mode and colour Doppler imaging are performed preoperatively by a musculoskeletal radiologist (JC), first with the knee in 90° flexion. Ultrasound exploration is then performed in extension to reduce the tension in the tendon and provide a better view of the inflammatory zone (neovascularisation) in the patellar tendon. The precise location of the inflammatory zone is then marked; it is usually seen on the medial side, seldom occurring on the lateral side (figure 1).

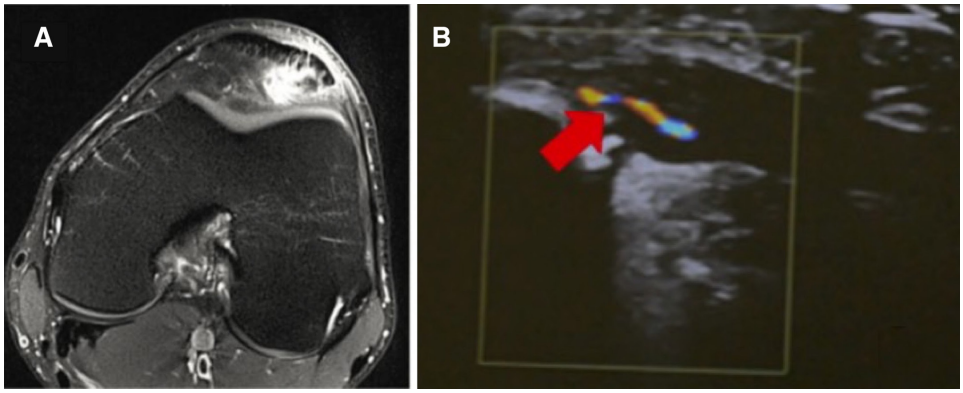

Figure 1 Radiographical appearance of chronic patellar tendinopathy. (A) MRI showing enhanced signal intensity in T2 sequences near the distal pole of patella with thickening of the tendon at this level. (B) Colour Doppler mode ultrasound (US) showing neovascularisation (arrow) of the proximal patellar tendon. Reprinted with permission from Zayni *et al*,[15] 2015.

Surgical procedures

All patients underwent a surgical technique that has previously been published.[14] All operations were performed by the same senior surgeon. Briefly, the patient was positioned supine with a lateral and foot roll to maintain 90° knee flexion. The limb was draped in a standard fashion for an arthroscopic knee procedure, with no tourniquet, and a sterile cover was placed over the ultrasound workstation and probe.

Preoperative ultrasound exploration was performed by a single experienced musculoskeletal radiologist. B-mode and colour Doppler mode were used to identify neovascularised zones and these were marked on the skin using a sterile pen. A portal was created with a No 11 scalpel blade on the same side as and parallel to the main inflammatory zone. Then, electrocoagulation was performed with a 90° bipolar radiofrequency probe, set at maximum 50°C, under ultrasound guidance on the areas of neovascularisation until vascular flow was confirmed to be abolished using colour Doppler ultrasound (figure 2).

Rehabilitation

Postoperatively, immediate full weight bearing was permitted, without a brace. The early focus of rehabilitation in the first 2 weeks was on progressive range-of-motion exercises. Participation in the Stanish Physical Therapy programme started after 2 weeks.[13] Patients were cleared to return to sport from the eighth week.

Follow-up

Patients were reviewed at 2 and 6 weeks, and 3, 6, 12 and 24 months postoperatively by the senior surgeon. In addition, all patients were reassessed in consultation between July and September 2022 for final follow-up. Patients who were not to attend an in-person final follow-up participated in a video telemedicine interview instead. Regardless of the type of final follow-up, all patients completed patient-reported outcome measures (PROMs), including the Victorian Institute of Sport Assessment Questionnaire for Patients with Patellar Tendinopathy (VISA-P),[22] Kujala score[23] and the modified Blazina score.[24] The Visual Analogue Scale (VAS) for pain and Tegner Activity Scale were also recorded.[25] All patients were asked whether they had been able to return to sport postoperatively, timing for return sports, and if they had experienced any complications, reoperation, or if they underwent other injuries at the ipsilateral knee. A review of medical notes was used to extract data regarding demographics, PROMs recorded at each follow-up, VAS for pain, preoperative sports participation and any complications.

Statistical analysis

All analyses were performed with SPSS Statistics software (V.27.0.1; IBM SPSS). Statistical significance was set at $p<0.05$. Descriptive data were analysed for the entire patient cohort. Descriptive data analyses were conducted depending on the nature of the considered criteria. For quantitative data, this included the number of observed

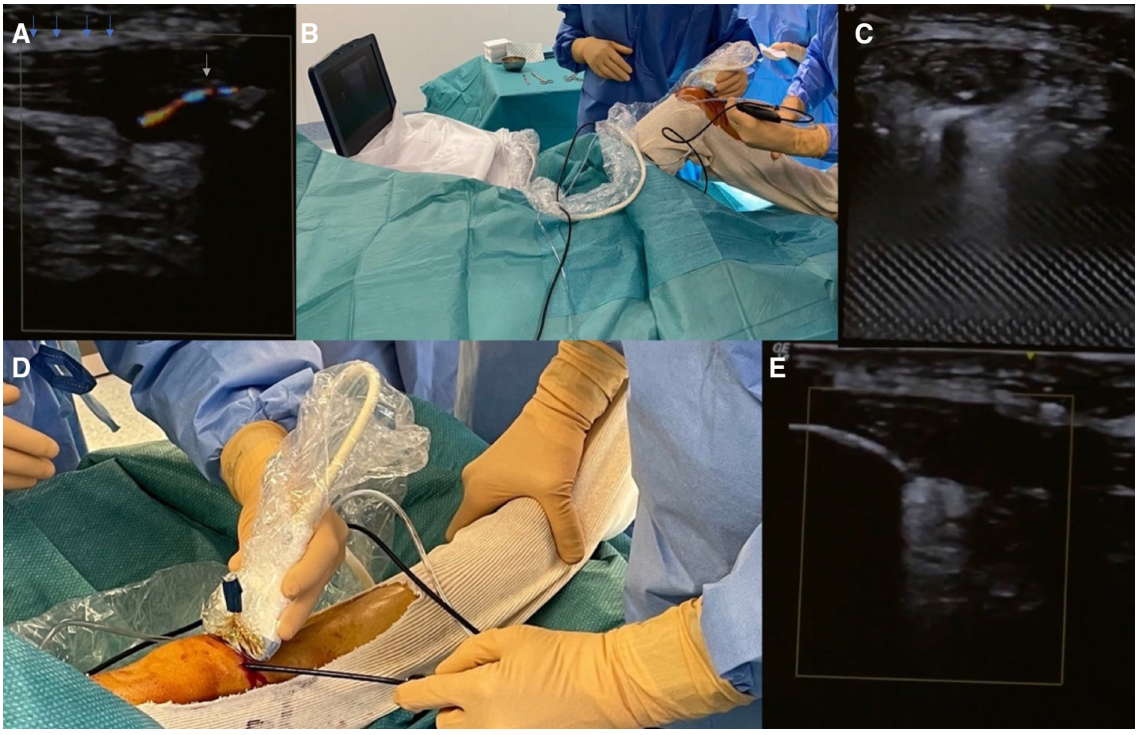

Figure 2 Intraoperative imaging. (A) Neovascularisation is identified examining the patellar tendon (blue arrows) with echo-Doppler (grey arrow). (B, C) Electrocoagulation of the vessels is performed with the knee flexed to 90°. (D, E) Final control with the knee extended to confirm no more signal of neovascularisation on echo-Doppler.

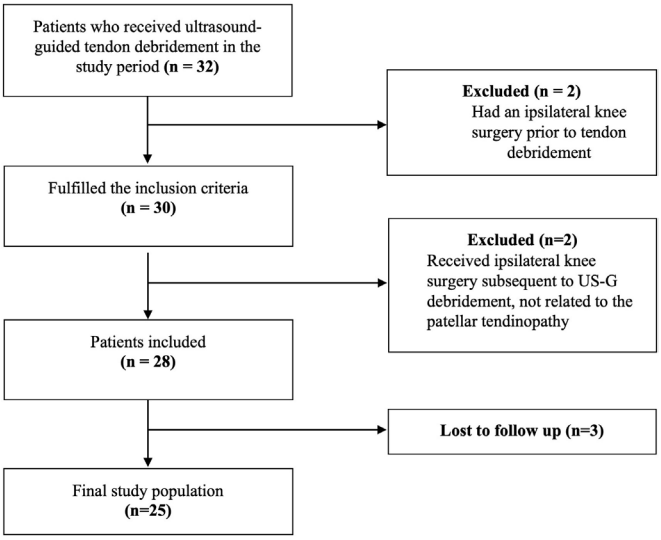

Figure 3 The study flow chart in line with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[41] US-G, ultrasound-guided.

Table 1 Patient demographics

Age, mean±SD (range), years	26.7±7.4 (17.1–46.3)
Sex, n (%)	
Male	22 (88)
Female	3 (12)
Side, n (%)	
Right	7 (28)
Left	18 (72)
BMI, mean±SD (range), kg/m^2	22.8±2.2 (18.9–27.4)
Sport played	
Basketball	6 (24)
Soccer	12 (48)
Handball	4 (16)
Decathlon	2 (8)
Rugby referee	1 (4)

BMI, body mass index; SD, Standard Deviation.

values (and missing values, if any), mean, SD. For qualitative data, this included the number of observed and missing values and the number and percentage of patients per class, range. The normality of variables was assessed with a Kolmogorov-Smirnov test. The primary endpoint was significant progression in PROMs after surgical treatment. Minimal clinical important difference (MCID) for VISA-P was achieved when the absolute value change was greater than 13 points in the baseline as reported from Hernandez-Sanchez *et al*.[26] At the time this study was conducted, to the best of the authors' knowledge, an MCID or patient acceptable symptom state (PASS) values for the other scores regarding PT had not been published.

Comparisons between variables were assessed with χ^2 test or the Fisher's exact test for categorical variables and the Student's t-test or Wilcoxon test for quantitative variables.

RESULTS

Patients

The study flow is presented in figure 3.

Overall, 32 patients received US-G tendon debridement in the study period. Three patients (9.4%) were lost to follow-up. The final study population, after applying exclusion and inclusion criteria and excluding patients lost to follow-up, comprised 25 patients with a mean follow-up of 61.5±28.6 months (range, 24–111) and a median Tegner Activity Scale score of 7 (range, 6–10). Demographics of the study population are summarised in table 1.

Complications and reinterventions

No early or late complications related to US-guided electrocoagulation of neovessels on patellar tendon were recorded. At a mean final follow-up of 61.5 months, the reintervention rate in the overall population was 4% (1/25). One patient reported no benefit from electrocoagulation therapy and underwent patellar tendon debridement via an open technique and obtained full recovery.

Return to sport and clinical outcomes

24 out of 25 patients returned to the same preoperative activity level (96%) at a mean of 3.8 months. Three out of 24 patients (12.5%) reported persistent pain during sport activity. At the last follow-up, there has been a significant improvement in mean VISA-P (53.1±14.9 vs 90±12.2; p<0.001), Kujala (59.7±17.9 vs 93.85±9.9; p<0.001) and VAS for pain (6.8±1.6 vs 1.65±1.5; p<0.001) scores. The distribution in the modified Blazina stages also demonstrated a significant improvement postoperatively (p<0.001). The VISA-P MCID was achieved in 23 out of 25 patients (92%). The preoperative and postoperative PROM values are displayed in table 2.

All the professional athletes included in the study (n=16) returned to preinjury sport practice level at a mean of 3.3±1.4 months. A total of 88.9% of the non-professional athletes returned to preinjury sporting participation at an average of 4.7±3 months (p=0.11) (table 3).

DISCUSSION

The main finding of this study is that, in a population of athletes diagnosed with PT who have failed conservative management, US-G electrocoagulation of neovessels is a safe and effective treatment option. This technique demonstrated significantly improved pain scores, function, a high rate and rapid return to preprocedure sport level, and had a 4% reoperation rate at a mean follow-up of 61.5 months. These findings have implications for

Table 2 Clinical outcomes

	Preoperative	Postoperative	P value
VISA–P, mean±SD	53.1±14.9	90±12.2	**<0.001**
Achieved VISA-P MCID, n (%)		23 (92)	
Kujala, mean±SD	59.7±17.9	93.85±9.9	**<0.001**
VAS for pain, mean±SD	6.8±1.6	1.65±1.5	**<0.001**
Modified Blazina, n (%)			**<0.001**
Stage 0	0	16 (64)	
Stage 1	0	4 (16)	
Stage 2	3 (12)	2 (8)	
Stage 3	12 (48)	2 (8)	
Stage 4	8 (32)	1 (4)	
Stage 5	2 (8)	0	
Tegner Activity Scale, median (range)	7 (6–10)	7 (6–10)	0.91

Boldface indicates statistical significance. MCID threshold for VISA-P was a difference from baseline of 13 points as reported from Hernandez-Sanchez *et al*.[26] Preoperative Tegner Activity Scale scores correspond to the level of activity the patient had prior to the onset of the disease.
MCID, minimal clinical important difference; SD, Standard Deviation; VAS, Visual Analogue Scale; VISA-P, Victorian Institute of Sport Assessment Questionnaire for Patients with Patellar Tendinopathy.

clinicians managing recalcitrant PT and demonstrate good medium-term outcomes.

Clinical implications

US-G coagulation of vessels has been described previously in the use of treatment for Achilles tendinopathy with promising results.[27] To the best of the authors' knowledge, outcomes following the use of US-G electrocoagulation of neovessels to treat recalcitrant PT have not been described. In the current study, US-G electrocoagulation of neovessels led to a significant improvement in mean VISA-P, Kujala, VAS for pain and modified Blazina scores. Also, 92% of patients (23/25) improved their subjective VISA-P score beyond the MCID value of 13. Overall, 96% of patients were able to return to the same level of sports that they had participated in prior to the injury. All 16 professional athletes included in the study and eight out of nine non-professional athletes returned at preinjury sports level.

Various treatments have been proposed to patients with PT who have failed conservative treatment. US-G sclerosing injections are considered less invasive than surgery. However, as reported by Hoksrud *et al*[28] in a relatively large series of 101 patients, sclerosing treatment only results in moderate improvement in knee function and reduced pain, and the majority of patients will still experience reduced function and substantial pain after 24 months. Furthermore, in a randomised controlled trial (RCT) comparing sclerosing injections to arthroscopic tendon debridement, patients who received the surgical treatment demonstrated less pain and higher rates of satisfaction.[29] Two RCT studies have demonstrated no benefit of adding ECSW to eccentric exercise therapy.[30 31] Similarly, PRP,[32] topical GTN[33] and ultrasound therapy[34] have not been shown to add any significant benefit when added to eccentric exercises compared with saline placebo treatments in the short term. However, a recent systematic review examining non-surgical treatment options for PT concluded that multiple PRP injections may offer good longer term results compared with other non-surgical treatments.[35] When such measures have failed, more invasive treatment options such as tendon debridement, performed by either arthroscopic or open surgery, can be used. This study combines arthroscopic surgery with coagulation of neovessels that are thought

Table 3 Data regarding return to sport in professional and non-professional athletes

	Overall (n=25)	Professional athletes (n=16)	Non-professional athletes (n=9)	P value
Returned to preoperative sport level, n (%)				0.36
Yes	24 (96)	16 (100)	8 (88.9)	
No	1 (4)	0	1 (11.1)	
Time to return to preoperative sport, mean±SD, months	3.8±2.1	3.3±1.4	4.7±3	0.11

SD, Standard Deviation.

to be pathological and associated with aberrant nociceptive fibres. The promising results of this series of patients demonstrate very good outcomes at a mean of 5 years and warrant further research including comparative studies to examine its efficacy in the treatment of PT.

The rate of return to sport in athletes being treated for PT varies in the literature. In a recent systematic review on surgical management of PT from Cognetti *et al*,[36] the authors reported that the return to sport rates were 89.8% (95% CI 86.4% to 92.8%, I^2=56.5%) higher for arthroscopic debridement (96.2% (95% CI 93.5% to 98.2%, I^2=26.6%)) in respect to open surgery (85.8% (95% CI 81.0% to 90.1%, I^2=52.0)). Looking in detail, though, of patients returning to sports, those who returned to the same level were 76.1% (95% CI 69.75% to 81.9%, I^2=76.4%), and these results are comparable between arthroscopic surgery (77.3% (95% CI 68.4% to 85.2%, I^2=60.3%)) and open surgery (75.0% (95% CI 65.2% to 83.6%, I^2=81.7%)). Pascarella *et al* reported the results of arthroscopic management of chronic PT in athletes. 27 professional athletes (70.4%) were able to return to sports and maintain the same level of participation, compared with 89.2% of the time in amateur athletes.[37] Alaseirlis *et al*[38] also analysed a population of high-level athletes treated arthroscopically and reported a return rate to preinjury level of 100% (11 out of 11 patients). In the current study, 100% of professional athletes and 88.9% of non-professional athletes were able to return to sport. While these results are superior to those reported in the literature, the relatively modest sample sizes mean these results must be interpreted with modesty and further research is required to confirm these new and encouraging results for treatment modality for PT.

In the present study population, the timing to return to preinjury level varied between 1 and 9 months from the date of surgery; the professional athletes returned in a faster time, but not statistically significant, than non-professional athletes. Pestka *et al*[39] performed a retrospective analysis of 54 patients after arthroscopic treatment for PT. The authors also performed a comparison between professional and amateur athletes and found no significant differences in timing for return to sport (not to preinjury level) at a 3-month median. These results on timing for return to sport are consistent also with Pascarella *et al* who reported that all the patients that they treated with arthroscopic debridement for chronic tendinopathy were able to return to sports activities at 3 months.[37] Instead, patients included in the current paper returned to preinjury levels at an average of 3.8 months after surgery, and the professional athletes at 3.3 months. This finding may make this procedure particularly attractive for elite athletes.

A major concern with invasive treatment techniques for PT is the risk of complications to the extensor mechanism. The complications described in the literature after surgical treatment of PT include haematomas, infections, scar hypersensitivity, anterior knee pain, unhealed wounds, algodystrophy and patellar tendon rupture.[17] This includes both open, arthroscopic and percutaneous procedures. Testa and coauthors described the results of a percutaneous patellar tenotomy and reported 14.7% (5 out of 34) developed complications including infection, scar hypersensitivity and haematoma, and open revision surgery was performed in 38% (13 of 34) of patients.[40] In the current series, no complications related to the procedure on patellar tendon were recorded and at a mean final follow-up of 61.5 months, indicating that it appears to be a relatively safe treatment option for the treatment of PT.

Limitations

This study has several limitations. It is a retrospective study and has no control group. Furthermore, the sample size is small; however, the study only included patients who had failed non-surgical management limiting the number of patients available for recruitment. Also, while two categories of patients were found within our population, only limited comparative analyses could be performed because the already small sample when divided into groups could not provide us with statistically relevant insights.

CONCLUSIONS

US-G electrocoagulation of neovessels is a safe and effective treatment option for athletes with PT who have failed conservative management. This novel treatment method demonstrated significantly improved pain scores, function, a high rate and rapid return to preprocedure sport level, and had a 4% reoperation rate at a mean follow-up of 5 years. These findings have implications for clinicians managing recalcitrant PT and demonstrate good medium-term outcomes.

Contributors Study conception and design: BS-C, TDV. Data collection: AC, AAA, AEH. Analysis and interpretation of results: AC, JS, FP. Draft manuscript preparation: AC, JC, AA. Revision of the manuscript critically for important intellectual content: BS-C, JS, TDV. All authors reviewed the results and approved the final version of the manuscript. Guarantor: AC.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Institutional Review Board (IRB) of IORG de Ramsay Santé Recherche & Enseignement (COS-RGDS-2024-01-004-SONNERY-COTTET-B). Participants gave informed consent to participate in the study before taking part.

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