Proximal Hamstring Injuries (ICL 8)

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8.1 Introduction

Proximal hamstring injury occurs frequently and ranges from minor muscle injury to complete avulsions which can be potentially career threatening for athletes. Medical care of these challenging injuries requires proper knowledge of hamstring anatomy, function, aetiology and treatment options. Treatment may be conservative and/or operative. After successful primary treatment, secondary prevention is important due to the high incidence of reinjury. These topics are discussed in the following chapter.

8.2 Anatomy of the Proximal Hamstring Muscle Complex

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The hamstring muscle complex comprises the three muscles in the posterior thigh compartment: semitendinosus (ST), semimembranosus (SM) and

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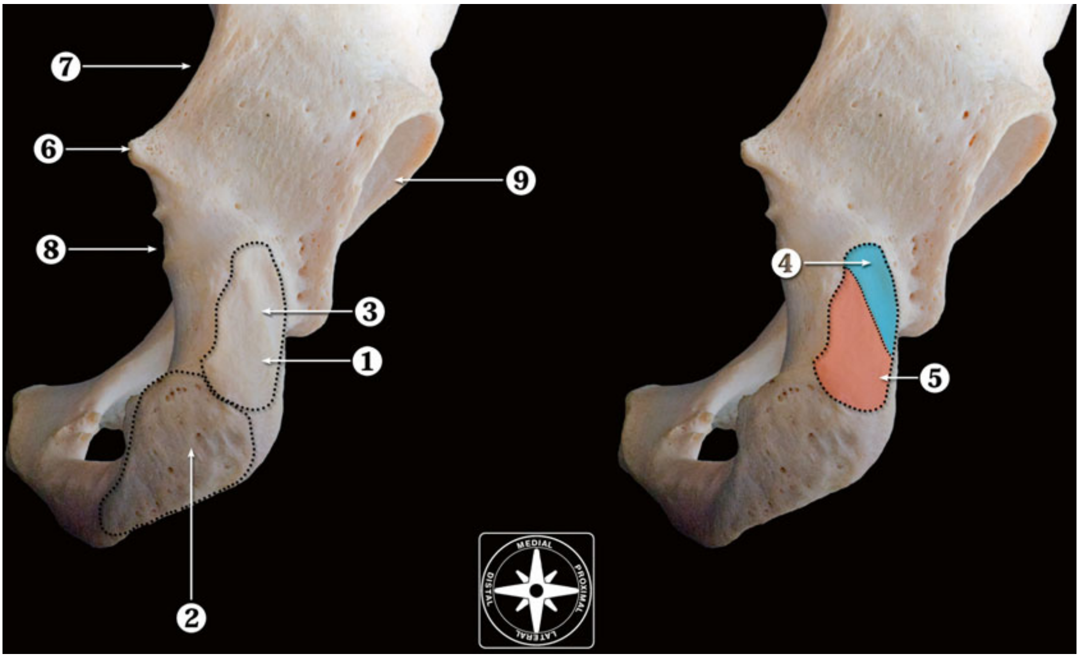

Fig. 8.1 Posterior view of the right coxal bone showing the ischial tuberosity which can be divided into two regions: *1* Upper region. *2* Lower region. *3* Vertical ridge, which divides the upper region in two facets. *4* Lateral facet, for insertion of the tendon of the semimembranosus muscle. *5* Medial facet, for insertion of the conjoint tendon of the long head of biceps femoris and semitendinosus muscle. *6* Sciatic spine. *7* Greater sciatic notch. *8* Lesser sciatic notch. *9* Acetabulum (From van der Made et al. [7]. With permission of Springer Science+Business Media)

biceps femoris which can be divided into a long head (BFLH) and a short head (BFSH) [1–7].

With the exception of the BFSH, these muscles span both the hip and knee joint, thereby acting as both flexors of the knee and extensors of the hip. The BFSH, spanning a single joint, acts only as a knee flexor.

The upper region of the posterior aspect of the ischial tuberosity can be divided into a medial and lateral facet (Fig. 8.1).

The BFLH and ST have a common origin on the medial facet to which the conjoint tendon is attached [1, 3, 5–8]. In addition, a part of the ST has a direct attachment on the ischial tuberosity [1, 4–8]. At the common proximal part, the ST consists mainly of a muscular portion with only a short tendon, whereas the BFLH has a longer tendinous part [1, 3–8] (Fig. 8.2).

The SM runs anterior to this common proximal part and attaches to its origin on the lateral facet (Fig. 8.1, Fig. 8.3a and Fig. 8.3b) [3, 5, 7].

More distally, the BFSH originates on the lateral lip of the linea aspera to join the BFLH [2, 4, 8].

While the proximal tendon of the BFLH is thick and round, the proximal SM tendon has a wide or aponeurotic appearance [7, 8]. The proximal tendons, originating as free tendons to which muscle fibres start to attach when continuing distally, extend along a considerable portion of the length of their respective muscles [7, 8]. In fact, when it comes to total tendon length, proximal and distal tendons are overlapping in the BFLH and SM [7]. Additionally, the ST has a tendinous inscription also referred to as the ‘raphe’, dividing the ST into two parts (Fig. 8.2) [7, 8] that are innervated by different nerve branches [8].

Anatomical variations of the hamstring muscle complex that have been described are as follows: an accessory SM, hypoplastic/absent SM, a separate proximal BFLH tendon and a separate distal BFSH insertion [2, 3].

The BFLH, ST and SM are innervated by the tibial part of the sciatic nerve, whereas the BFSH is innervated by the common peroneal part of the sciatic nerve [2]. The sciatic nerve passes the proximal hamstring muscle complex on the lat-

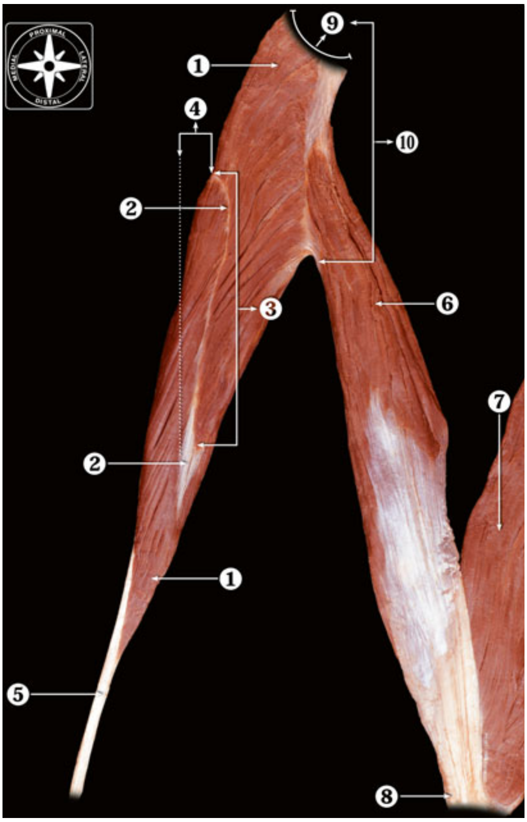

Fig. 8.2 Anatomical dissection showing the muscular characteristics of the biceps femoris and semitendinosus muscle. *1* Semitendinosus muscle. *2* Raphe. *3* Length of the raphe. *4* Width of the raphe. *5* Semitendinosus tendon. *6* Long head of biceps femoris muscle. *7* Short head of biceps femoris muscle. *8* Biceps femoris tendon. *9* Ischial tuberosity. *10* Conjoint tendon (From van der Made et al. [7]. With permission of Springer Science+Business Media)

eral side at a distance of approximately 1 cm from the most lateral aspect [4, 7, 9]. In case surgery is carried out in this region, the proximity of the sciatic nerve to the proximal hamstring muscle complex necessitates a careful approach and protection of the nerve.

8.3 Aetiology

Erik Witvrouw

It has been reported that the majority of hamstring injuries occur while the athlete is running at maximal or close to maximal speeds [10]. Therefore, a complete understanding of the biomechanical function of the hamstrings during sprinting is imperative in order to develop a good rehabilitation programme, targeting the mechanism of the injury.

Several studies have found the hamstrings to be active from mid-swing until terminal stance [11–16]. Looking at the exact timing of the hamstring injury, biomechanical data have identified the terminal swing phase as the period in the stride cycle when the injury most likely occurs [17, 18].

In an interesting paper [19], the different hamstring muscles during running were examined. The authors found the hamstrings as a whole to be lengthening, producing peak force, and absorbing a lot of energy (eccentric muscle work) during sprinting. However, looking at the different muscles within the hamstring group, the BFLH muscle had the largest increase in length (12 %) while the SM muscle produced the highest force and absorbed and generated the most power. The results suggest that the pathomechanics of a BF injury might be different from those of an SM injury, and consequently these injuries might need a different treatment approach. Based upon these results, an injury to the BF might need a treatment with emphasis on lengthening, while a SM muscle injury might be more orientated towards a strengthening approach.

In a recent study Askling et al. [20] compared a rehabilitation programme with hamstring exercises being performed at longer muscle length, mimicking movements occurring simultaneously at both knee and hip with a conventional eccentric and concentric hamstring strengthening programme with no emphasis on lengthening. They found that the protocol emphasising lengthening type of exercises was more effective than a conventional strengthening programme. However, the authors do not mention which type of injury was involved (BF versus SM). Though, since the majority of the hamstring injuries involve BF injuries, this study might confirm the hypothesis that a BF injury rehabilitation programme should be emphasising on lengthening. In addition, it also shows that a rehabilitation programme should attempt to mirror the particular situation and muscle work that lead to the injury.

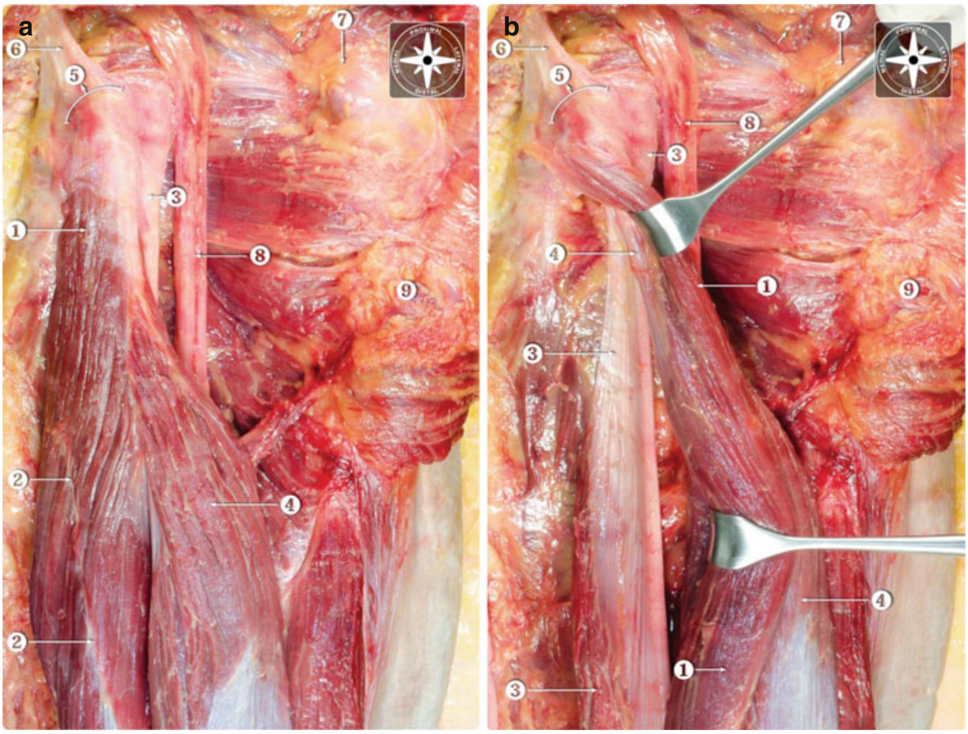

Fig. 8.3 Dissection of the hamstring tendons. (**a**) Normal topographic anatomy. (**b**) The semitendinosus and long head of biceps femoris muscles have been rejected laterally to observe its relationship with the ischial origin of the semimembranosus muscle. *1* Semitendinosus muscle. *2* Raphe of semitendinosus muscle. *3* Semimembranosus muscle. *4* Long head of biceps femoris muscle. *5* Ischial tuberosity. *6* Sacrotuberous ligament. *7* Great trochanter. *8* Sciatic nerve. *9* Gluteus maximus (cut and rejected) (From van der Made et al. [7]. With permission of Springer Science + Business Media)

Increasing the muscle length is traditionally performed by the means of a stretching programme, and research has proven its validity. Yet, if the goal of a rehabilitation programme is to mirror the particular situation and muscle work that lead to the hamstring (BF) injury, stretching alone might not be the treatment of choice. However, there is another way of increasing muscle length. Performing repetitive muscle contractions in elongated positions is found to increase the series compliance of muscles and allow for longer operating lengths [21, 22]. Considering the specificity of hamstring muscle work during sprinting and other high speed movements, eccentric muscle training in elongated positions seems a very good solution. It has been well established that eccentric training in elongated positions can shift the optimal length to longer muscle lengths. The goal of this training programme is therefore not to strengthen the hamstring muscle (although this is an additional and interesting benefit), but rather changing the optimal muscle length. This is in accordance with the results of studies which showed that very low intensity (but in elongated positions) eccentric hamstring exercises gave good treatment results, frequently superior to high intense eccentric exercises in non-elongated conditions. Therefore, hamstring exercises performed at longer muscle-tendon length, preferably mimicking movements occurring simultaneously at both the knee and the hip, could be a key strategy in the management of hamstring injuries [19, 23].

As the pelvis is the origin of the hamstring muscles, pelvic position plays an important role in the total hamstring length over the hip and knee joint. Sufficient neuromuscular control of the lumbopelvic region, including anterior and posterior tilt, is needed to create optimal function of the hamstrings during sprinting and other high-speed skilled movements. Changes in pelvic position could lead to changes in length-tension relationships. The concept of that trunk stabilisation and neuromuscular control exercises should be included into the rehabilitation. Indeed, studies have shown that a progressive agility and trunk stabilisation programme gave as good, or better, results compared to a progressive running and eccentric training programme following acute hamstring injury [24, 25].

A recent study demonstrated significantly more symmetrical activation patterns between the BF, ST and SM in an injury group compared to a control group [26]. The prominent role of the ST was evident in both groups. However, in the injury group, the activity of the ST was partly traded in for more involvement of its synergists. The ST seems to be activated most during the prone leg curling exercise. Previous research reported that the ST had the highest muscle activity and was recruited more than both the BF and the SM in strength exercises and in locomotion [27].

This activation pattern appears to be the result of a sophisticated, complex neuromuscular coordination within the hamstring muscle complex, which possibly provides the most efficient muscle functioning and economic force production. They also demonstrated that the ST has the highest levels of muscle activity during the terminal swing phase (whereas the BF is predominantly active from the middle to late swing phase), where the hamstring muscle group has to withstand the highest levels of muscle tendon stretch and negative work. This supports the hypothesis and suggests that under high loading conditions, the ST has a prominent role in producing and controlling the torques around both hip and knee joints.

8.4 Surgical Treatment of Acute Proximal Hamstring Injuries

Gino M.M.J. Kerkhoffs

There is no consensus on the indication for surgical treatment of acute proximal hamstring injury. Surgery is mainly reserved for avulsion fractures of the ischial tuberosity and hamstring avulsions; complete rupture of a hamstring tendon from its origin [28, 29]. The choice for surgical repair of proximal hamstring avulsions is made based on the number of ruptured tendons and/or amount of retraction, but these criteria are not consistently applied in current literature [28]. In our hospital, the choice for a surgical or conservative approach is made by shared decision-making.

Evidence on clinical outcomes following repair of proximal hamstring avulsions is limited to studies of low methodological quality [28]. Surgical repair is reported to lead to high patient satisfaction (88–100 %) and a return to sports rate of 76–100%. However, decreased hamstring strength (78–101 %), residual pain (8–61 %) and decreased activity level (55–100 % returned to pre-injury activity level) have been reported by a relevant number of patients [28].

Despite a very small number of conservatively managed published cases and lack of a quality assessment of the included studies, a recent systematic review [29] concluded that surgical repair yields significantly better subjective outcomes, rate of return to pre-injury level of sport and greater strength/endurance compared to conservative treatment.

The same review concluded that acute repair (≤4 weeks) leads to significantly better patient satisfaction, subjective outcomes, pain relief, strength/endurance and higher rate of return to pre-injury level of sport than delayed repair (>4 weeks). This difference has not been confirmed by a second systematic review, which found no to minimal differences between acute and delayed repair [28]. Note that 4 weeks is an arbitrary limit, reflecting the development of scar tissue at the avulsion site. Furthermore, there is moderate evidence that clinical outcome is less favourable if the (complete) avulsion is treated later than 6–12 weeks [30, 31]. Moreover, delayed repairs are considered technically more challenging due to development of scar tissue [28].

Both systematic reviews did not differentiate between results of partial (1- or 2-tendon) avulsions and complete (3-tendon) avulsions. According to a study that compared outcome of surgical repair of partial and complete ruptures, no significant differences in return to pre-injury sporting level and patient satisfaction were found [32].

Surgical repair comprises reinsertion of the ruptured tendons to their correct anatomic position. The patient is typically placed in prone position. The type of incision is chosen based on the expected difficulty of the repair (i.e. amount of retraction, adhesions). For more exposure a longitudinal incision can be used, while a transverse incision in the gluteal crease is used for improved cosmetic results. Also, a combination of both may be used. The tendons are then cleared of scar tissue and mobilised. It is very important to identify and protect the sciatic nerve to prevent iatrogenic injury. Once the tendons are mobilised and the sciatic nerve is protected, suture anchors are placed in a debrided ischial tuberosity to which the tendons are tightly secured [28]. A recent (in vitro) biomechanical analysis demonstrated that size of the anchors did not affect the strength of the repair, but that the number of anchors (5 versus 2) used significantly affects the strength [33].

Alternatively, the repair may be augmented in cases where there is too much tension on the repair, or if retraction prevents re-approximation of the rupture tendon. This occurs mainly in delayed repairs. An auto- or allograft may be used to bridge this defect, such as an iliotibial tract autograft or an Achilles tendon allograft reconstruction [28, 30]. Endoscopic techniques have also been described [28].

Postoperatively, the entire leg may be placed in a cast or brace. Intraoperatively, tension on the repair is assessed, and the knee is placed in an angle that prevents the repair from being at risk of rerupture. Over the coming weeks, the cast is changed and eventually replaced with a brace and knee extension/hamstring lengthening is gradually increased. If no tension in the tendon is felt after the repair, bracing may not be needed. A phased rehabilitation programme is started.

8.5 Chronic Proximal Hamstring Injury: Tendinopathy

Sakari Orava

Proximal hamstring tendinopathy (PHT) is a disabling disease often causing underperformance in athletes.

The main symptom of PHT is lower gluteal pain, especially during running or prolonged sitting. Typically, it starts without any sudden trauma and gradually becomes worse with continued loading of the hamstrings. Palpation reveals tenderness over the ischial tuberosity, with pain on resisted knee flexion. Pain is often provoked at this site by active hamstring stretching. Sensorimotor functions are intact.

Imaging by means of ultrasound or MRI is used to confirm the diagnosis and to assess the extent of the injury. MRI of PHT will reveal increased signal intensity on T1- and T2-weigthed images with thickened tendons and peritendinous/bone marrow oedema. Note that these changes can also be seen in asymptomatic patients.

Common consensus and high-level evidence on the optimal conservative treatment are lacking. Conservative treatment may include an initial phase of relative rest and icing to relieve symptoms followed by a rehabilitation programme focusing on (eccentric) hamstring strength and core stability. Use of nonsteroidal anti-inflammatory drugs (NSAIDs), trigger point dry needling, PRP or corticosteroid injections, electric muscle stimulation, proprioceptive training and soft tissue mobilisation have also been described. Time to full recovery is usually between one to three months.

Surgical treatment aims at improving symptoms in cases that do not respond well to a conservative approach and comprises a transverse tenotomy of the thickened semimembranosus tendon. This approach appears to lead to mainly good results with a low complication rate.

PHT is a considerable challenge for treating health-care professionals. As a tendinopathic pathology, it is an overload type injury. As with other chronic tendon overuse injuries, current treatment strategies are unspecific with uncertain outcomes due to the unknown aetiology of the tendon degeneration [34].

8.6 Rehabilitation of Incomplete Proximal Stretch-Type Hamstring Injuries: Worst Case Scenario?

Håvard Moksnes

Acute hamstring strains are common in sports, and various demands on the hamstring complex in different sports are reflected by variations in injury mechanisms and injury sites [29, 35]. Over the past decade consensus has been established that differentiation between sprinting type and stretching type injuries is of importance because different treatment algorithms should be applied, and prolonged recovery time can be expected with stretching-type injuries [36]. Stretch-type hamstring injuries occur with combined excessive hip flexion and knee extension and are most likely to result in a proximal injury that affect one, two or all three of the hamstring tendons. Proximal stretch-type hamstring injuries are frequently associated with prolonged morbidities consisting of impaired lower extremity function due to deficits in muscle strength and long-standing pain following either surgical or conservative management [29, 37–39]. Evidence-based rehabilitation protocols are lacking in the literature, although some level IV studies are available [40–42].

Accurate anatomical and functional diagnosis is of great importance when rehabilitation is initiated as the different muscle bellies must be targeted with different exercises [40, 43]. Proximal hamstring injuries affecting one of the two medial tendons are usually considered to have a favourable prognosis following conservative treatment due to the agonist function of the semitendinosus (SM) and semimembranosus (ST) muscles. Conversely, an avulsion of both medial tendons or the long head of the biceps femoris tendon (BFLH) is less likely to result in a favourable outcome following conservative treatment – in particular if the athlete is participating in a sport with high demands for high-speed running. Additionally, the sciatic nerve passes in close proximity to the hamstring tendons and muscles which makes it vulnerable when a stretching type injury occurs. Reduced function of the peroneal branch may occur after a stretch-type injury and may result in weakness of the short head of the biceps femoris muscle and also possibly affect the function of ankle dorsiflexion.

Worst-case scenarios after an incomplete stretch-type hamstring injury resulting in chronic functional impairments and pain occur in the following circumstances: (1) a large avulsion (BFLH or SM + ST) is missed and treated conservatively or left untreated, (2) specific exercises are not provided during rehabilitation, (3) pain is ignored during rehabilitation and (4) nervous tissue involvement. Rehabilitation algorithms, clinical application and functional progression models to avoid the worst-case scenarios will be discussed at the ESSKA 2016 ICL.

8.7 PRP for Acute and Chronic Proximal Hamstring Injuries

Gustaaf Reurink

There is a growing interest in sports medicine and athletic communities for using endogenous growth factors directly into the injury site to facilitate healing after injury [44, 45]. The most popular is the injection of platelet-rich plasma (PRP). Platelets release various growth factors upon activation that are assumed to provide regenerative benefits. Basic science studies have shown that myoblasts and tenocytes can be proliferated by growth factors like platelet-derived growth factor (PDGF), insulin-like growth factor (IGF-1), basic fibroblast growth factor (bFGF-2) and nerve growth factor (NGF) [46, 47]. In deliberately injured animal muscles, these growth factors increase regeneration [46, 47].

8.7.1 Acute (Proximal) Hamstring Injuries

Despite the promising results from basic research, and apparent widespread clinical use, a recent meta-analysis with pooled data of three randomised controlled trials (RCTs) [48–50] showed no superiority of PRP in treating acute hamstring muscle injuries on the time to return to play and the re-injury rate [51]. As these RCTs excluded all complete hamstring ruptures (grade III), and the lack of clinical studies available on the use of PRP in proximal hamstring avulsions, it remains unknown to what extent these result can be generalised to complete proximal hamstring injuries. Despite this unknown generalisability, we do not expect that PRP injections in complete muscle ruptures would show different efficacy than in partial ruptures. Therefore, we discourage the use of PRP injections in acute proximal hamstring injuries.

8.7.2 Chronic Proximal Hamstring Tendinopathy

PRP is widely used for treatment of chronic tendinopathy, including proximal hamstring tendinopathy. Nonetheless, the scientific evidence for its effectiveness in proximal hamstring tendinopathy is limited to one RCT comparing PRP and whole blood injections [52] and three low quality case series (level IV evidence) [53–55]. There are currently no studies that compare PRP treatment with a control group without injections or placebo. High-quality systematic reviews on other chronic tendinopathic conditions, such as lateral epicondylitis and Achilles and rotator cuff tendinopathy, show no benefit of PRP over placebo treatment on pain and function [56, 57].

As there is no high-level evidence to support its use in proximal hamstring tendinopathy, and the strong evidence against a therapeutic benefit in other tendinopathies, we also do not recommend PRP injections in proximal hamstring tendinopathy.

8.7.3 PRP: Many Unanswered Questions

Our current scientific knowledge about PRP remains at a basic science level, and there are many unanswered questions regarding its use in muscle injury [46]. These include some very basic questions, such as what concentrations and ratio of growth factors are required for optimal muscle healing? Which specific growth factors are active? Is timing and number of injections important? Does the injected PRP remain at the injection site? Is the presence of leucocytes in the PRP beneficial or detrimental for tendon and muscle healing? In addition to these unanswered basic questions, currently no proven scientific mechanism is available for a therapeutic effect of PRP in tendon and muscle injury.

Conclusion

As there is no high-quality evidence that justifies the use of PRP in proximal hamstring injuries, we do not recommend PRP injections in both acute and chronic injuries.

Take Home Message

- Different injury mechanisms lead to distinct injuries in different hamstring muscles with different prognoses.
- A rehabilitation programme should aim at mimicking the particular situation and muscle work that lead to the injury.
- Surgical repair of proximal hamstring avulsions comprises reinsertion at the correct anatomical site and should ideally be performed within 6–12 weeks. Chronic total tears may be reconstructed with an auto- or allograft.

- Proximal hamstring tendinopathy (PHT) is a disabling disease often causing underperformance in athletes.
- High-quality evidence to support the use of PRP is lacking and its use in proximal hamstring injury is therefore not recommended.

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