Proximal Hamstring Tendinosis and Partial Ruptures
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abstract

Proximal hamstring tendinosis and partial hamstring origin ruptures are painful conditions of the proximal thigh and hip that may occur in the acute, chronic, or acute on chronic setting. Few publications exist related to their diagnosis and management. This systematic review discusses the incidence, treatment, and prognosis of proximal hamstring tendinosis and partial hamstring ruptures. Conservative treatment measures include nonsteroidal anti-inflammatory drugs, physical therapy, rest, and ice. If these measures fail, platelet-rich plasma or shockwave therapy may be considered. When refractory to conservative management, these injuries may be treated with surgical debridement and hamstring reattachment. [Orthopedics. 2017; 40(4):e574-e582.]

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ympomatic presentation of hamstring injuries varies based on severity of pathology. Acute injuries generally follow rapid acceleration or deceleration movements and frequently occur in soccer, football, skiing, and hockey.1-7 Chronic injuries present with an insidious onset of unrelenting pain made worse with sports activities and sitting.8-13 Chronic injuries are often found in runners.7 Weakness and difficulty running are common.9 The hamstring tendon may be injured at a variety of locations along its anatomical course. A variety of forms of damage exist, including inflammation, degeneration, partial tearing, complete tearing, or a combination of these pathologies.

Chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin are known causes of chronic posterior thigh and posterior hip pain. Tendinosis is defined as a degenerative condition of tendons; partial tearing is defined as an incomplete rupture. Chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin may present in the acute, chronic, or acute on chronic setting.11,14-18 Complete or near-complete high-grade partial tearing of the hamstring origin with multiple tendon involvement has been reported more extensively, with surgical treatment generally being recommended.1-4,19,20 In contrast, relatively few publications exist related to diagnosis of and management strategies for chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin. Injuries are frequently diagnosed late as a result of poor recognition and understanding of them.5 Partial tears often occur in the setting of degenerative tendinosis of various degrees, and occur more frequently with older age. This systematic review discusses the incidence, treatment, and prognosis of chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin.21

MATERIALS AND METHODS

Identification of appropriate studies involved a search of both the PubMed and MEDLINE databases from 1985 to 2015. Search terms included “proximal hamstring tendinopathy,” “hamstring tendinopathy treatment,” “proximal hamstring tear,” “proximal hamstring tear treatment,” “hamstring tear treatment,” “hamstring tendinosis,” “proximal hamstring tendinosis,” “partial rupture of proximal hamstring,” Proximal Hamstring Tendinosis and Partial Ruptures

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and “partial hamstring rupture.” Studies were reviewed for criteria by 2 authors (A.N.S., O.F.). In instances of disagreement, the article in question was submitted to the senior author (D.C.) for review.

Studies were included in the review based on documenting patient outcomes following conservative or surgical management; mentioning a tendon injury, including tendonitis (inflammation), tendinosis (degeneration), tendinopathy (nonspecific tendon injury), and partial tears; being written in English; being published within the past 30 years; and reporting at least 1 follow-up interview.

Studies were excluded based on being review articles and expert opinion articles; including complete tears, ruptures, or avulsions; being single case reports; and including surgical techniques with no mention of patient outcomes.

**RESULTS**

The search revealed 367 articles. Twenty-one of the articles met inclusion criteria (Table 1). Six articles discussed surgical criteria and outcomes (Table 2). Two articles discussed magnetic resonance imaging data.

### Table 1: Systematic Review of Data

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>No. of Participants</th>
<th>Average Age, y</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetzel et al (2013)</td>
<td>17 (10 PRP)</td>
<td>37.1</td>
<td>PRP</td>
<td>8.7 VAS; 90% (9 of 10) returned to sport</td>
</tr>
<tr>
<td>Fader et al (2015)</td>
<td>18</td>
<td>42.6</td>
<td>PRP</td>
<td>4.6 VAS; 63% had average improvement</td>
</tr>
<tr>
<td>Davenport et al (2015)</td>
<td>17 (11 PRP; 6 WB)</td>
<td>46.6 (PRP); 45.4 (WB)</td>
<td>PRP and WB</td>
<td>WB showed greater improvement at 12 weeks, while PRP showed greater improvement in all outcome measures at 6 months</td>
</tr>
<tr>
<td>Hamid et al (2014)</td>
<td>28 (14 PRP)</td>
<td>20.00</td>
<td>PRP</td>
<td>PRP is effective in reducing severity of pain and allowing shorter time to return to play after acute hamstring injury; PRP group achieved full recovery earlier than controls (P=.02)</td>
</tr>
<tr>
<td>Cacchio et al (2011)</td>
<td>40 (20 SWT)</td>
<td>N/A</td>
<td>SWT</td>
<td>85% (17 of 20) of patients from SWT group achieved at least 50% reduction in pain compared with 10% (2 of 20) from the conservative treatment group</td>
</tr>
<tr>
<td>Bowman et al (2013)</td>
<td>17</td>
<td>43.4</td>
<td>Surgery</td>
<td>13 patients satisfied; 8 with 100% recovery</td>
</tr>
<tr>
<td>Aldridge et al (2012)</td>
<td>23</td>
<td>42</td>
<td>Surgery</td>
<td>81/100 mean satisfaction rating; 20 patients would have the same procedure again; 21% average increase in strength compared with preoperative</td>
</tr>
<tr>
<td>Benazzo et al (2013)</td>
<td>17</td>
<td>26.6</td>
<td>Surgery</td>
<td>15 patient outcomes reported as excellent; 9.1 overall satisfaction score</td>
</tr>
<tr>
<td>Lempainen et al (2006)</td>
<td>47</td>
<td>25 (competitive); 33 (recreational)</td>
<td>Surgery</td>
<td>33 excellent outcomes with 100% of participants benefiting from surgery</td>
</tr>
<tr>
<td>Puranen and Orava (1988)</td>
<td>59</td>
<td>25 (athletes=50); 39 (joggers=4); 35 (nonathletes=5)</td>
<td>Surgery</td>
<td>52 good; 7 had symptoms lasting greater than 6 months after surgery and had a poor result concerning maximal sports performance</td>
</tr>
<tr>
<td>Lempainen et al (2009)</td>
<td>103</td>
<td>26 (professional and competitive athletes); 45 (recreational athletes)</td>
<td>Surgery</td>
<td>80 of 90 patients (89%) had excellent or good results and were able to return to their preinjury level of sporting activity; 5-month average for full recovery</td>
</tr>
<tr>
<td>Zissen et al (2010)</td>
<td>65</td>
<td>37.7</td>
<td>MRI, ultrasound, percutaneous corticosteroid injection</td>
<td>50% had symptom relief for at least 1 month; 24% has symptom relief for at least 6 months</td>
</tr>
</tbody>
</table>

Abbreviations: MRI, magnetic resonance imaging; N/A, not applicable; PRP, platelet-rich plasma; SWT, shockwave therapy; VAS, visual analog scale; WB, whole blood.
aging (MRI) and ultrasound as diagnostic and therapeutic modalities. Four articles discussed platelet-rich plasma (PRP) as treatment of hamstring tendinopathy in cases refractory to conservative measures. One study discussed shockwave therapy (SWT). Eight studies discussed conservative, noninvasive treatments (Table 3).

All surgical articles were retrospective. Of the 4 PRP studies, 1 was retrospective, 1 was a randomized controlled trial, 1 was a cohort study, and 1 was a double-blind

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>No. of Patients</th>
<th>Mean Age, y</th>
<th>Sex</th>
<th>Side of Injury</th>
<th>Time to Surgery</th>
<th>Surgical Technique</th>
<th>Follow-up</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benazzo et al (2013)</td>
<td>17</td>
<td>26.6</td>
<td>12 male</td>
<td>6 right</td>
<td>11 left</td>
<td>23.3 mo</td>
<td>Prone, leg flexed 90°, longitudinal incision</td>
<td>71 mo</td>
</tr>
<tr>
<td>Lempainen et al (2006)</td>
<td>47</td>
<td>30</td>
<td>32 male</td>
<td>31 right</td>
<td>17 left</td>
<td>13 mo</td>
<td>Prone, knee flexed 30°, vertical incision (45 cases) Transverse incision</td>
<td>36 mo</td>
</tr>
<tr>
<td>Bowman et al (2013)</td>
<td>17</td>
<td>43.4</td>
<td>3 male</td>
<td>8 right</td>
<td>9 left</td>
<td>6 mo</td>
<td>Prone, hip flexed 20°, transverse incision</td>
<td>32 mo</td>
</tr>
<tr>
<td>Aldridge et al (2012)</td>
<td>23</td>
<td>42</td>
<td>10 male</td>
<td>12 right</td>
<td>11 left</td>
<td>41 wk</td>
<td>Prone, longitudinal incision</td>
<td>3.1 y</td>
</tr>
<tr>
<td>Puranen and Orava (1988)</td>
<td>59</td>
<td>25 (athletes=50) 39 (joggers=4) 35 (nonathletes=5)</td>
<td>45 male</td>
<td>Approximately half involved right and half involved left</td>
<td>Several months without relief from conservative treatment</td>
<td>65% received modified Kocher’s incision, with patients lying on unaffected side 35% received a straight posterior incision while prone with hips flexed 30°</td>
<td>2 y</td>
<td>52 good—able to train and compete without symptoms 7 poor—residual symptoms after 6 mo</td>
</tr>
<tr>
<td>Lempainen et al (2009)</td>
<td>103</td>
<td>26 (professional and competitive athletes) 45 (recreational athletes)</td>
<td>58 male</td>
<td>57 right</td>
<td>46 left</td>
<td>21 mo</td>
<td>Prone, via transverse gluteal crease incision or longitudinal posterior incision</td>
<td>49 mo</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>No. of Patients</td>
<td>Mean Age, y</td>
<td>Follow-up/Measurements</td>
<td>Intervention</td>
<td>Outcome</td>
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<tr>
<td>Peterson et al(^\text{12}) (2011)</td>
<td>461</td>
<td>23</td>
<td>1 year</td>
<td>Increasing eccentric hamstring muscle strength</td>
<td>12 new injuries, 3 recurrent injuries (n=49)</td>
<td></td>
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</tr>
<tr>
<td>Askling et al(^\text{10}) (2014)</td>
<td>56 (28 lengthening, 28 conventional)</td>
<td>23 (lengthening group)</td>
<td>1 year for re-injuries</td>
<td>Assigned 2 rehabilitation protocols, lengthening exercise and conventional exercise</td>
<td>Time to return was significantly shorter (P&lt;.001) in lengthening protocol (49 days) compared with conventional protocol (86 days)</td>
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<td></td>
<td></td>
<td>19 (conventional group)</td>
<td>Number of days to return to full training</td>
<td></td>
<td>2 re-injuries were seen in C-protocol</td>
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<tr>
<td>Askling et al(^\text{11}) (2013)</td>
<td>75 (37 lengthening, 38 conventional)</td>
<td>25</td>
<td>1 year for re-injuries</td>
<td>Assigned 2 rehabilitation protocols, lengthening exercise and conventional exercise</td>
<td>Time to return was significantly shorter (P&lt;.001) in lengthening protocol (28 days) compared with conventional protocol (51 days)</td>
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<tr>
<td>Cibulka et al(^\text{18}) (1986)</td>
<td>10 (20 total, only 10 treated)</td>
<td>24.5</td>
<td>Not applicable</td>
<td>Manipulation of the sacroiliac joint</td>
<td>No significant changes in peak torque or hamstring muscle strength existed</td>
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<tr>
<td>Malliaropoulos et al(^\text{11}) (2004)</td>
<td>80</td>
<td>20.5</td>
<td>Number of days until ROM equalized between injured and non-injured leg</td>
<td>Static stretches of the hamstring muscles for 30 seconds (4×1 session)</td>
<td>Group A (n=40) stretched 1 time per day, Group B (n=40) stretched 4 times per day</td>
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<tr>
<td>Silder et al(^\text{14}) (2013)</td>
<td>25</td>
<td>24</td>
<td>MRI and physical examinations conducted after completion of rehabilitation and up to 6 mo following return to sport</td>
<td>Progressive agility and trunk stabilization exercises</td>
<td>23 days to return to sport (progressive agility and trunk stabilization exercises)</td>
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<tr>
<td>Sherry and Best(^\text{29}) (2004)</td>
<td>24 (11 static stretching, isolated progressive hamstring resistance exercise, and icing; 13 progressive agility and trunk stabilization exercises)</td>
<td>24.3 (static stretching, isolated progressive hamstring resistance exercise, and icing)</td>
<td>Time to return to sports after completion of rehabilitation</td>
<td>Static stretching, isolated progressive hamstring resistance exercise, and icing</td>
<td>28 days to return to sport (progressive running and eccentric strengthening exercises)</td>
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<tr>
<td></td>
<td></td>
<td>23.2 (progressive agility and trunk stabilization exercises)</td>
<td></td>
<td>Progressive agility and trunk stabilization exercises</td>
<td>4 re-injuries</td>
<td></td>
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<tr>
<td>De Smet et al(^\text{26}) (2012)</td>
<td>21 had a clinical diagnosis of hamstring tendinopathy (118 reviewed in all)</td>
<td>41</td>
<td>Retrospective review of MRI at 4 consecutive axial locations of the proximal hamstrings bilaterally</td>
<td>Not applicable</td>
<td>Time needed to return to sports showed no significant difference (P=.2455)</td>
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<td>Re-injury 2 weeks after rehabilitation with 6 of 11 (54.5%) in the static stretching, isolated progressive hamstring resistance exercise, and icing group compared with 0 of 13 in the progressive agility and trunk stabilization exercises group (P=.00343)</td>
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<td>Ischial tuberculosis edema (P=.004) and a feathery appearance (P=.001) of the peritendinous T2 signal distally were significantly more common in symptomatic hamstrings</td>
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<td></td>
<td></td>
<td>Increased tendon size is also significantly associated with hamstring tendinopathy</td>
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</tbody>
</table>
randomized controlled trial investigating PRP vs whole blood injections. The SWT study was a prospective, level I randomized study. Of the conservative studies, 7 were randomized controlled trials and 1 was a double-blind placebo study.

Of the 13 articles that discussed invasive treatment modalities, 266 patients were treated surgically, 53 were treated with PRP, 6 were treated with whole blood, 20 were treated with SWT, and 183 were treated with MRI or ultrasound for diagnostic evaluation and follow-up. Eight hundred were treated with conservative management.

**DISCUSSION**

**Population Characteristics**

**Activity Level/Athletic Status.** All 6 articles that reviewed surgical outcomes reported data on preinjury activity and sports level of participation. Twenty-eight professional athletes were included across 4 articles. Seventy-two patients were competitive athletes and 126 patients were recreational athletes. Of the professional athletes, 10 soccer players, 1 basketball player, 1 body builder, 1 ice hockey player, 1 aerobic athlete, 1 triathlete, 1 judo athlete, 1 karate athlete, 1 pole vaulter, 3 hurdlers, 3 long-distance runners, 2 middle-distance runners, and 2 professional triple jumpers were identified. Of the competitive and recreational athletes, 3 hurdlers, 2 triple jumpers, 8 middle-distance runners, 15 long-distance runners, 1 field hockey player, 1 track runner, 3 sprinters, 14 soccer players, 1 basketball player, 4 ice hockey players, 2 ballerinas, 1 cross-country skier, 1 floorball player, 1 handball player, 1 orienteering (a timed racing and navigation sport) athlete, 1 tennis player, 1 figure skater, 3 Finnish baseball players, 3 heptathlon athletes, 1 decathlon athlete, 2 long jumpers, 1 aerobics athlete, and 3 power lifters were identified.

Two PRP articles specifically indicated the activity level of patients. Wetzel et al. described 11 competitive athletes. Hamid et al. discussed 15 national-level, 3 state-level, 2 club-level, and 8 school athletes. Further, there were 12 track runners, 9 soccer players, and 7 hockey, netball, basketball, rugby, tennis, or shot put athletes. All 40 patients were professional athletes in the SWT article. No specific mention of type of professional sport was made in the Wetzel et al. or SWT article.

In the conservative, noninvasive articles, athletes were identified as follows: 541 soccer players, 63 sprinters and jumpers, 5 baseball players, 6 football players, 3 basketball players, 1 ultimate Frisbee player, 1 raquetball player, 5 softball players, 1 triathlete, 1 tennis player, 1 hockey player, 1 cross-country runner, and 1 runner.

**Age.** The average age of patients for all of the articles was 34 years. Average age across PRP, SWT, and surgical treatment groups was 36 years. Within the surgical treatment group, average age was 36 years. Average age across the conservative, noninvasive treatment group was 27 years.

**Side of Injury.** The surgical articles used for analysis included right or left side of injury. A total of 120 injuries occurred on the right leg and 121 on the left leg; 7 cases were bilateral. The SWT article included 22 right leg injuries and 18 left leg injuries. Handedness and side of injury did not correlate across these studies.

**Male vs Female.** Across all surgical and injection treatment studies, 229 men and 204 women were included in follow-up. Surgery was performed for 160 men and 94 women. Platelet-rich plasma was injected in 24 men and 29 women. Whole blood was injected in 5 women and 1 man. Shockwave therapy was administered to 27 men and 13 women. The conservative, noninvasive study groups included 668 men and 98 women.

**Imaging**

Radiographs are of little benefit in the diagnosis of hamstring tendinopathy. Prior to surgical treatment, and in the setting of chronic hamstring pain, MRI is typically performed. Magnetic resonance imaging reveals the extent of tendon involvement, but positive findings do not consistently correlate with symptoms. De Smet et al. found a higher correlation of tendinopathy symptoms in patients with edema noted at the ischial tuberosity, and in those with increased signal in a feathery pattern at the peritendinous junction on T2 images.

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**Table 3 (cont’d)**

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>No. of Patients</th>
<th>Mean Age, y</th>
<th>Follow-up/Measurements</th>
<th>Intervention</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reynolds et al. (1995)</td>
<td>44 (13 meclofenamate group, 17 diclofenac group, 14 placebo group)</td>
<td>33.8 (meclofenamate group)</td>
<td>7 days</td>
<td>All groups received 7 days of intensive physiotherapy treatment, then either: Meclomenenate (100 mg 3 times a day) or diclofenac (50 mg 3 times a day) or placebo</td>
<td>With severe injuries, the reported pain score at day 7 was significantly lower in the placebo group than in either the meclofenenate group or the diclofenac group (P&lt;.05)</td>
</tr>
</tbody>
</table>

Abbreviations: MRI, magnetic resonance imaging; ROM, range of motion.
Two studies detailed specific tendon involvement seen on MRI. Twenty-one (32.8%) patients had semitendinosus and biceps tendon involvement. Thirty-one (48.4%) patients had semimembranosus and 3-tendon involvement. Of those with single-tendon involvement, 5 (7.8%) patients had only semimembranosus involvement, 7 (11%) patients had only biceps femoris involvement, and 1 (1.5%) patient had only semitendinosus involvement.

Ultrasound has lower reliability than MRI for diagnosis of hamstring tendinopathy. Zissen et al reported evidence of peritendinous fluid or edema in 62.9% of patients on MRI and in only 20% of patients on ultrasound. In patients who underwent both ultrasound and MRI, the findings noted on ultrasound were compatible with those on MRI in only 13 (37%) of 35 patients. Twenty (57%) of 35 studies had abnormal MRI findings with normal ultrasound findings. Despite the lower reliability, ultrasound may be used as a therapeutic tool for injection of corticosteroid.

Zissen et al performed 65 corticosteroid injections with ultrasound guidance as both a diagnostic and therapeutic tool. All but 9 patients reported immediate symptom relief. There were no side effects identified following injection. Half of the patients experienced symptomatic improvement for 1 month, and 24% reported prolonged symptom resolution for more than 6 months.

Treatment

Conservative Measures. No consensus exists in the literature regarding an appropriate algorithm for nonoperative management. The standard “rest, ice, compression, elevation” method is used acutely. Nonsteroidal anti-inflammatory drugs may also be used, along with physical therapy. The literature does not contain quantifiable benefits of conservative methods; conservative measures are mostly historically represented.

Across the literature, most patients have a trial of conservative treatment prior to more invasive surgical management. Specific conservative treatment protocols varied across all publications. In a double-blind, placebo-controlled trial investigating 45 patients allocated into a meclofenamate, diclofenac, or placebo treatment group for 7 days after sustaining a hamstring injury, Reynolds et al analyzed patients on days 1, 3, and 7. At the end of day 7, the visual analog scale (VAS) was employed, swelling was assessed, and muscle testing was performed. When assessing the most severe injuries, the placebo group experienced a significantly lower pain score than the treatment groups (P < .05). Reynolds et al concluded that nonsteroidal anti-inflammatory drugs offered no benefit in the treatment of an acute hamstring injury.

Eccentric training may be performed as both a preventive and treatment modality in hamstring tendinopathy. In a study by Peterson et al of male soccer players, the Nordic Training Program reduced the rate of new hamstring injury by more than 60%. Asking et al performed 2 different studies investigating rehabilitation protocols among Swedish football players and sprinters/jumpers. Athletes were placed into 2 protocols. The L-protocol loaded the hamstrings with eccentric motions. The C-protocol used standard exercises without a focus on eccentric motions. In both studies, there was a significantly shorter time to sport return using the L-protocol (mean of 28 days for football players and 49 days for sprinters/jumpers). Asking et al concluded that a rehabilitation focus on lengthening exercises will lead to a faster return to sport. Sherry and Best discussed a prospective randomized study of 24 athletes assigned to static stretching vs agility and trunk stabilization rehabilitation. Quicker return to function was noted with the agility and trunk stabilization exercises.

Fader et al treated 18 patients with PRP injections, all of whom had failed conservative treatment options consisting of a 6-month course of activity modifications, physical therapy, and oral anti-inflammatory medications. Following PRP...
injection, patients were restricted from taking anti-inflammatory medications and in their activities to minimal chores for 1 week. Jogging with progression to incline running was initiated from 2 to 3 weeks after injection. Following this protocol, 5% of patients had 80% or greater improvement in subjective pain at 6 months after injection, and the total average improvement was 63%.\textsuperscript{15}

Davenport et al\textsuperscript{24} also required all patients to have trialed conservative measures prior to treatment with PRP or whole blood. Patients must not have had a corticosteroid injection within 6 months of treatment with PRP to be included in the study.\textsuperscript{24}

Cacchio et al\textsuperscript{8} performed the first level I study investigating SWT for chronic proximal hamstring tendinopathy in professional athletes. This was a randomized controlled study that enrolled 20 patients in the SWT group and 20 in a traditional conservative treatment group. At 3 months, the SWT group had statistically significant improvement in the VAS; the traditional conservative treatment group did not. At an average of 9 weeks, 16 of the patients in the SWT group returned to their professional sport. None of the patients in the traditional conservative treatment group returned to sport.\textsuperscript{8}

In the treatment of chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin, a trial of conservative measures is typically completed prior to surgical intervention. Bowman et al\textsuperscript{12} required a minimum of 6 months of nonoperative management with activity modification, physical therapy, nonsteroidal anti-inflammatory drugs, and PRP prior to surgical intervention. Benazzo et al\textsuperscript{9} required all 17 patients to undergo a trial of conservative therapy before surgery. Specific therapy included local steroid injections in 7 patients, physical therapy in 8 patients, soft tissue mobilization and isometric exercises in 12 patients, local and systemic nonsteroidal anti-inflammatory drugs in 5 patients, and eccentric contraction exercises in all 17 patients.\textsuperscript{9} In a retrospective study of 28 athletes, Lempainen et al\textsuperscript{10} noted that 18 of 28 were in too much pain to trial nonsurgical management and proceeded with surgical treatment. All patients in the Lempainen et al\textsuperscript{10} and Puranen and Oraiva\textsuperscript{16} studies required a trial of conservative measures prior to surgery.

**Time Until Surgery.** An average time of 15 months from symptom onset to surgical procedure was discussed across all surgical articles.\textsuperscript{9,10,12,13,36} Among the 4 PRP publications, 2 discussed time to treatment. Patients differed significantly regarding time from onset to PRP treatment, averaging 10 months\textsuperscript{7} and 32 months.\textsuperscript{15}

**Surgical Technique.** Surgical options include debridement alone vs debridement and tendon repair with or without neurolysis. All studies employed prone positioning, and all surgeons used some degree of leg flexion during the procedure, ranging from 20° to 90°. Three of the 6 surgeons performed neurolysis regularly; Bowman et al\textsuperscript{12} rarely performed this procedure. Lempainen et al\textsuperscript{9} always investigated the sciatic nerve, but commented that full neurolysis was rarely indicated. Tendon repair was performed with suture or suture anchors.

Benazzo et al\textsuperscript{9} performed a partial transverse tenotomy of the involved tendon, followed by a sciatic nerve release from the ischial tuberosity to 10 cm distal. Lempainen et al\textsuperscript{10} preferred a vertical incision in one article and a transverse incision in another. In the first, they performed sciatic neurolysis, followed by tendon reattachment.\textsuperscript{10} In the second, they performed a transverse incision and tenotomy of the semimembranosus, followed by tendon reattachment and sciatic nerve exploration.\textsuperscript{8} Bowman et al\textsuperscript{12} reported using a transverse incision with debridement of all diseased tissue, followed by anatomic primary repair of the native footprint with suture anchors placed in an “X” pattern. Aldridge et al\textsuperscript{13} performed a longitudinal incision over the ischium and frequently exposed the sciatic nerve; the ischial tuberosity was prepared to reveal the defect, then 2 or 3 anchors were inserted.

**Rehabilitation Protocol.** Rehabilitation protocols differed across publications. All postoperative protocols recommended partial weight bearing for 2 to 6 weeks.\textsuperscript{9,10,12,13} Two of the 6 studies reported use of aspirin or enoxaparin for deep venous thrombosis prophylaxis.\textsuperscript{9,12}

Lempainen et al\textsuperscript{6,10} discouraged sitting for 2 weeks. Three studies specifically recommended return to swimming at 3 weeks.\textsuperscript{6,9,10} All recommended limiting hip flexion for several weeks. A brace was used for immobilization postoperatively in all studies, but the type of brace differed. Return to biking and concentric stretching occurred at an average of 4 weeks, and running at an average of 11 weeks.\textsuperscript{3,9,10} Full return to sport averaged 5 months.\textsuperscript{9,10,12}

Rehabilitation protocol varied between PRP studies. Fader et al\textsuperscript{15} recommended no anti-inflammatory drugs for 6 weeks, limited activity for 1 week, return to jogging at 3 weeks, and activity as tolerated after 3 weeks. Wetzel et al\textsuperscript{2} advocated for limited hip flexion not past 30° for 3 weeks, then physical therapy for 6 weeks. An abduction brace was used for 5 patients.\textsuperscript{2} Hamid et al\textsuperscript{28} recommended reduced activity for 48 hours following injection, and then required physical therapy weekly.

In the SWT article, no activity limitations were recommended. All patients applied ice for 4 hours following the procedure.\textsuperscript{8}

**Follow-up.** Surgical patients were followed for an average of 37 months. Patients who received PRP were followed for an average of 5.5 months. Patients who received SWT were followed for 11 months.

**Complications.**

Anecdotal evidence exists related to high-level athletes having complications, including muscle atrophy, skin hypopigmentation, delayed healing, and repeat injury, following corticosteroid injection.\textsuperscript{7}

Complications were reported in all studies involving surgical treatment. Com-
used a return to sport. Hamid et al\textsuperscript{28} used return to sport as a primary outcome measure in their PRP randomized controlled trial. Half of the patients in the PRP group made a full recovery by 26 weeks; the control group required a much longer time of 39 weeks for half to return to sport. The PRP group elucidated a statistically significant time to return to play.\textsuperscript{28}

Davenport et al\textsuperscript{24} showed that patients injected with whole blood, compared with PRP, had greater improvement in all measures at 12 weeks. Patients treated with PRP injections, compared with whole blood, had greater improvements in all measures at 6 months. Statistically significant improvements occurred in activities of daily living scores at 6 months, sport-specific function scores at 2 weeks, and international Hip Outcome Tool-33 scores at 2 weeks, 12 weeks, and 6 months after injection with PRP. Patients injected with whole blood had significantly decreased pain with 15 minutes of sitting at 6 months and a greater proportion of improved tendon appearance on ultrasound at 6 months. All patients injected with either PRP or whole blood had increased evidence of calcifications on ultrasound (45% for PRP and 30% for whole blood).\textsuperscript{24}

Conservative, noninvasive treatment programs published regarding outcomes of rehabilitation concluded that increased frequency of sessions with an emphasis on lengthening and core exercises yielded quicker return to play.\textsuperscript{29,33,35}

**Conclusion**

Chronic proximal hamstring tendinosis and partial tearing of the hamstring origin remain challenging to treat. Conservative treatment measures include nonsteroidal anti-inflammatory drugs, physical therapy, rest, and ice. If these measures fail, PRP or SWT may be considered. Chronic hamstring tendinopathy refractory to conservative management can be treated with surgical debridement and hamstring reattachment. The role of sciatic neurolysis is unclear.
References