Systematic Review

Treatment Options for Patellar Tendinopathy: A Systematic Review

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Purpose: To compare the efficacy of common invasive and noninvasive patellar tendinopathy (PT) treatment strategies. **Methods:** A systematic search was performed in PubMed, Google Scholar, CINAHL, UptoDate, Cochrane Reviews, and SPORTDiscus. Fifteen studies met the following inclusion criteria: (1) therapeutic outcome trial for PT, and (2) Victorian Institute of Sports Assessment was used to assess symptom severity at follow-up. Methodological quality and reporting bias were evaluated with a modified Coleman score and Begg's and Egger's tests of bias, respectively. **Results:** A total of 15 studies were included. Reporting quality was high (mean Coleman score 86.0, standard deviation 9.7), and there was no systematic evidence of reporting bias. Increased duration of symptoms resulted in poorer outcomes regardless of treatment (0.9% decrease in improvement per additional month of symptoms; $P = .004$). Eccentric training with or without core stabilization or stretching improved symptoms (61% improvement in the Victorian Institute of Sports Assessment score, 95% confidence interval [CI] 53% to 69%). Surgery in patients refractory to nonoperative treatment also improved symptoms (57%, 95% CI 52% to 62%) with similar outcomes among arthroscopic and open approaches. Results from shockwave (54%, 95% CI 22% to 87%) and platelet-rich plasma (PRP) studies (55%, 95% CI 5% to 105%) varied widely though PRP may accelerate early recovery. Finally, steroid injection provided no benefit (20%, 95% CI −20% to 60%). **Conclusions:** Initial treatment of PT can consist of eccentric squat-based therapy, shockwave, or PRP as monotherapy or an adjunct to accelerate recovery. Surgery or shockwave can be considered for patients who fail to improve after 6 months of conservative treatment. Corticosteroid therapy should not be used in the treatment of PT. **Level of Evidence:** Level IV, systematic review of Level II-IV studies.

Patellar tendinopathy (PT) is a common cause of anterior knee pain among athletes.[1] The incidence of PT within a sports season among a general population of athletes was estimated to be 14.2% in one study,[2] with the highest incidence occurring in jumping sports and ranging as high as 44.6% for volleyball.[2] The condition affects men more frequently than women at a ratio of approximately 2:1.[2] The pain can hinder athletic ability, prevent sports participation, and even affect daily activities.[2] PT is also known as patellar tendinitis or "jumper's knee," although studies have shown that this is a chronic degenerative process rather than acute inflammation.[3,4] The major cause of this degenerative condition is repetitive movements that cause excessive loading of the tendon, particularly during sports that involve cutting, sudden acceleration, and jumping.[2,5] Sports such as basketball, volleyball, football, and soccer have a higher incidence of athletes with PT.[3]

Many methods to treat PT have been evaluated, and there is no true consensus on the most efficacious treatment strategy. Physical therapy is a common intervention with treatment emphasizing eccentric quadriceps exercises.[6] Other nonsurgical techniques that have been employed to address this condition include injections with sclerosing agents, low-intensity pulsed ultrasound, shockwave therapy, platelet-rich plasma (PRP) injections, and corticosteroid injections. Sclerosing agent injections are meant to obliterate vessels in areas of neovascularization, thus reducing

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inflammation.[7] PRP contains many growth factors and have been shown to stimulate healing.[8] Corticosteroid injections inhibit proinflammatory cytokine synthesis, thus decreasing inflammation.[9] Shockwave application is thought to work by stimulating neovascularization at the tendon-bone junction.[10] Ultrasound has been shown to promote soft tissue healing and stimulate collagen 1 production.[11] For recalcitrant cases, open or arthroscopic debridement of areas of chronic inflammation and degeneration in the tendon has been used to promote a healing response.[12]

Several qualitative reviews have been conducted on the treatment of PT, including a recent review by Larsson et al.[13] These reviews can provide valuable information but do not attempt to use reported data to provide a statistical estimate of treatment efficacy. We believe that the widespread use of standardized symptom scores such as the Victorian Institute of Sports Assessment Patellar Tendinopathy Questionnaire (VISA-P)[14] in the current PT literature allows for a more quantitative assessment of treatment outcomes using statistical techniques to gain new insight into the efficacy of various treatments. Treatment providers may use this information when selecting a treatment strategy to better assess the relative efficacy of a treatment and the variability of the treatment outcomes reported in the current literature. The purpose of this systematic review is to compare the efficacy of common invasive and noninvasive PT treatment strategies. We hypothesized that eccentric training would have greater evidence supporting its use for initial therapy compared with other nonsurgical treatments.

Methods

Using guidelines outlined in the PRISMA and QUORUM statements for standardized reporting of systematic reviews in the preparation of this manuscript,[15,16] a search was conducted of the PubMed database (1975 to February 11, 2013) using the Medical Subject Headings advanced search tool (Fig 1) and the terms "patellar tendon" AND "tendonitis" OR "tendinopathy" AND "treatment outcome," which resulted in 686 hits. Systematic searches of CINAHL, UptoDate, Google Scholar, Cochrane Reviews, and SPORTDiscus provided an additional 5 studies, for a total of 691 studies. The titles and abstracts of these studies were reviewed for our inclusion criteria (Table 1). The inclusion criteria are as follows: (1) therapeutic outcome study; (2) enrolled patients had a diagnosis of PT; (3) the VISA-P questionnaire was used; (4) the study is published in a peer-reviewed journal; (5) the study reports original research; and (6) the study is reported in English. Studies that were not published in full-length manuscript formats such as poster presentations or meeting abstracts were excluded.

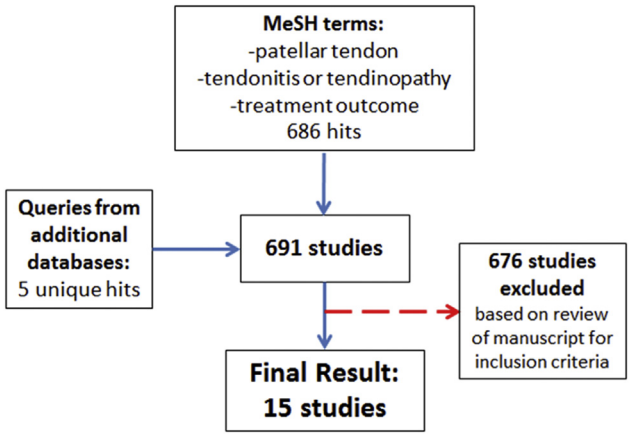

Fig 1. Study screening process. We initially conducted a Medical Subject-Heading (MeSH) search on Medline, which identified 6448 studies. After a review of additional databases including SPORTDiscus, Scopus, and Google Scholar and application of our inclusion criteria, 15 studies were identified for inclusion in our review.

In this review, the VISA-P questionnaire results from each study were extracted and used as a common outcome measure between treatment strategies.[14] The VISA-P questionnaire is a sensitive reliable tool for measuring PT severity and has the ability to detect the subtle changes in symptoms necessary for comparing treatment outcomes.[14] The questionnaire is self-administered to assess symptoms, simple tests of function, and ability to play sports.[14] VISA scores range from 100 to 0, correlating to completely asymptomatic patients with no functional limitations and patients with maximum disability, respectively. In general, the VISA-P score was validated in the languages spoken with appropriate references provided by the study authors. In general, the VISA-P score was validated in the languages spoken with appropriate references provided by the study authors. Van der Worp and Zwerver used a validated Dutch version.[17] Kongsgaard and Frohm used a validated Swedish translation.[18] Dimitrios et al. conducted the study in Greece with native Greek speakers, and although they did not specify whether an English or Greek version was used, there is a validated Greek VISA-P questionnaire.[1,19] Wang et al. conducted their

Table 1. Study Inclusion and Exclusion Criteria

Inclusion criteria
1. Therapeutic outcome study
2. Enrolled patients have diagnosis of chronic or acute patellar tendinosis (jumper's knee)
3. VISA or VISA-P score used as an outcome measure
4. Study is published in a peer-reviewed journal
5. Original research study
6. Study is reported in English
Exclusion criteria
1. Poster presentations or meeting abstracts

VISA-P, Victorian Institute of Sports Assessment Patellar Tendinopathy Questionnaire.

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study in Taiwan and cite the English version of the VISA-P questionnaire; there is no reference to using a translated version in their study.[20] All other studies were conducted in primarily English-speaking countries.

Statistical Analysis

All statistical tests were performed with a standard software package (STATA 13.1, StataCorp, College Station, TX). Reporting quality was assessed with the Coleman score, which is an itemized assessment tool originally created to improve the methodological quality of PT surgical outcome studies.[21] To adapt this score for use in surgical or conservative treatment studies, we modified the criteria "quality of description of surgery" to "quality of description of treatment"; we rated a treatment description as high quality if we felt that the provided information was sufficient for an experienced provider to replicate the key aspects of the intervention. Study bias was assessed by Begg's and Egger's tests of bias.[22,23] A general positive trend was observed between baseline symptom severity and observed improvement in the VISA score. This is likely due to both a ceiling effect (improvements in the VISA score became increasingly harder to observe as the maximum possible score is approached) and a regression to the mean (the most symptomatic patients are more likely to have improved scores over time regardless of the treatment method). To account for these factors in our analysis, a standardized measure of treatment efficacy was calculated as the mean percent possible improvement ([mean follow up score − mean baseline score]/[100 − baseline mean score]). To avoid excluding studies with missing baseline scores (Peers and Coleman),[12,24] these studies were assigned a mean score equal to the baseline mean within the given treatment category and a standard deviation (SD) equal to the follow-up SD. Of note, Pascarella et al.[24] likely reported the standard error of the mean (2.6 baseline, 3.3 follow-up) in their study rather than the SD, as the resulting variance was more than an order of magnitude smaller than all other studies. Therefore, the SD used in this systematic review (22.2 baseline, 28.2 follow-up) was calculated from what was presumed to be the standard error of the mean, which resulted in a variance similar to other studies. Simple linear regression with inverse variance weighting was used to assess whether there was an association between mean duration of symptoms and treatment outcome across studies. Finally, a random effects model using the DerSimonian and Laird method was created to estimate the efficacy of individual treatment methods.[26] Effect heterogeneity among studies of a given treatment method was assessed using the *I*-squared measure as described by Higgins et al.[27] A formal meta-analysis directly comparing treatment methods could not be performed because of between-study differences in study methods that cannot be adequately accounted for in a statistical model.

Results

A total of 15 studies were included in the review. The average length of follow-up was 15.2 months (SD 13.6), and reporting quality was high with a mean Coleman score of 86.0 (SD 9.7). Five studies evaluated eccentric training,[1,28-31] 4 evaluated surgery,[12,24,25,31] 4 evaluated shockwave therapy,[20,24,32,33] 2 evaluated PRP,[33,34] 2 evaluated steroid therapy,[28] 1 evaluated ultrasound,[35,36] and 1 evaluated sclerotherapy.[7] There does not appear to be a systematic bias against reporting marginal or nonsignificant results, and the results of Begg's test ($P = .62$) and Egger's test ($P = .20$) of bias were not significant. There was a slight trend toward a worse outcome with longer duration of symptoms, with an average 0.9% decrease in improvement with each additional month of symptoms before treatment ($P = .004$).

Eccentric Training

There is strong evidence that eccentric training as a treatment strategy will lead to a significant improvement in PT symptoms (Table 2, Fig 2). The high heterogeneity ($I^2 = 72\%$) is likely due to differences in treatment protocols (Fig 2). Some protocols used eccentric training alone, while others supplemented eccentric training with static stretching or core stabilization (Table 2). There is some evidence that a supplemented protocol may produce superior results; Dimitrios et al.[1] saw a significantly higher improvement in VISA scores in the treatment arm with eccentric training plus stretching (89% improvement, 95% CI 77% to 100%) compared with the treatment arm with eccentric training alone (57% improvement, 95% CI 49% to 65%).

Surgery

There is strong evidence to support the use of surgery to treat recalcitrant PT cases (Table 3, Fig 2). In general, these patients had the most severe baseline symptoms (33.1 mean VISA score) and had already failed nonsurgical management (Table 3). The moderate heterogeneity ($I^2 = 44\%$) was considered to be due to differences in the surgical technique (Fig 2). Although arthroscopic and open surgery outcomes appear similar on qualitative comparison of all included studies (Table 3), Coleman et al.[12] found a lower percent improvement among their arthroscopically treated group (57%, 95% CI 49% to 65%) compared with the open surgery group (89%, 95% CI 77% to 100%).

Shockwave Therapy

The overall estimated improvement in VISA scores from shockwave therapy had considerable variability

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Table 2. Included Patient Groups: Eccentric Training

Author	Methodology	Coleman Methodology Score	Participants	Follow-up	Rehab Protocol	Results
Bahr et al., 2006[31]	20 patients randomized to eccentric strength training	93	Average age 31 ± 8 yr 18 men, 2 women	12 mo	12-wk minimum rehab, weekly sessions on 25° decline board with home exercise as well	Mean improvement from the baseline VISA score of 29 ± 16 to 63 ± 10 (from graph), 70 ± 8 from pooled data
Dimitrios et al., 2012[1]	22 patients randomly selected for eccentric training with static stretching incorporated	85	Average age 26 ± 4 yr 16 men, 6 women	6 mo	Training sessions occurred once daily, 5 times a week for 4 weeks. Eccentric exercises with static stretching	Patients increase their baseline VISA median score of 44 (31-68) to 94 (75-100)
	21 patients randomly selected for eccentric training		Average age 27 ± 5 yr 15 men, 6 women	6 mo	Training sessions occurred once daily, 5 times a week for 4 wk. Eccentric exercises only, no stretching	Patients increase their baseline VISA median score of 46 (33-60) to 77 (68-84)
Frohm et al., 2007[30]	11 patients randomly selected for eccentric overload training (Bromsman)	87	Average age 26 ± 8 yr 9 men, 2 women	12 wk	Twice weekly for 12 wk, eccentric strength training was alternated with trunk and foot stability exercises	Patients increased from the baseline VISA median score of 49 (38-61) to 86 (71-92)
	9 patients randomly selected for one-legged standard eccentric training (Curwin)		Average age 28 ± 8 yr 7 men, 2 women	12 wk	Twice weekly for 12 wk, eccentric strength training was alternated with trunk and foot stability exercises. Eccentric training was carried out on a 25° decline board	Patients increased from the baseline VISA median score of 36 (23-61) to 75 (46-83)
Jonsson et al., 2005[29]	10 patellar tendons from 8 patients were randomly selected for eccentric training	88	Average age 25 ± 9.9 yr 7 men, 1 women	12 wk	Twice daily, 7 d a week for 12 wk. Eccentric squats on a decline board	Patients increased from the baseline VISA score of 41.1 ± 17.9 to 83.3 ± 23.4
Kongsgaard et al., 2009[28]	12 patients were randomly selected for eccentric decline squat training	83	Average age 31.3 ± 8.3 yr	12 wk	Twice daily, 7 d a week for 12 wk, 3 sets of 15 slow eccentric unilateral squats on a 25° board	Patients increased from the baseline VISA score of 53 ± 13 to 75 ± 3

VISA, Victorian Institute of Sports Assessment.

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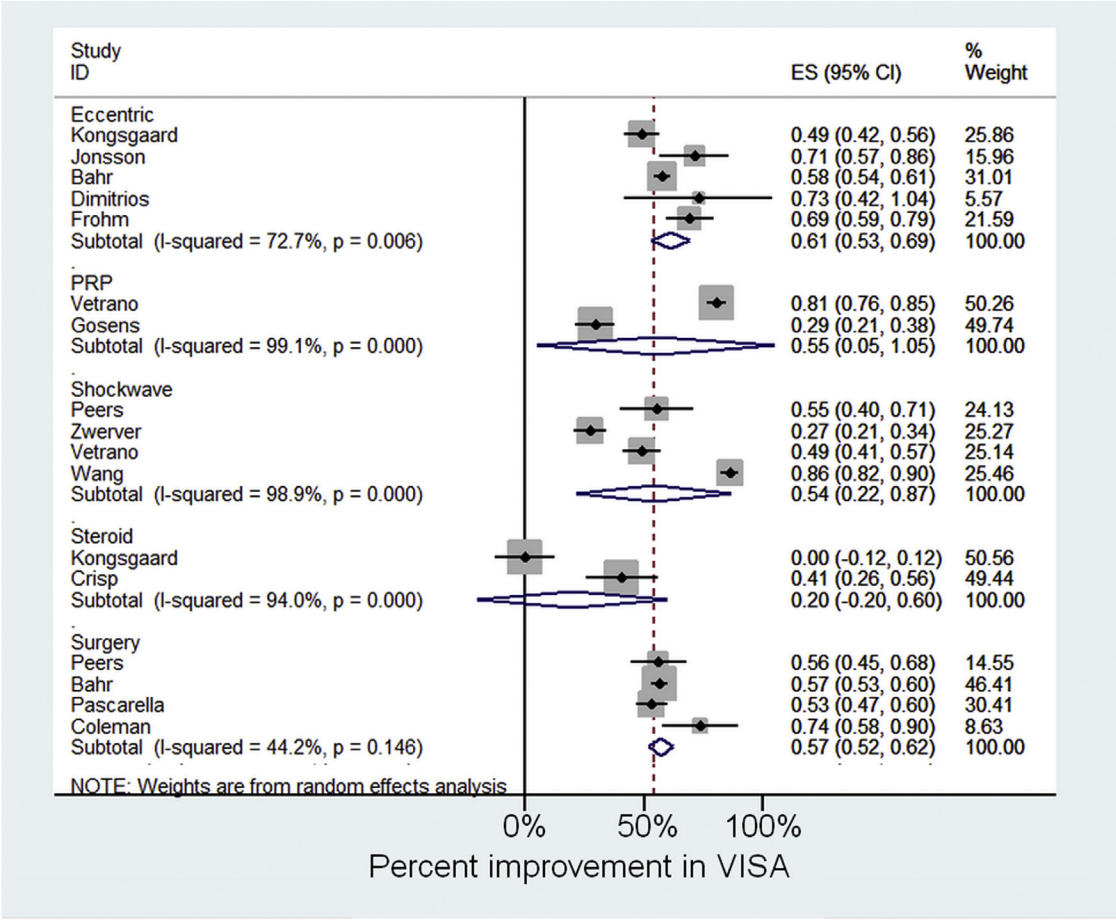

Fig 2. Forest plot of all treatment modalities. The average percent improvement is displayed for each study group in addition to the average improvement for each treatment modality. A random effects model was used to account for the high heterogeneity (I^2) in at least one treatment category. (CI, confidence interval; ES, effect size; PRP, platelet-rich plasma; VISA, Victorian Institute of Sports Assessment.)

(Fig 2, Table 4). This may be related to an inverse relationship between symptom improvement and total dose of treatments (Table 5). Wang et al.[20] reported the best results by using an intermediate dose in a single session. Both Peers et al.[24] and Vetrano et al.[33] used low to intermediate dosing over 3 weekly sessions resulting in only moderate results. Lastly, Zwerver et al.[32] reported the worst results after using an unconventionally high dose over 3 weekly sessions.

Platelet-Rich Plasma Therapy

Although PRP may confer some benefit, there was high variability in the estimated treatment effect (Fig 2, Table 4). A possible source of outcome variability was the use of different treatment protocols between studies. Vetrano et al.[33] used the MyCells system (Kalight, Ramat-Hasharon, Israel) for preparation of 2 ultrasound-guided intralesional injections of PRP given over a 2-week period and concluded PRP therapy to be the effective treatment strategy. Gosens et al.,[34] however, used the Recover System (Biomet Biologics, Warsaw, IN) for a single nonimage-guided injection of PRP and subsequently did not find their treatment response to be nearly as robust in either of his treatment arms, prior treatment or no prior treatment.

Corticosteroid Injection Therapy

Corticosteroid injection therapy offers no significant benefit for PT (Table 4, Fig 2). Kongsgaard et al.[28] found no improvement in VISA scores at 6 months' follow-up. Crisp et al.[35] noted a moderate improvement in symptoms; however, their study protocol included an eccentric squatting program after injection, which significantly confounds their results considering the findings above for eccentric training as an independent variable.

Ultrasound and Sclerotherapy

Only 1 study each was identified for ultrasound and sclerotherapy (Table 4). Warden et al.[36] found a modest improvement (38% improvement, 95% CI 31% to 45%) after administering low-intensity pulsed ultrasound to patients daily for 12 weeks. Hoksrud et al.[7] found a similar improvement in VISA scores (43%, 95% CI 38% to

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Table 3. Included Patient Groups: Surgery

Author and Year	Methodology	Coleman Methodology Score	Participants	Follow-up	Surgical Procedure	Results
Bahr et al., 2006[31]	20 patellar tendons were randomly selected for surgical treatment	93	Average age 30 ± 8 yr 17 men, 3 women	12 mo	Open tenotomy with the postoperative eccentric training program (6 wk)	Patients increased from the baseline VISA score of 31 ± 15 to 72 ± 10
Coleman et al, 2000[12]	29 tendons were treated with open tenotomy by a single surgeon	95	Average age 27 yr 22 men, 3 women	3.8 yr	Open tenotomy, arthroscopic tenotomy, and postoperative physical therapy with concentric and eccentric exercises starting week 2	VISA scores at follow-up was 88 (range, 22-100)
Coleman et al., 2000[12]	25 tendons were treated with arthroscopic surgery by a single surgeon	95	Average age 25 yr 17 men, 6 women	4.3 yr	Arthroscopic tenotomy and postoperative physical therapy with concentric and eccentric exercises starting week 2	Mean VISA score at follow-up was 77 (range, 22-100)
Pascarella et al., 2011[25]	73 patellar tendons were all treated with arthroscopic surgery performed by the same surgeon using the same technique after failure of nonoperative management	95	Average age 24.6 yr 40 men, 24 women	12 mo	Arthroscopic tenotomy technique	Patients increased from the median baseline VISA score of 35.3 ± 2.6 to 69.8 ± 3.3
Peers et al., 2003[24]	14 tendons were treated surgically after failed conservative management and symptoms >6 mo	82	Average age 27.4 yr 11 men, 3 women	22.2 mo	Open tenotomy followed by postoperative physiotherapy	A mean VISA score of 70.7 + 22.2 was observed at follow-up

VISA, Victorian Institute of Sports Assessment.

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Table 4. Included Patient Groups: PRP, Shockwave, Sclerosing Agent, Corticosteroid, Ultrasound

Author and Year	Methodology	Coleman Methodology Score	Participants	Follow-up	Procedure	Results
Gosens et al., 2012[34]	36 patients with patellar tendinopathy were treated with a PRP injection. 14 had previous procedures done (group 1) and the remaining 22 had yet to have anything done before the procedure (group 2)	67	Average age 30.9 ± 12.6 23 men, 13 women	18.4 mo	Recover System compacted the patients' blood by centrifuge. 3 mL of PRP was obtained from each patient. PRP was injected into the area of most tenderness	Patients in group 1 increased from their median baseline VISA score of 41.8 ± 14.3 to 56.3 ± 26.2. Patients in group 2 also increased their median baseline VISA score of 39.1 ± 16.6 to 58.6 ± 25.4
Vetrano et al, 2013[33]	23 patients with patellar tendinopathy were treated with PRP injections. All patients received treatment from the same doctor	95	Average age 26.9 ± 9.1 yr 20 men, 3 women	12 mo	Using the MyCells Autologous Platelet Preparation System, the PRP was collected by single centrifugation to isolate platelets. Each patient received 2 analogous PRP injections over 2 wk under ultrasound guidance	Patients increased their median baseline VISA score of 55.3 ± 14.3 to 91.3 ± 9.9
Vetrano et al., 2013[33]	23 patients with PT were randomly selected to be treated with extracorporeal shockwave therapy	95	Average age 26.8 ± 8.5 yr 17 men, 6 women	12 mo	The Modulith SLK was used to send focused electromagnetic shockwaves to each patient. Each patient attended 3 sessions at 48- to 72-h intervals	Patients increased their median baseline VISA score of 56.1 ± 19.9 to 77.6 ± 19.9
Wang et al., 2007[20]	30 patellar tendons with patellar tendinopathy were treated with extracorporeal shockwave therapy	95	Average age 29.4 ± 10.5 yr 14 men, 13 women	32.7 ± 10.8 mo	The OssaTron was used to send 1500 impulses of shockwave at 14 kV (0.18 mJ/mm^2) in a single session. An ultrasound gel was applied to the area of concentration to limit the energy loss	Patients increased their median baseline VISA score of 42.57 ± 10.2 to 92.0 ± 10.17
Zwerver et al., 2011[32]	30 patients suffering from patellar tendinopathy were randomly selected for extracorporeal shockwave therapy.	92	Average age 24.2 ± 5.2 yr 20 men, 11 women	22 wk	Extracorporeal shockwave therapy was given to the patients in 3 different sessions in 1-wk intervals. These impulses were concentrated on the area that the patient deemed most painful through palpation	Patients increased their median baseline VISA score of 59.4 ± 11.7 to 70.5 ± 18.9

(continued)

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Table 4. Continued

Author and Year	Methodology	Coleman Methodology Score	Participants	Follow-up	Procedure	Results
Kongsgaard et al., 2009[28]	12 patients suffering from patellar tendinopathy were treated with peritendinous corticosteroid injections	83	Average age 34.3 ± 10.0 yr	6 mo	Patients received 1 mL of 40 mg/mL methylprednisolone in 0.5 mL lidocaine (1%) under ultrasound guidance. A second injection was administered at 4 wk after the initial injection. Return to activities allowed as tolerated	Patients increased their median baseline VISA score of 64 ± 14 to 62 ± 22
Crisp et al., 2008[35]	9 patients who were diagnosed with patellar tendinopathy were treated with ultrasound-guided corticosteroid injections	61	Average age 29 ± 8.3 yr	9 mo	Local injection of 10 mL of bupivacaine 0.5% and 25 mg of hydrocortisone and 12-40 mL saline (mean 25 ± 8 mL) followed by an eccentric squatting program after 3-4 d	Patients increased their median baseline VISA score of 46 ± 27 to 68 ± 23
Warden et al., 2008[36]	17 patients were randomly selected for LIPUS (low-intensity pulsed ultrasound)	91	Average age 27 ± 7 yr 12 men, 5 women	12 wk	LIPUS was administered to patients for 20 min a day, 7 d a week for 12 wk. The LIPUS consisted of 2-ms burst of 1.0 MHz with a frequency of 100 Hz	Patients improved from their median baseline VISA score of 58.1 ± 15.9 to 74 ± 14.3. It was noted that the placebo group increased from 56.6 (18.5) to 69.2 (17.8)
Hoksrud et al., 2012[7]	101 patients were treated with ultrasound-guided scleropathy	81	Average age 27 yr 86 men, 15 women	24 mo	Polidocanol (Aethoxysklerol [10 mg/mL], Inverdia AB, Solna, Sweden) was used as the sclerosing agent. Polidocanol was injected with a 0.7 × 50-mm needle	VISA scores went from 39 (95% CI 36-42) to 65 (95% CI 60-70) at follow-up

CI, confidence interval; PRP, platelet-rich plasma; PT, patellar tendinopathy; VISA, Victorian Institute of Sports Assessment.

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Table 5. Relationship Between Intensity (Dosing and Frequency) of Ultrasound and Symptom Improvement

Author	Dosing and Frequency	Improvement in VISA Score
Wang et al., 2007[20]	Moderate dosing (1500 impulses at 0.18 mJ/mm^2), single session	86% (95% CI 82% to 90%)
Peers et al., 2003[24]	Low (Peers, 1000 impulses at 0.08 mJ/mm^2) to moderate dosing	50% (95% CI 42% to 58%)
Vetrano et al., 2013[33]	(Vetrano, 2400 impulses at 0.17-0.25 mJ/mm^2), repeated 3 sessions	
Zwerver et al., 2011[32]	High dose (2000 impulses, scaled up every 100 impulses from 0.1 to 0.58 mJ/mm^2 as tolerated), repeated 3 sessions	27% (95% CI 21% to 34%)

CI, confidence interval; VISA, Victorian Institute of Sports Assessment.

48%) on 24 months' follow-up, after administering up to 5 ultrasound-guided sclerosing treatments.

Discussion

The most important finding of this systematic review was that several nonsurgical treatment options provide significant symptom relief. Eccentric squat-based physical therapy has good evidence for use as an initial conservative treatment, though shockwave treatment and PRP can be considered as initial therapy as well. Surgery, whether arthroscopic or open, and shockwave therapy are appropriate second-line treatments for patients who have failed 6 months of conservative treatment. Current evidence indicates that corticosteroid injections should not be considered for treating PT.

We recommend a standard treatment algorithm that begins with an initial nonsurgical treatment, as described in Table 6, lasting a minimum of 6 months. At our institution, the most patients undergo eccentric squat-based physical therapy as initial monotherapy, though there is evidence to support the use of shockwave therapy and, to a lesser extent, PRP, as an alternative. With eccentric squat therapy, although patients should experience significant symptom improvements for up to 12 weeks, evidence suggests that the rate of improvement will drop significantly by 6 months. For this reason we recommend waiting a minimum 6 months after the initiation of eccentric therapy before considering surgery. When surgery is considered, the difference in long-term symptom improvement between arthroscopic and open surgery appears to be

Table 6. Recommended Treatment Protocol for Patellar Tendinopathy

First-line monotherapy	Eccentric quadriceps therapy • Working up to the effective dose of 3 sets of 15 eccentric squats per session on a 25° decline board. Add progressive weight as tolerated by pain • Incorporation of stretching and/or core stability exercises is recommended • Minimum frequency of twice weekly • Minimum duration of 12 wk Shockwave treatment • Shockwave monotherapy may provide benefit though results vary by the dosing protocol; high energy densities (approaching 50 mJ/mm^2) should be avoided PRP • PRP may be of benefit as monotherapy. However, clinical results vary widely across studies and PRP composition varies across preparation systems
Second-line therapy monotherapy	Surgery • For patients who failed 6 mo of conservative therapy • Consider an arthroscopic approach in athletes requiring accelerated return to sport Postoperative care • Partial weight bearing for 2-7 d • Isometric quadriceps and non–weight-bearing range of motion exercises during week 1 • Progressive load bearing exercises starting week 2 • Load increases and progression from concentric to eccentric exercises or running to cutting should be guided by none or minimal pain Shockwave treatment • For patients who failed 6 mo of conservative therapy • Good alternative to surgery in patients who failed to improve with physical therapy and decline surgery or who for medical reasons are poor surgical candidates • Shockwave monotherapy may provide benefit though results vary by the dosing protocol; high energy densities (approaching 50 mJ/mm^2) should be avoided
Adjunct treatment	• PRP may be of benefit as an adjunct treatment particularly to accelerate recovery. However, clinical results vary widely across studies and PRP composition varies across preparation systems • Efficacy of shockwave as an adjunct treatment has not been established • Corticosteroid therapy is contraindicated

PRP, platelet-rich plasma.

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negligible. We recommend that technique selection be based on surgeon preference and the patients' short-term recovery goals. There is likely a role for shockwave treatment as a second-line therapy. Shockwave treatments could be considered for patients who are no longer improving with physical therapy management and either decline surgery or are poor surgical candidates. However, analysis of the data from these treatments does indicate a direct relationship between symptom chronicity and treatment response. There is a gradual increase in resistance to treatment with duration of symptoms (approximately 10% decrease in improvement per year of symptoms).

PRP therapy had highly variable results across PT studies. In the context of recent literature showing variable platelet and growth factor concentrations across preparation systems,[37,38] this suggests that additional comparative research is needed to identify which preparation systems provide maximal benefit. There may be a role for PRP as part of a combination therapy, particularly for athletes seeking rapid return to sport. Dragoo et al.[39] conducted a randomized trial of eccentric therapy combined with dry needling or PRP and found that symptoms were significantly more improved at 12 weeks in the PRP group but were similar between groups at 26 weeks. However, practitioners should be aware that PRP as an adjunct is not entirely risk free because there have been several reports of patients who initially failed physical therapy and whose symptoms significantly worsened between several days and 2 months after PRP injection.[40]

An interesting trend was observed between symptom improvement with shockwave therapy and the intensity (energy delivery and number of sessions) of the treatment protocols, suggesting that higher intensity protocols may be less efficacious than moderate or low intensity protocols. Zwerver et al.[41] acknowledge that the poor clinical results they observed for shockwave treatment may have been due to a higher intensity protocol than what was used by previous clinical studies and use of an energy density (up to 50 mJ/mm^2) that approached the range (50-60 mJ/mm^2) that caused tissue edema and fibroid necrosis in animal models.[42,43] Further dose-efficacy research is indicated for the use of shockwave treatment as monotherapy and may also be needed for use as adjunct therapy because certain treatment combinations (e.g., shockwave therapy and concurrent eccentric training) may require that a lower energy threshold achieve a clinical benefit.

To understand why corticosteroids injections are less than beneficial for patients with PT, it was important to consider the biological process of the condition. Patellar tendinopathy is not an inflammatory condition. Therefore, anti-inflammatory medications, such as corticosteroids, do not serve a role in its treatment. Interestingly, all of the treatment modalities in this systematic review that were found to provide some amount of benefit to the patient in some way were inducing inflammatory responses. In doing so, they are attempting to promote a level of healing that extends beyond the damage caused by therapy. Because corticosteroids counteract this process, our conclusion against their use in treating PT is easily appreciated.

Limitations

The conclusions that could be drawn from this review were directly dependent on the currently available body of original research on PT and are an inherent limitation of all systematic reviews. Larsson et al.'s[13] review of PT studies was limited to randomized controlled trials but did not allow for any statistical analysis due to the use of various outcome scoring tools. All studies in this review used the VISA-P questionnaire facilitating more direct comparison of study outcomes within a given treatment, but it also required us to use Level II-IV evidence studies. The overall reporting quality of the included studies was high, and there was no evidence of reporting bias, supporting the validity of the current analysis. The average length of follow-up of 15.2 months (SD 13.6) among studies is comparable with other knee tendon or extra-articular ligament injury outcome studies in the recent literature; however, longer-term follow-up is always preferable to better assess whether an intervention is of durable benefit. Baseline symptom scores between treatment groups were highly variable, particularly those between patients treated with surgical versus nonsurgical methods. To allow fair comparison between treatment modalities, these score differences were accounted for by creating a standardized measure of treatment effect. Our ability to draw conclusions for ultrasound and sclerotherapy was limited by our inability to assess between-study variability of outcomes. Finally, although the use of a single outcome measure (VISA) allowed for the use of statistical techniques to compare outcomes between studies, inclusion of studies that used other outcomes instruments would have allowed for a more comprehensive qualitative review of the existing literature. We also recognize that there are many factors not discussed in this review that go into making decisions about patient management. We designed this systematic review to provide practitioners with the evidence-based support necessary for developing individualized treatment strategies for their patients with PT.

Conclusions

Initial treatment of PT can consist of eccentric squat-based therapy, shockwave, or PRP as monotherapy or an adjunct to accelerate recovery. Surgery or shockwave can be considered for patients who fail to improve

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after 6 months of conservative treatment. Corticosteroid therapy should not be used in the treatment of PT.

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