Journal of Hip Preservation Surgery Vol. 7, No. 4, pp. 721–727
doi: 10.1093/jhps/hnab006
Advance Access Publication 31 May 2021
Research article

Combined endoscopic and mini-open repair of chronic complete proximal hamstring tendon avulsion: a novel approach and short-term outcomes

Shai Factor , Amal Khoury, Ran Atzmon, Matias Vidra, Eyal Amar† and Ehud Rath*,†

Department of Orthopedic Surgery, Affiliated with the Sackler Faculty of Medicine, Tel Aviv Medical Center, Tel Aviv University, Weizmann St 6, Tel Aviv-Yafo 6423906, Israel.
†Both authors are equal contributors as last author.
*Correspondence to: E. Rath. E-mail: udirath@gmail.com
Submitted 22 November 2020; Revised 5 January 2021; revised version accepted 13 January 2021

ABSTRACT

To evaluate the outcome of a novel, combined endoscopic and mini-open repair (CEMR) of a chronic complete retracted proximal hamstring tendon avulsion (PHA). A retrospective case series of a single-surgeon database for all patients, with a minimum of 1-year follow-up, who underwent CEMR between July 2015 and September 2019 was performed. Patients were evaluated for their functional outcome using the Perth Hamstring Assessment Tool (PHAT). At the latest follow-up, patients were evaluated for their muscle strength, subjective satisfaction and post-operative complications. Twelve patients who underwent endoscopic surgery for chronic PHA were identified, of which seven patients underwent CEMR. After exclusion of one patient from the study due to an open claim for health insurance, six patients (five males) with a mean age of 48 years (range 20–61 years) were evaluated. The mean time from injury to surgery was 12 months (range 2–43 months). At a mean follow-up of 28 months (range 12–55 months), the average PHAT score was 73 (range 70–80). The mean subjective activity level percentage improved from 34 (range 20–50) pre-surgery to 81 (range 75–90) post-surgery. The mean strength of the quadriceps, hamstring at 30°, and hamstring at 90° of the operated leg compared to the uninjured leg did not differ significantly. One patient underwent adhesiolysis 1 year after the index procedure for treatment of subcutaneous adhesions. CEMR is a viable and safe option for the treatment of chronic complete proximal hamstring tears, with good to excellent short-term functional outcome. Level of evidence: IV.

INTRODUCTION

The hamstring muscles are the most commonly injured group of muscles in professional athletes [1]; however, proximal hamstring avulsion (PHA) is an uncommon injury [2]. This injury is often seen in athletes but is common in middle-aged patients as well [3, 4]. PHA is a result of an eccentric contraction of the muscle trying to resist a fall forward, while the hip is in flexion and ipsilateral knee in extension [5]. This debilitating injury is associated with noticeable functional and strength deficits [6], pain with sitting and during exercise. Delayed and misdiagnosis of complete avulsion are common [7]. Strains occurring at the myotendinous junction [8] can be treated non-operatively with good outcomes [9]. However, partial or complete proximal tendinous avulsions managed non-operatively have been associated with significant morbidity and unpredictable results [6, 10, 11]. Surgery for proximal hamstring ruptures leads to improved outcomes and return to sports [12–15]. Acute repairs (within 6 weeks from injury) overall show better outcomes than repair of a chronic injury [10]. The principles of surgical repair of proximal hamstring avulsion include adequate exposure of the ischial tuberosity (IT), identification and protection of the sciatic nerve and the posterior femoral cutaneous nerve (PFCN),

mobilization of the avulsed muscle tendon unit and secure fixation to the IT [3, 16, 17].

To avoid the morbidities of the extensile open approach, such as sciatic nerve injury, re-tear and post-operative infection [18] in addition to the benefits of full endoscopic technique [10, 19], a combined endoscopic and mini-open approach (CEMR) for the treatment of chronic complete proximal hamstring avulsions has been developed [20].

The endoscopic stage of the procedure facilitates exposure of the IT, protection of sciatic nerve and PFCN and anchor placement. The open stage consists of a minimal skin incision over the proximal hamstring stump, release of the stump from adhesions to adjacent structures, and repair to the IT. To our knowledge, this is the first study to evaluate the outcomes of CEMR for chronic complete proximal hamstring avulsion. The purpose of this study was to review the functional outcomes of CEMR in patients with chronic complete proximal hamstring avulsions.

The hypothesis of this study was that CEMR of a chronic hamstring avulsion would result in good functional outcome.

MATERIALS AND METHODS

Following institutional review board approval, a retrospective case series of a single sports medicine fellowship trained orthopedic surgeon database was reviewed for all patients who underwent proximal hamstring repairs between July 2015 and September 2019. Inclusion criteria were, patients who underwent CEMR for hamstring's tendon tear of minimum two tendons with >2 cm retraction, confirmed by magnetic resonance imaging (MRI) and a minimum of 6 weeks between the injury and the surgical intervention and a minimum 1-year follow-up. Exclusion criteria were prior hip surgery and an active compensation claim.

Pre-operative evaluation and diagnosis

All patients were assessed by the senior author who is a sports medicine fellowship trained orthopedic surgeon.

The pre-operative assessment consisted of history taking, physical examination and confirmation of the suspected injury with MRI. MRI was used to demonstrate the location and severity of the injury to identify the number of involved tendons and to quantify the retraction distance of the torn tendon ends from their bony origin. Physical examination included gait evaluation, palpation of the IT for focal tenderness and provocative tests for the diagnosis of PHA including the Puranen–Orava and the bent–knee stretch tests [21].

Surgical technique

The surgical technique is demonstrated in Supplementary Video S1.

The surgical technique and portal establishment were performed in accordance with surgical technique previously described by Atzmon *et al.* [20]. Surgery was performed under general anesthesia with the patient in a prone position at 0° of hip and knee flexion and 10–20° of hip abduction. Prior to sterile draping, for each case, the location of the hamstring stump was identified using palpation of the gap between the IT and the stump and confirmed by sonographic imaging (SonoSite M-Turbo, 6–13 MHZ, Bothell, WA, USA) (Fig. 1). Prophylactic IV antibiotics were administered. All bony and soft tissue prominences were padded. The IT was identified; the anatomic structures and portal incision location were marked and infiltrated with bupivacaine. The first central viewing portal was established, in line and just distal to the IT, adjacent to the gluteal fold (Fig. 2). A plane was developed by blunt dissection using the scope sheath. Then, with the aid of a spinal needle, an ideal lateral working portal was created, 4–5 cm laterally to the central portal. Advancing the scope from postero-medial to antero-lateral, the PFCN and then the sciatic nerve were identified and protected. Adhesions between the sciatic nerve and the torn tendons stumps were released as needed. A 3.5-mm full radius shaver and a 5.5-mm round burr (Smith and Nephew, Andover, MA, USA) were used to prepare the IT for two double-loaded suture anchors. (FASTIN® RC DePuy Mitek, Synthes).

CEMR was used when the full endoscopic approach was particularly difficult, due to typical findings of chronic injury—scar formation, adhesions surrounding the proximal stump and the severity of the retraction—all of which

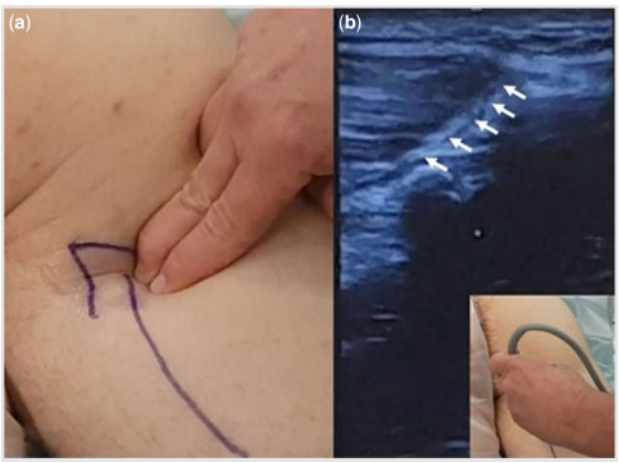

Fig. 1. The patient is in the prone position for a right proximal hamstring CEMR repair. (**a**) The location of the hamstring stump is identified using palpation of the gap between the IT and the stump. (**b**) Location is confirmed by sonographic imaging (white arrows demonstrating hamstring stamp). CEMR, combined endoscopic and mini open repair.

Fig. 2. The patient is in the prone position for a right proximal hamstring CEMR repair—the first portal (white arrow) was established, in line and just distal to the IT, adjacent to the gluteal fold. The location of the second, lateral portal is marked with asterisk. IT, ischial tuberosity; CEMR, combined endoscopic and mini open repair.

made the mobilization of the stump difficult, if not impossible.

A longitudinal incision (average 5 cm long) was made just above the stump of the torn hamstring tendon. The tendon was identified and released from adhesions to allow mobilization of the tendon-muscle unit. One limb of each anchors suture which were previously placed at the IT was passed through the stump in a whip stitch manner (Fig. 3). With the knee flexed to 45°, the free limb of each anchor was pulled to facilitate proximal sliding of the stump toward the IT. The repair was completed by firm, yet controlled tying using a knot pusher. The stability of the repair was confirmed throughout the range of motion by slow extension of the knee under endoscopic visualization of the tendon attachment to the IT. In one patient, Achilles Allograft was used due to inability to achieve adequate approximation of the hamstring to the IT with without excessive tension of the repair while the knee was in full extension. The wound was closed with absorbable sutures. A hinged knee brace, locked at 60° of knee flexion was applied at the end of the procedure.

Post-operative rehabilitation

All patients received prophylactic anti-coagulation therapy (Enoxaparin 0.5 mg\kg) until return to full mobility. The physiotherapy protocol included toe-touch weight bearing for the first 2 weeks then partial weight bearing for another 3–4 weeks. All patients were instructed to use a four-wheel scooter to restrict hip motion (Fig. 4).

Data collection and clinical outcome measures

At the final follow-up, each patient was interviewed and clinically assessed by an independent observer (other than the surgeon). Patient outcome score was assessed using the Perth Hamstring Assessment Tool (PHAT) [22]. PHAT is specifically designed and validated for the assessment of patients with PHA. Post-operative muscle strength of the quadriceps (tested while the patient sitting and knee in 90° flexion), hamstring at 30° and hamstring at 90° in prone position was measured in both the operated and the uninjured leg, using a dedicated device (microFET2, Hoggan Scientific, Salt Lake City, UT, USA). Additionally, patients were asked to answer three questions: first, they were asked how they would rate the overall satisfaction of their hip joint on a scale of 1–100, with 1 being 'least satisfied' and 100 being 'most satisfied'. Second, in a yes/no question, patients were asked, given what they know now, whether they make the same decision (i.e. undergo the hip surgery) again. Third, patients were asked at most recent follow-up to subjectively quantify the level of activity of their post-operative hip compared to their status pre-operatively.

Complications including superficial and deep infection, re-tear of the repair site, iatrogenic sciatic nerve or PFCN injury and subsequent surgery were recorded.

Statistical analysis

All data were de-identified in an Excel spreadsheet (Microsoft Corporation, Redmond, WA, USA). Descriptive statistics were computed for each pre-operative and post-operative variable. Mann–Whitney test (a non-parametric test) was used for comparison of continuous data. The Mann–Whitney test was chosen since it does not rely on any assumptions hence obviate the need for normality test of the data. An alpha value of <0.05 was considered statistically significant.

RESULTS

Twelve patients that underwent endoscopic proximal hamstring repair were identified, of which, five patients were excluded for having full endoscopic procedure, seven patients underwent CEMR for chronic complete avulsion. One patient was excluded due to an open claim for health insurance.

Six patients (five males) were included with a mean age of 48 years (range 20–61 years) at the time of the surgery. The mean time from injury to surgery was 12 months

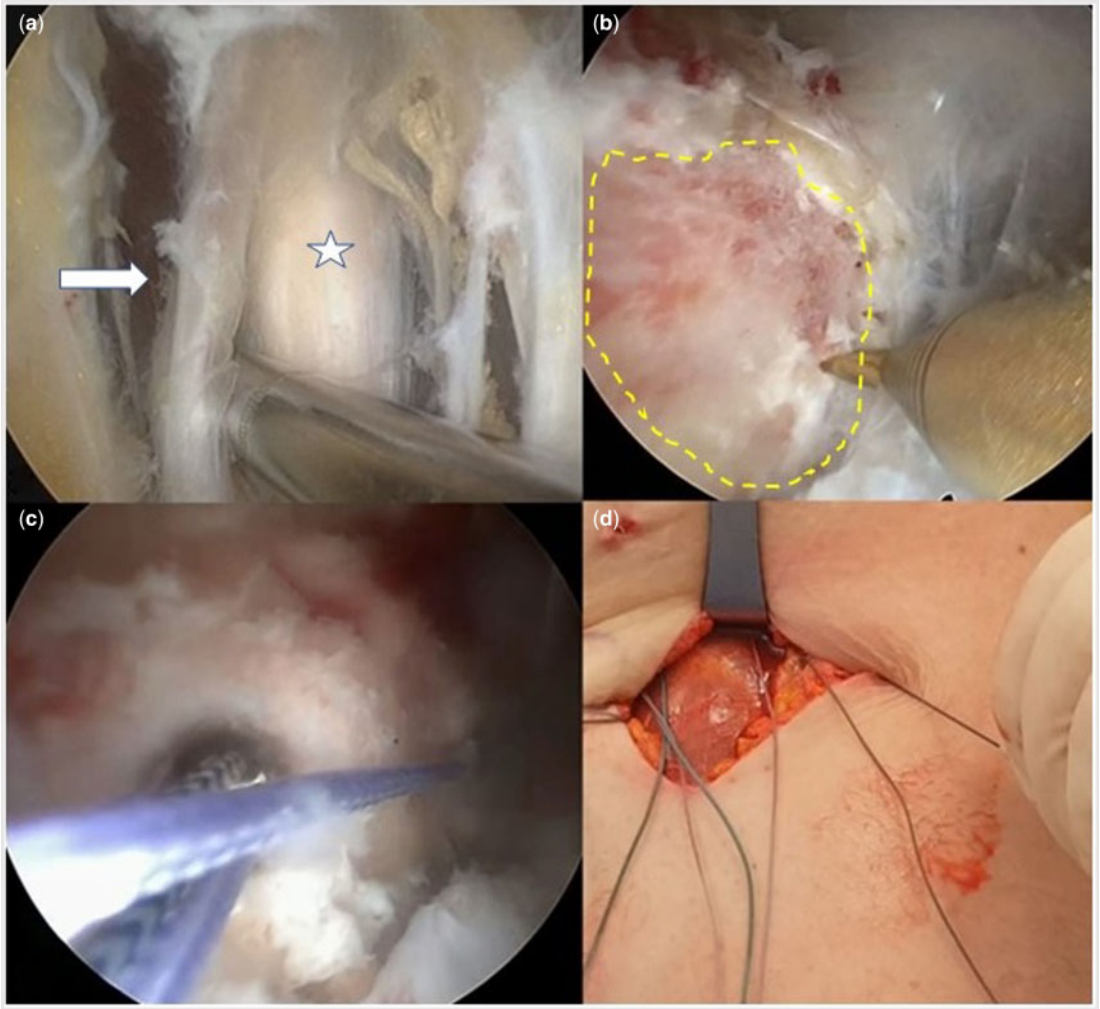

Fig. 3. (a) The PFCN (white arrow) and sciatic nerve (asterisk) were identified and protected. (**b** and **c**) The IT (dashed line) exposed and prepared for two double-loaded suture anchors. (**d**) Through the longitudinal incision, the free limb of each anchor was pulled to facilitate proximal sliding of the stump towards the IT. PFCN, posterior femoral cutaneous nerve; IT, ischial tuberosity.

(range 2–43 months). The mean distance between the IT and the proximal hamstring tendon stump demonstrated through MRI was 5.75 cm (range 2–10 cm). In patient number 3, Achilles Allograft was used due to inability to achieve direct repair. Patient demographics are presented in Table I.

At a most recent follow-up (mean 28 months, range 12–55 months), all patients demonstrated good to excellent clinical improvement. The mean Perth Hamstring Assessment Tool (PHAT) score was 73 (range 70–80) at latest follow-up. The mean subjective activity level percentage improved from 34 (range 20–50) pre-surgery to 81 (range 75–90) post-surgery (Fig. 5).

The mean strength of the quadriceps, hamstring at 30° and hamstring at 90° of the operated leg compared to the uninjured leg did not differ significantly (Table II).

All patients were satisfied with the results of the surgery regarding pain relief and their ability to return to daily and recreational activities. All patients answered that they would undergo this procedure again. Besides one patient underwent lysis of adhesions 1 year after the index procedure for treatment of subcutaneous scarring, no other complications were noted.

DISCUSSION

The most important findings of this study were that the CEMR was feasible for all patients included and resulted in good clinical outcome and patient satisfaction. All patients reported they would undergo this procedure again.

Over the last decade, there has been a significant development in the understanding and treatment of PHA [23]. Open repair of PHA has high complication rate with the

delayed treatment subgroup demonstrating the worse results [10, 24]. Bodendorfer *et al.* [10] performed the most recent systematic review and meta-analysis of open repair of PHA and concluded that acutely repaired injuries (within 2 months) demonstrated significantly better results in terms of patient satisfaction, pain, strength and functional scores compared to chronic repairs.

The complication rate of the open surgical repair was 23%; including sciatic nerve damage, PFCN damage and post-operative infections.

Willinger *et al.* [24] presented, at mid-term follow-up, an overall complication rate of 8.5% in patients that underwent open surgical treatment, with significantly higher complication rates in delayed surgery (21.7%) compared

Fig. 4. Patients were instructed to use a hinged knee brace, locked at 60° of knee flexion and a four-wheel scooter to restrict hip motion (with permission from *Journal of Hip Preservation Surgery* License number 4881520067598).

Fig. 5. Post-operative scars of right CEMR in patient number 6. CEMR, combined endoscopic and mini open repair.

Table I. Patient demographics

Patient number	*Sex (male\female)*	*Age at surgery (years)*	*Operated side (right\left)*	*Time from injury to surgery (month)*	*Follow up (months)*	*Retraction (cm)*
1	M	56	R	2	55	5.5
2	M	46	L	11	41	5
3	F	61	R	10	23	10
4	M	56	R	2	21	2
5	M	51	L	3	16	6
6	M	20	R	43	12	6

Table II. Post-operative muscle strength

	Operated leg	*Uninjured leg*	P-*value*
Hamstring at 30°	29.48 ± 6.74	36.08 ± 6.85	0.225
Hamstring at 90°	24.76 ± 6.4	27.4 ± 5.26	0.686
Quadriceps	42.72 ± 9.25	52.58 ± 5.75	0.08

Values are presented as mean ± standard error, measurement units are lbs.

to acute surgery performed within 6 weeks from the injury (4.2%).

In a recent retrospective case series, Kurowicki *et al.* [25] evaluated the short-term outcomes of full endoscopic repair of proximal hamstring tear in a group of 20 patients. The authors demonstrated improvement in subjective and functional short-term outcomes. However, their study included a heterogeneous population that included patients with partial and complete tears who underwent acute or delayed surgery. Their mean age was 46 years (range 18–63). The mean tendon retraction of the complete tears was 3.9 cm (range 1.5–5.7 cm). There were no complications or subsequent surgeries.

Hamstring weakness and persistent pain with sitting were reported in 40% and 0% of patients who had complete proximal hamstring tears repaired, respectively.

The aforementioned studies cannot be directly compared to the results presented in the current study. Bodendorfer *et al.* [10] reviewed a population of patients who underwent open repair of PHA. Willinger *et al.* [24] presented results of a mixed population of open repair (acute versus delayed repair). Kurowicki *et al.* [25] presented results of a mixed population, in terms of tear characteristics (i.e. complete versus partial tear) and timing of endoscopic repair (delayed versus acute).

The patient population in our study included mainly older patients with only chronic, complete and retracted injuries who underwent CEMR and evaluated using a hamstring specific questionnaire rather than by general patient-reported outcome questionnaires. Nevertheless, the results of the current study are in agreement with the results presented in previous studies of surgically treated patients with PHA, demonstrating good function and activity level following CEMR.

Only one minor complication was recorded in this study—local pain due to subcutaneous adhesions that required adhesiolysis.

Given that the patient population in this study was comprised of chronic, complete PHA in mainly older patients (population with potentially higher complication rate and worse outcome), the results of CEMR to treat proximal hamstring avulsion are encouraging.

To our knowledge, there are no previous reports of a series of patients with chronic retracted PHA treated in a CEMR. The approach facilitates the more complex and surgically demanding part of the surgery, which is exposure of the IT and anchors placement while protecting the sciatic nerve. Introducing a new surgical technique can be difficult and should follow a specific, stepwise process. The stages of innovation include (i) concept/theory formation; (ii) procedure development and exploration; (iii) procedure assessment and (iv) long-term studies, ideally in an evidence-based manner [26].

As in other joints, and recently in the hip, there is a transition from open to 'minimally invasive' approaches that includes arthroscopic or endoscopic techniques, mainly to reduce the morbidity in extensive open approach [3]. The concept of CEMR was developed and was the first step for addressing the challenge and difficulty to repair a chronic complete PHA via a full endoscopic approach. The technique inception was introduced in a case report of CEMR to repair a chronic retracted PHA [20].

This case report emphasized the advantages of this technique over an open hamstring repair which included; (i) facilitated approach to the IT and avoidance of the use of blunt retractors which may place the sciatic nerve at risk; (ii) improved and direct view by the endoscopic technique allowing for preservation of the sciatic nerve and PCFN; and (iii) a markedly smaller skin incision of the mini-open step of this procedure compared to the one used in conventional open approach (avoidance of transverse incision) which is located just above the retracted stump of the avulsed tendon. For the skilled arthroscopic surgeon, this approach can be less technically demanding compared to a full open treatment.

CEMR was developed and explored in this case series study according to the abovementioned stepwise process, with short-term functional outcome and yielded promising results. In order to further assess this novel procedure, randomized controlled trials with long-term outcomes should be conducted.

There are several limitations regarding this study. The retrospective nature of this study may introduce bias. There were no control groups so direct comparisons cannot be made. There is no pre-operative functional data due to the fact that some of the patients were operated prior to the introduction of the PHAT score, preventing the use of the same evaluation tool for both pre- and post-operative outcome. Finally, small sample size may make our results difficult to extrapolate. Since proximal hamstring tears are uncommon injuries and the study population (complete

and chronic tear) represents an even rarer subgroup, a large comparative study will be hard to achieve and likely will require a multicenter study.

CONCLUSIONS

Combined proximal endoscopic and distal mini open repair for chronic complete hamstring proximal avulsion is a viable and safe treatment option. This treatment demonstrated encouraging clinical outcome and patient satisfaction. CEMR should be considered in this group of patients.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Hip Preservation Surgery* online.

ACKNOWLEDGMENTS

We would like to acknowledge Dr. Mark Safran, who took part in this study and Joshua Ovadia for his help.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Chang JS, Kayani B, Plastow R *et al.* Management of hamstring injuries: current concepts review. *Bone Jt J* 2020; **102B**: 1281–8.
2. Blakeney WG. Editorial commentary: proximal hamstring tendon injuries: is the research hamstrung by the use of poor outcome measures? *Arthroscopy* 2020; **36**: P1308–10.
3. Domb BG, Linder D, Sharp KG *et al.* Endoscopic repair of proximal hamstring avulsion. *Arthrosc Tech* 2013; **2**: e35–9.
4. Van Der Made AD, Reurink G, Gouttebarge V *et al.* Outcome after surgical repair of proximal hamstring avulsions. *Am J Sports Med* 2015; **43**: 2841–51.
5. Bencardino JT, Mellado JM. Hamstring injuries of the hip. *Magn Reson Imaging Clin N Am* 2005; **13**: 677–90, vi.
6. Hofmann KJ, Paggi A, Connors D *et al.* Complete avulsion of the proximal hamstring insertion: functional outcomes after nonsurgical treatment. *J Bone Jt Surg Am* 2014; **96**: 1022–5.
7. Subbu R, Benjamin-Laing H, Haddad F. Timing of surgery for complete proximal hamstring avulsion injuries: successful clinical outcomes at 6 weeks, 6 months, and after 6 months of injury. *Am J Sports Med* 2015; **43**: 385–91.
8. Järvinen TAH, Järvinen TLN, Kääriäinen M *et al.* Muscle injuries: biology and treatment. *Am J Sports Med* 2005; **33**: 745–64.
9. Cohen S and Bradley J. Acute proximal hamstring rupture. *J Am Acad Orthop Surg* 2007; **15**: 350–5.
10. Bodendorfer BM, Curley AJ, Kotler JA *et al.* Outcomes after operative and nonoperative treatment of proximal hamstring avulsions: a systematic review and meta-analysis. *Am J Sports Med* 2018; **46**: 2798–808.
11. Shambaugh BC, Olsen JR, Lacerte E *et al.* A comparison of nonoperative and operative treatment of complete proximal hamstring ruptures. *Orthop J Sport Med* 2017; **5**: 2325967117738551.
12. Folsom GJ, Larson CM. Surgical treatment of acute versus chronic complete proximal hamstring ruptures: results of a new allograft technique for chronic reconstructions. *Am J Sports Med* 2008; **36**: 104–9.
13. Cohen SB, Rangavajjula A, Vyas D *et al.* Functional results and outcomes after repair of proximal hamstring avulsions. *Am J Sports Med* 2012; **40**: 2092–8.
14. Lempainen L, Sarimo J, Heikkilä J *et al.* Surgical treatment of partial tears of the proximal origin of the hamstring muscles. *Br J Sports Med* 2006; **40**: 688–91.
15. Blakeney WG, Zilko SR, Edmonston SJ *et al.* A prospective evaluation of proximal hamstring tendon avulsions: improved functional outcomes following surgical repair. *Knee Surg Sport Traumatol Arthrosc* 2017; **25**: 1943–50.
16. Laskovski JR, Kahn AJ, Urchek RJ *et al.* Endoscopic proximal hamstring repair and ischial bursectomy using modified portal placement and patient positioning. *Arthrosc Tech* 2018; **7**: e1071–8.
17. Klingele KE, Sallay PI. Surgical repair of complete proximal hamstring tendon rupture. *Am J Sports Med* 2002; **30**: 742–7.
18. Harris JD, Griesser MJ, Best TM *et al.* Treatment of proximal hamstring ruptures a systematic review. *Int J Sports Med* 2011; **32**: 490–5.
19. Bataillie F, Bataillie S, van Beek N *et al.* Portal placement for endoscopic surgery in the deep gluteal area: a cadaveric study. *J Hip Preserv Surg* 2020; **7**: 147–52.
20. Atzmon R, Amar E, Maor D *et al.* A combined endoscopic and open surgical approach for chronic retracted proximal hamstring avulsion. *J Hip Preserv Surg* 2019; **6**: 284–8.
21. Ahmad CS, Redler LH, Ciccotti MG *et al.* Evaluation and management of hamstring injuries. *Am J Sports Med* 2013; **41**: 2933–47.
22. Blakeney WG, Zilko SR, SJ E *et al.* Proximal hamstring tendon avulsion surgery: evaluation of the Perth Hamstring Assessment Tool. *Knee Surg Sport Traumatol Arthrosc* 2017; **25**: 1936–42.
23. Kayani B, Ayuob A, Begum F *et al.* Surgical management of chronic incomplete proximal hamstring avulsion injuries. *Am J Sports Med* 2020; **48**: 1160–7.
24. Willinger L, Siebenlist S, Lacheta L *et al.* Excellent clinical outcome and low complication rate after proximal hamstring tendon repair at mid-term follow up. *Knee Surg Sport Traumatol Arthrosc* 2020; **28**: 1230–5.
25. Kurowicki J, Novack TA, ES S *et al.* Short-term outcomes following endoscopic proximal hamstring repair. *Arthroscopy* 2020; **36**: 1301–7.
26. Öhlin A, Coughlin RP, Ahldén M *et al.* The evolution of femoroacetabular impingement surgical management as a model for introducing new surgical techniques. *Knee Surg Sport Traumatol Arthrosc* 2020; **28**: 1333–40.