Chapter 6

An exercise-based physical therapy program for patients with patellar tendinopathy after platelet-rich plasma injection

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*Physical Therapy in Sport* 2013; 14(2): 124-130
Abstract

Objectives: To describe a post platelet-rich plasma (PRP) injection, exercise-based physical therapy program, investigate feasibility and report the first results of patellar tendinopathy patients treated with PRP injection combined with the physical therapy program.

Study Design: Case series.

Setting: A PRP injection followed by a physical therapy program seems promising for the treatment of patellar tendinopathy. However, descriptions of physical therapy programs are often limited and incomplete.

Participants: Five patellar tendinopathy patients (six tendons) in the degenerative phase.

Main outcome measure: VISA-P score.

Results: Muscle strength, endurance, power and retraining sport-specific function form the basis for the physical therapy program aiming to improve the load capacity of the knee. The program is characterised by gradually increasing intensity and difficulty of exercises. Five of the six tendons showed an improvement of at least 30 points on the VISA-P after 26 weeks.

Conclusions: This study extensively describes, based on current knowledge, a physical therapy program after PRP injection for patellar tendinopathy patients. The combination treatment reported in this study is feasible and seems to be promising for patients in the late/degenerative phase of patellar tendinopathy.
Introduction

Patellar tendinopathy is a common injury among athletes who place a high load on the extensor mechanism of the knee.\(^1\)\(^2\) It is often seen in ‘jump sports’ like volleyball and basketball.\(^1\) Patellar tendinopathy, also known as jumper’s knee, is characterised by pain and tenderness most commonly at the proximal end of the patellar tendon.\(^1\) This injury can have a major impact on an athlete’s career/sporting life because of its chronic character.\(^1\) The results of treatments for patellar tendinopathy are variable. First-line usual care is based on load adjustment and eccentric training.\(^5\)–\(^9\) A wide range of treatments like anti-inflammatory medication, extracorporeal shockwave therapy, injection treatments and surgery are often tried subsequently. However, no consensus exists on the treatment to be implemented, as results are often disappointing.\(^9\)\(^10\) The variable results might be explained by the phase of patellar tendinopathy in which the patient is treated. A distinction in treatment might be necessary between the reactive tendinopathy/early tendon disrepair and the degenerative/late tendon disrepair phase of a tendinopathy.\(^11\) This study focuses on the degenerative/late tendon disrepair phase of patellar tendinopathy.

The healing of a tendinopathic patellar tendon is a complex system in which mechanical and biological factors work together.\(^8\)\(^12\) A combination of treatment strategies therefore seems to be required to heal a tendinopathic tendon. One promising although not yet extensively investigated injection treatment for a tendon in the degenerative/late tendon disrepair phase is injection with platelet-rich plasma (PRP). The literature states that the presumed working mechanism is not solely the injection of PRP (‘cocktail’ of growth factors) in or near the patellar tendon, but the co-action of chemical and mechanical factors.\(^14\)\(^15\)

A study from Virchenko et al.\(^16\) on the interplay of injection of platelets and mechanical stimulation on rat tendons showed that both biological and mechanical stimulation is needed to optimise healing of a tendon. They concluded that only the early phases of regeneration are influenced by platelets; this stresses the importance of development through mechanical stimulation early on in the process of healing. The necessity to combine a PRP injection with physical therapy is also emphasised by Kon et al.,\(^17\) who performed a pilot study on PRP injections for the treatment of patellar tendinopathy. The participants who did not follow the rehabilitation program achieved poorer results at follow-up. Overall, the literature indicates that to optimise treatment PRP injection should be combined with mechanical stimulus of the tendon.

Although all the available studies on different injection treatments state the importance of mechanical loading through a physical therapy program, the description of such program is often limited and incomplete.\(^18\) Furthermore, large differences exist between the physical therapy programs, and the content of the most effective program is not clear.\(^18\) Since a physical therapy program plays a major role in the outcome of the treatment, a well-described program with a clear rationale is essential to guide the physical therapist and to compare treatments.\(^39\) The aim of this study is therefore to describe a post-PRP injection, exercise-based physical therapy program based on current literature insights and expert opinion, investigate feasibility and report on the
first results of patients treated with a combination of PRP injection with this physical therapy program.

Case description

Study design
This prospective case-series study reported the first results of a combination treatment of PRP injection followed by a well-described physical therapy program. In order to gain insight into the outcome of the combined treatment, outcome measures were assessed before the treatment (baseline) and 6 weeks, 12 weeks, 16 weeks and 26 weeks after injection. Patients also had to fill in a web-based diary every week. The injection and all the tests and physical therapy sessions took place at the Center for Sports Medicine of University Medical Center Groningen, The Netherlands. Patients were included during the period March–November 2010.

Participants
The participants were all patients of the Sports Medical Center of University Medical Center Groningen. They were diagnosed with patellar tendinopathy by one single sports medicine physician (JZ). Inclusion and exclusion criteria are described in Table 1. All patients gave their informed consent for participation in the study.

Table 1. Inclusion and exclusion criteria

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
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<tbody>
<tr>
<td>• History of knee pain in the proximal section of the patellar tendon or its patellar insertion in connection with training and competition</td>
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<td>• Symptoms for over 12 months (current symptoms for at least three months)</td>
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<td>• Age 18-40</td>
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<td>• Palpation tenderness of the corresponding painful area</td>
</tr>
<tr>
<td>• VISA-P score &lt; 80</td>
</tr>
<tr>
<td>• Ultrasound characteristics of a tendon in the degenerative phase (hypoechoic zones)</td>
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<td>• Recalcitrant to previous conservative treatment (at least 12 weeks eccentric training)</td>
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<table>
<thead>
<tr>
<th>Exclusion criteria</th>
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<tbody>
<tr>
<td>• Acute knee or patellar tendon injuries</td>
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<tr>
<td>• Chronic joint diseases</td>
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<tr>
<td>• Signs or symptoms of other coexisting knee pathology</td>
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<td>• Pregnancy</td>
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<tr>
<td>• Bleeding disorders and haematological diseases</td>
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<tr>
<td>• Malignancy</td>
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<tr>
<td>• Knee surgery</td>
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<tr>
<td>• Injection of any kind in the patellar tendon in the preceding three months</td>
</tr>
<tr>
<td>• Use of NSAIDs in the last 5 days before or first 6 weeks after injection or daily use of drugs with a putative effect on patellar tendinopathy in the last year (e.g. nonsteroid anti-inflammatory drugs, fluorchinolones)</td>
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<tr>
<td>• Current use of anticoagulants</td>
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Procedure

Injection
Patients received an ultrasound-guided PRP injection in the degenerative zone of the patellar tendon. PRP was prepared using a 15 ml ACP double syringe (Arthrex Nederland B.V., The Netherlands). For the preparation of PRP, 10 ml venous blood was withdrawn from the patient. The blood was centrifuged for 5 minutes at 3500 RPM. The PRP was injected under ultrasound guidance into the hypoechoic area of the tendon using a 22-gauge needle. One single physician performed the injections (JZ). The patient had to wear a temporary splint for the first 48 hours after injection. Platelet counts of the PRP were performed after injection in a laboratory of the University Medical Center Groningen. The PRP injections contained a relatively low concentration of platelets \((433 \times 10^9/l, 95\%CI (256-609))\).

Physical therapy program
The physical therapy program was designed based on current insights from the literature and expertise of a physical therapist, a sports medicine physician and human movement scientists. Muscle strength, endurance, power and retraining sport-specific function form the basis for the physical therapy program aimed at improving the load capacity of the knee. The program is characterised by gradually increasing intensity and difficulty of exercises. Before increasing load, execution of exercises should be correct and controlled, and pain should not exceed a score of 50 on the Visual Analogue Scale (VAS) (0-100). The load can be increased relatively quickly when exercises are executed properly, to ensure a quick return to sports. The program consists of five phases. The aim of the first three phases is to create conditions for an optimal recovery. The final two phases target the sport-specific load of a patient. The duration of each phase is a time indication and individually dependent on the progression of the patient. A description of the physical therapy program is provided in Figure 1. Besides an explanation of the program from the physical therapist, the patients received a printed version of the program and an explanation of the exercises on DVD. This DVD was created to ensure a correct (qualitatively good) execution of the exercises and to increase patient compliance. All exercises of the physical therapy program were explained and displayed using video clips.
Phase 1 – Inflammation/proliferation phase (0-2 weeks)
Inform and advise patient, rest, low load (1x week physical therapy)
Day 1-3 Inform and advise patient
• Rest.
• Low load (walk with two crutches).
• Reduce pain (cryotherapy).
Day 4-7 Inform and advise patient
• Optimise ROM, if necessary combined with isometric exercises for m. Quadriceps.
• Increase ADL with VAS pain score < 50.
Day 7-14 Exercise
• Optimise knee flexion and extension combined with unloaded cycling (hometrainer).
• Walking: 100% load without crutches.
• Home exercise program: m. Quadriceps isometric contraction, active straight-leg raise, abduction side-lying (2x day, 3 x 20 reps., rest interval 30–60 sec.).
Pain score must not exceed 50 on the VAS scale during all exercises and activities of daily living.

Phase 2 – Proliferation phase (weeks 2-4)
More dynamic and active exercises (1x 2 weeks physical therapy)
• Higher cycling intensity (build up load), goal: 20-30 minutes.
• Home exercise program:
  – Squats, calf extensions, single-leg squat with arm swing, abduction side-lying. Cycling on home trainer (3 x 20 reps. rest interval 30-60 sec.).
  – Exercises have to be possible (need to be executed) in complete ROM.
  – Closed chain exercises, mainly coordination and strength endurance. Stability plays no major role yet.
  – Light pain (VAS < 50) allowed during exercises, however the pain must decrease after the exercise.

Phase 3 – Remodelling phase (weeks 5, 6)
Active exercises are expanded (2x week physical therapy)
• Eccentric exercises are integrated into the program.
  Home exercise program (on days without supervised physical therapy): 2 days/week single-leg squat on decline board (25°).
• Various exercises (strength endurance) to increase load capacity of lower extremity, including hometrainer warm-up, core stability exercises, lunges, abduction side-lying, squats and step-downs (3x15 reps., rest interval 30 sec.).
• Integrate core stability exercises (e.g. prone bridge, side bridge).
A pain increase within 48 hours is allowed (VAS < 50), but the pain must have disappeared after 48 hours. No leg extension in open chain.

Phase 4 – Integration phase (weeks 7, 8)
Exercises progressing to higher %1RM, 3 x 8-15 reps., rest interval 30 sec., more muscular hypertrophy (2x week physical therapy)
• Daily eccentric training (2x day, 3 x 20 reps.).
• Run-and-Walk exercises of increasing intensity and difficulty (starting with interval walking/jogging, advancing to multidirectional, acceleration and deceleration running).
• Jump exercises with increasing difficulty. (Correct execution with controlled landing important. Start with height jumps, progress to long jumps.)
• Core stability with higher difficulty.
• Sport-specific exercises at maximal and speed strength.

Phase 5 – Sport-specific phase (After 8 th week)
• Daily eccentric training continues (2x day, 3x20 reps.) until end of supervised physical therapy program (± 12 weeks).
• Advance to more sport-specific exercises, e.g. plyometric, a-lactic, multidirectional running, acceleration and deceleration.

ADL = Activities of Daily Living; reps. = repetitions; ROM = Range Of Motion; sec. = seconds; VAS = Visual Analogue Scale

Figure 1. Physical therapy program
Outcome measures
Primary outcome measure was the VISA-P score, rated using a self-reported questionnaire and found to be reliable and valid to measure the severity of patellar tendinopathy. The score ranges from 0 to 100. A score of 100 indicates the maximum score for an asymptomatic athlete.

Secondary outcome measures were pain ratings on a VAS during Activities of Daily Living (ADL) and functional tests: 1x single-leg decline squat (SLDS), 10x SLDS, maximal jump test and triple-hop test. The SLDS is a squat performed on one leg to 60° of knee flexion on a 25° decline board. The maximal jumping test entails three countermovement jumps performed on the injured leg of the patient. The triple-hop test consists of three consecutive jumps; patients are instructed to jump as far as possible in three jumps on the injured leg while maintaining balance on one leg for at least 2 seconds after every jump. The tests were assessed by a specially trained human movement scientist. Patients were also asked if they had experienced improvement and if they would recommend this treatment to a friend or relative. Furthermore, patients were asked to fill in a web-based diary every week. They were asked for pain, degree of compliance with the program, complications, side effects, other treatments, other activities and medication used.

Degree of compliance with the program was determined with the question ‘To what extent did you comply with the exercise program? (0-10)’. The mean self-reported compliance with the program was determined by calculating the mean score on this question for all weeks. Descriptive statistics were used to report the results. Means and 95% confidence intervals were displayed for all outcome measures.

Results
Subject characteristics
Subject characteristics per case are presented in table 2. Two men and three women participated; mean age was 27 years. One of the patients had bilateral complaints and received the treatment for both knees with an interval of two weeks between treatments (case numbers 1a and 1b). The patients had a mean duration of symptoms of 38.4 months. Previous treatments of the patients included rest, eccentric training, extracorporeal shockwave therapy and deep friction of the tendon. All patients were recreational athletes.

Compliance and side effects
Table 2 also shows patients’ self-reported compliance with the program. The patients stated in the diary that they never performed exercises more often than prescribed in the program. They did not comply fully with the program; reasons for non-compliance were no time, no motivation, holidays or other injuries.

None of the patients consulted other medics/paramedics or physicians for their patellar tendinopathy during the course of this study. One of the patients (case number 5) underwent
Table 2. Subject characteristics, self-reported compliance and VISA-P scores per case

<table>
<thead>
<tr>
<th>Case number</th>
<th>Sex</th>
<th>Age</th>
<th>BMI</th>
<th>Sport</th>
<th>Hours sport participation per week (pre injury)</th>
<th>Duration of symptoms (months)</th>
<th>Mean self-reported compliance with the program, 0-10 (95%CI)</th>
<th>VISA-P Baseline</th>
<th>VISA-P 6 weeks</th>
<th>VISA-P 12 weeks</th>
<th>VISA-P 16 weeks</th>
<th>VISA-P 26 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a*</td>
<td>F</td>
<td>28</td>
<td>27.7</td>
<td>Soccer</td>
<td>4.5</td>
<td>18</td>
<td>7.6 (6.5-8.8)</td>
<td>60</td>
<td>43</td>
<td>67</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>1b*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.7 (6.3-9.0)</td>
<td>62</td>
<td>44</td>
<td>66</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>30</td>
<td>24.2</td>
<td>Soccer</td>
<td>4</td>
<td>60</td>
<td>8.1 (7.0-9.2)</td>
<td>43</td>
<td>53</td>
<td>70</td>
<td>68</td>
<td>94</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>27</td>
<td>27.2</td>
<td>Volleyball</td>
<td>4.5</td>
<td>30</td>
<td>5.7 (4.7-6.6)</td>
<td>58</td>
<td>50</td>
<td>57</td>
<td>60</td>
<td>54</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>21</td>
<td>23.0</td>
<td>Volleyball</td>
<td>9</td>
<td>24</td>
<td>6.2 (4.3-8.1)</td>
<td>43</td>
<td>53</td>
<td>67</td>
<td>77</td>
<td>76</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>28</td>
<td>26.6</td>
<td>Handball</td>
<td>5</td>
<td>60</td>
<td>6.5 (5.6-7.5)</td>
<td>30</td>
<td>46</td>
<td>61</td>
<td>67</td>
<td>60</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>27 (23-31)</td>
<td>25.7 (23.2-28.3)</td>
<td>5.4 (2.9-7.9)</td>
<td>38.4 (13.4-63.4)</td>
<td>7.0 (6.5-7.5)</td>
<td>49.3 (36.0-62.6)</td>
<td>48.2 (43.5-52.8)</td>
<td>64.7 (59.7-69.7)</td>
<td>67.7 (62.0-73.4)</td>
<td>80.1 (59.2-102.1)</td>
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</table>

* Case number 1 is a patient with bilateral patellar tendinopathy and received the injections with an interval of two weeks (1a first knee and 1b second knee treated)
a foot operation in the treated leg 18 weeks after injection, which influenced his activities in the following weeks (i.e. the participant performed fewer physical activities). This could have caused the drop in VISA-P score between weeks 16 and 26. Patients did not report any complications or side effects during and after the treatment. No problems were reported by the sports medicine physician and the physical therapist during the treatment either.

**Clinical assessment measures**

Table 2 and figure 2 show the primary outcome measure (VISA-P) per case. Five of the six tendons show an improvement of at least 30 points on the VISA-P after 26 weeks. The mean results of all outcome measures are presented in Table 3. The descriptive statistics show some improvements starting at 12 weeks after injection (around the end of the physical therapy program). Outcome measures did not improve after 6 weeks compared to baseline.

At 26 weeks follow-up four of the five patients indicated that they would positively recommend this treatment to family or friends with the same injury.
Table 3. Mean results of a PRP injection followed by a physical therapy program (n=6)

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Baseline, mean (95%CI)</th>
<th>6 weeks, mean (95%CI)</th>
<th>12 weeks, mean (95%CI)</th>
<th>16 weeks, mean (95%CI)</th>
<th>26 weeks, mean (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISA-P score (0-100)</td>
<td>49.3 (36.0-62.6)</td>
<td>48.2 (43.5-52.8)</td>
<td>64.7 (59.7-69.7)</td>
<td>67.7 (62.0-73.4)</td>
<td>80.1 (59.2-102.1)</td>
</tr>
<tr>
<td>Pain (VAS) during ADL (0-100 mm)</td>
<td>27 (3-50)</td>
<td>22 (13-31)</td>
<td>9 (-2-21)</td>
<td>8 (-3-19)</td>
<td>7 (-7-21)</td>
</tr>
<tr>
<td>Pain (VAS) during 1x SLDS (0-100 mm)</td>
<td>33 (19-47)</td>
<td>27 (7-47)</td>
<td>10 (-5-25)</td>
<td>9 (-2-19)</td>
<td>9 (-5-23)</td>
</tr>
<tr>
<td>Pain (VAS) during 10X SLDS (0-100 mm)</td>
<td>47 (29-66)</td>
<td>43 (26-60)</td>
<td>26 (12-39)</td>
<td>18 (3-34)</td>
<td>15 (-3-34)</td>
</tr>
<tr>
<td>Pain (VAS) during maximal jump test (0-100 mm)</td>
<td>37 (6-67)</td>
<td>a</td>
<td>8 (-7-23)</td>
<td>8 (-7-23)</td>
<td>13 (-9-35)</td>
</tr>
<tr>
<td>Pain (VAS) during triple-hop test (0-100 mm)</td>
<td>36 (11-61)</td>
<td>a</td>
<td>12 (-1-26)</td>
<td>14 (0-28)</td>
<td>14 (-3-31)</td>
</tr>
</tbody>
</table>

*a No jumps allowed in this stage of the physical therapy program

Discussion

The main aim of this study was to describe a post-injection physical therapy program for patellar tendinopathy patients. This is, to our knowledge, the first paper that extensively describes a post-injection physical therapy program. The combined treatment of a PRP injection followed by a physical therapy program seems to be feasible. This case series further shows promising results of this combined treatment.

An important role exists for a physical therapy program after PRP injection treatment in patellar tendinopathy patients, because a mechanical loading is needed after this injection. As proposed in the literature, the rehabilitation of patellar tendinopathy is aimed at improving muscle-tendon function and normalising the pelvic/lower limb kinetic chain. The post-injection physical therapy program therefore includes training muscle strength, endurance and power, and retraining sport-specific function.

Rationale physical therapy program

The first phase of the physical therapy program starts with informing and advising the patient about the content and rationale of the program. As walking can be painful after an injection in the patellar tendon, a splint can be used to reduce pain and crutches can be used to facilitate walking in the first days. The first few days after injection, rest, walking with crutches and only a low load are indicated because an injection causes some damage to the tendon and the tendon needs to ‘calm down’. The effects of platelets are present in the first days after injection without the need for mechanical loading. Furthermore, in usual treatment of patellar tendinopathy the load on the patellar tendon is lowered first before increasing it again. Additionally, cryotherapy can be used by the patient to reduce pain in the first days after injection. The program starts with increasing activities of daily living and low-load exercises a few days after the injection, so the patient will
not be completely immobilised. This is supported by a laboratory study from Virchenko et al., who state that complete unloading after an injection with PRP could impair the healing process. They hypothesised that early mechanical loading by physical therapy is needed to benefit from the inflammatory response induced by the PRP injection.

The second phase is characterised by more dynamic and active exercises than the first phase. Intensity is increased and exercises are prescribed in the home exercise program with mounting complexity to improve the entire kinetic chain. Patients familiar with long-term patellar tendinopathy symptoms have generally shown a moderate coordination of the lower extremities and atrophy based on disuse developed in time. For this reason, the rehabilitation starts with exercises to improve coordination and strength endurance. This is intended to be achieved through many repetitions in closed-chain exercises.

Eccentric training is currently the best-evidence treatment for patellar tendinopathy. According to the assumed working mechanism, a PRP injection should always be combined with mechanical loading. Eccentric exercises should therefore be included in a post-injection physical therapy program, even though all patients performed an eccentric exercise program in the past. The eccentric exercises are integrated into phase 3 of the program (around week 5 after injection). Eccentric exercises are performed only twice a week in this phase of the program, to give the tendon time to adapt; after this phase the load on the tendon is gradually increased further to augment its load capacity. Although eccentric training plays an important role in the physical therapy program, this is combined with exercises which include concentric training. Results of concentric and eccentric heavy slow resistance training compared to solely eccentric training appear to be similar. The combination of concentric and eccentric training is used to train the entire kinetic chain and might promote collagen synthesis. Leg extensions in open chain exercises are avoided in the first 3 phases of the program, because a high load on the tendon was found in the last ±10° of knee extension and the load on the tendon is gradually increased in the physical therapy program.

Core muscles are important in the load distribution on the patellar tendon, therefore core stability exercises are also integrated starting in the third phase of the program. Various other exercises are also integrated into the program to increase load capacity of the lower extremity.

Phase 4 consists mainly of daily eccentric training based on the protocol proposed by Alfredson. The eccentric training consists of single-leg squats performed on a decline board (25°). It seems that some pain is needed and therefore acceptable during the eccentric exercises for them to be effective, but no studies exist that specify an optimal level of discomfort/pain during the execution of these exercises. In this program, pain during eccentric training should not exceed 50 on the VAS scale (0-100), which has been demonstrated to be a reasonable approach in Achilles tendinopathy.

Since walking and running are an essential part of daily activities and most sports, this needs to be included in a physical therapy program. Running and walking exercises of increasing intensity and difficulty are part of the integration phase of the physical therapy program. The run-and-walk
exercises start around the 7th week of the program with interval walking/jogging advancing to multidirectional running. To further increase the load capacity of the tendon, jump exercises with increasing difficulty and sport-specific exercises are also started in this phase. In the final phase the exercises become increasingly sport-specific, as every sport has its own demands and the program is aimed at returning to sports.

There is extensive debate on physical therapy programs, which often differ per therapist due to a lack of thorough research on aspects of the program and experiences of the physical therapist. This study tried to cluster pragmatic and theoretical knowledge into one physical therapy program which can be used for patellar tendinopathy patients after a PRP injection treatment. There is a scarcity of research, for example, on the length of the rest interval between sets of exercises. The exercises in this program are performed with a rest interval of 30-60 seconds to promote muscular hypertrophy. Multiple sets of exercises are performed because this is more effective than single sets. This program's support from the literature, combined with sports medicine expertise, shows its suitability as a physical therapy program after PRP injection treatment. The program might also be suitable to follow other injection treatments like autologous blood and dry needling, because of their comparable working mechanism.

**Feasibility**

The combined treatment of a PRP injection followed by a physical therapy program seems feasible because neither patients nor practitioners reported complications. Further, a self-reported compliance with the program of 7.0 (0-10) was indicated in the diaries. This seems to be a fair number; by comparison, previous research reports compliance with an eccentric exercise program of 60-65%.

**First results**

It is important to state that due to several limitations of this case-series, no well-grounded statements can be made on the effectiveness of the treatment. Limitations are the small number of participants and lack of a control group. Another limitation is the heterogeneity of the participants. Four unilateral and one bilateral patient were treated. A second injection in the other knee two weeks after the first injection might have interfered with the rehabilitation in the bilateral patient. Finally, men as well as women were included.

While keeping these limitations in mind, the data show mainly positive results after treatment. Five of the six treated knees show improvement in outcome measures and patients would recommend this treatment to family or friends. It is remarkable that the only patient who did not show improvement after treatment was the one with the lowest self-reported program compliance. Three patients with the highest self-reported compliance showed the largest improvement in VISA-P score. This is in accordance with a pilot study on PRP from Kon et al. Poorer results of a PRP injection were obtained when compliance was low. More research is needed to obtain full insight into the results of PRP combined with physical therapy and the additional value of
the combination of treatments over one treatment alone. Currently, the results of PRP treatments have not yet been extensively studied, and results of the few high-quality studies conducted are contradictory.\textsuperscript{13,38}

**Final reflections and future research**

This study can be an important guideline for physical therapists in the rehabilitation of patients with patellar tendinopathy after an injection with PRP. A physical therapy program, based on current insight in literature and expert opinion, after PRP injection is extensively described and underpinned in this article. This study proposes a combination treatment of an injection with PRP followed by a physical therapy program. The combination seems to be required, because a previous eccentric exercise physical therapy program and other treatments alone did not result in positive effects. The healing of a tendinopathic tendon is an interplay of mechanical and biological factors.\textsuperscript{8,12} This supports use of a multifactorial approach with more than one treatment modality for patients in the late/degenerative phase of patellar tendinopathy. An implication of a combined treatment and design used in the study is that this case-series does not provide evidence for an effect of this treatment or one of its components; it provides only initial insight into the outcome of a combined treatment of PRP injection together with a physical therapy program which results seem promising.

It is important for further research to standardise post-injection physical therapy programs. A clear description of a program is needed to compare effects of different programs. Future research needs to address this to investigate the best injection treatment and subsequent physical therapy program. Ideally, standardised physical therapy programs, like the program described in this study, need to be compared in randomised clinical trials.

**Conclusion**

A post-PRP injection physical therapy program was described in this study. This is, to our knowledge, the first study to extensively describe an exercise based physical therapy program after an injection treatment for patellar tendinopathy patients that is based on current literature insights and expert opinion. The study demonstrated feasibility of the combination treatment. The combination treatment reported in this study seems to be promising for patients in the late/degenerative phase of patellar tendinopathy.
References


