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SPORTS TRAUMATOLOGY

Surgical excision of symptomatic mature posttraumatic myositis ossificans: characteristics and outcomes in 32 athletes

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Abstract

Purpose The purpose of this study was to report characteristics and outcomes of surgical excision of symptomatic mature posttraumatic myositis ossificans in adult athletes. The hypothesis was that surgical excision of the ossified mass in these circumstances can effectively relief symptoms and result in return to high-level sports with minimal postoperative complications.

Methods All operations involving excision of posttraumatic heterotopic ossifications performed between 1987 and 2015 were reviewed. Included cases had isolated excision of posttraumatic myositis ossificans, whereas excluded cases had: (1) concomitant reattachment of tendon to bone; (2) chronic overuse injuries which preceded the development of the heterotopic mass or large calcifications which were excised from tendon-to-bone insertions; and (3) excision of heterotopic ossification from a ligament, capsule, or tendon insertion following avulsion injury without tendon-to-bone repair. After surgery, return to sports was allowed at 4–6 weeks.

Results Of 57 athletes undergoing excision of heterotopic ossifications, 32 were eligible as isolated excision of posttraumatic myositis ossificans. Twenty-four (75%) were ice hockey or soccer players. Median age was 23 years. Prior to surgery, patients were unable to continue their sports. At surgery, the ossification was excised from a thigh muscle in 27 (84%) cases. Median follow-up was 2 years (range 1–20 years). Outcome was *Good/Excellent* in 26 (81%) patients, corresponding to return to preinjury sports with minimal symptoms at sports activities. Preinjury Tegner activity level was resumed after surgery in 30 of 32 (94%) athletes, of whom 28 (94%) were involved in high-level sports corresponding to Tegner levels 8–10. No postoperative complications were recorded other than minimal insensitive areas at the periphery of skin incisions.

Conclusion In high-level athletes who present chronic disabling mature posttraumatic myositis ossificans that interferes with their sports career, surgical excision of the heterotopic mass results in effective clinical improvement with return to sports and minimal postoperative risks.

Level of evidence Case series, Level IV.

Keywords Myositis ossificans · Surgical excision · Indomethacin · Tegner scale · Ice hockey

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Introduction

Posttraumatic myositis ossificans is predominantly a self-limiting benign process. In athletes involved in contact sports, it is most commonly preceded by muscle contusion at the anterior thigh area [7, 13, 21, 24]. In these cases, intramuscular haematoma initiates a cascade which results, after several months, in the formation of consolidated bone mass within the contused muscle or upon the surface of the bone to which the contused muscle is attached [7, 13, 21, 24]. Nonoperative modalities are the mainstay of treatment because the process tends to regress within several months. When the consolidated mass persists, it tends to result in minor clinical significance that respond satisfactorily to activity modifications, stretching, anti-inflammatory medications, or other modalities such as shock-wave treatment [3, 7, 12–14, 16, 19, 21]. In rare cases, however, sports participation may be affected due to persistent pain during muscle activation or stretching, limitations in range of knee motion, tethering of muscle against a prominent bone [13, 22], or neurological symptoms which arise when nerve tissue is compressed against the ectopic ossified mass [8]. In these circumstances, surgical intervention may be considered.

Recently, surgical excision of heterotopic ossifications showed effective improvement in function in high-level athletes after proximal hamstrings eccentric overload injuries [18]. In these cases, however, apart from excising the heterotopic mass, and because the injury involved not only the muscle belly, but also the tendinous area, reattachment of the hamstrings tendons to the ischium was concomitantly performed [18]. Therefore, the contribution of heterotopic mass excision by itself from within and around the hamstrings muscles to patient functional improvement could not be determined. To the best of our knowledge, and with the exception of case reports [8, 22], there are no studies reporting the clinical value and the reproducibility of surgical excision of posttraumatic myositis ossificans performed as an isolated procedure and particularly in terms of return to sports. The purpose of this study was to report characteristics and outcomes of surgical excision of myositis ossificans in a series of adult athletes. It was hypothesized that surgical excision of symptomatic mature posttraumatic myositis ossificans in athletes can effectively relief symptoms and result in return to high-level sports with minimal postoperative risks.

Materials and methods

All cases of athletes who underwent surgical excision of posttraumatic heterotopic ossifications between 1987 and 2015 by the senior author (SO) were reviewed. In order to include in the cohort of this study only patients who had isolated excision of myositis ossificans, the following exclusion criteria were applied: (1) cases with concomitant reattachment of tendon to bone (performed in addition to excising the heterotopic ossification); (2) cases that involved chronic overuse injuries which preceded the development of the heterotopic mass or large calcifications which were excised from tendon-to-bone insertions; and (3) cases that involved excision of heterotopic ossification from a ligament, capsule, or tendon insertion following avulsion injury without tendon-to-bone repair.

Following the acute trauma, patients had initial nonoperative treatment which consisted of rest, indomethacin (50 mg daily) for 21 days, followed by activity modification and physical therapy with gradual return to sports. Once heterotopic ossified mass was formed and identified (Fig. 1), this was treated with further nonoperative management, stretching, and physical therapy.

At more than 6 months after the acute injury, in the absence of literature-based return-to-sports criteria after myositis ossificans formation, surgery was suggested to

Fig. 1 15-cm-long juxtacortical myositis ossificans at the anterior–lateral thigh in ice hockey player

patients who were defined as "failure" of nonoperative treatment because they did not fulfil return-to-sports criteria based on previously suggested guidelines after hamstrings injuries [1]. These included local dull pain with tenderness of the involved area during direct contact at sports activities, painful limitation during stretching of the involved muscle during forced contraction, or friction against the surrounding tissue with tethering of the muscle during sports activities. Symptoms in all patients were severe enough to result in inability of the athlete to perform sports-specific tasks and resume his/her sports level, and in professional athletes specifically, without further intervention, this would have been resulted in abandoning the sports career.

Surgical technique

Preoperative planning included: (1) evaluation of heterotopic mass location and the muscle involved; (2) measurement of heterotopic mass dimensions and appreciating its shape; and (3) delineating relative proximity of the mass to important neurovascular structures. During surgery, tourniquet cuff was used when applicable (i.e. when the heterotopic mass involved the distal thigh and further distally). Anatomical landmarks including bony prominences, neurovascular structures, and surgical approach were drawn on the skin. Soft tissue layers were meticulously incised and inter-muscular planes were developed where possible with special care to minimize bleeding. Electrocautery device was used for small bleeders, and ligation of larger vessels was performed as needed. Blunt dissection with Metzenbaum scissors was used until the heterotopic mass was identified. The mass was pealed off from within and around the muscle in one piece or in several pieces (Fig. 2). Once all heterotopic particles were excised, the overall size of the excised masses was measured on a side table and compared to the preoperative measurement in order to ascertain complete excision of all ossified particles. Tourniquet was deflated before soft tissue closure to ascertain no excessive bleeding at the operative site.

Postoperatively, full weight bearing was allowed, and no brace or crutches were recommended. Indomethacin (50 mg daily) was prescribed for 21 days. Return to sports was allowed after 4–6 weeks, but when symptoms persisted and return to sports criteria were not fulfilled as suggested for severe thigh muscle injuries [1] this was delayed for up to another month. Postoperative office visits were scheduled at 2 weeks and then 1, 3, 6 months, and 1 year after the operation. Additional visits were performed as needed to maintain adequate follow-up records regarding how these patients were functioning. Postoperative radiographs or ultrasound were not performed routinely, but were ordered if needed due to residual symptoms.

Clinical data were retrieved from office charts and operative reports of hospital databases and included: sex, age at injury, type of sports, level of activity according to Tegner scale [23] before the injury and at follow-up, mechanism of injury, myositis ossificans location, interval injury–surgery (months), size of excised ossified mass, postoperative complications, follow-up time (years), and a self-reported outcome scale which was rated as "Excellent" (patient was able to return to preinjury activity level, free of any symptoms during any activity), "Good" (patient was able to return to preinjury activity level, with mild pain or discomfort during sports, and without symptoms during activities of daily living), "Moderate" (patient was able to return to preinjury activity level with minor symptoms during sports, alongside minor symptoms during activities of daily living), "Fair" (patient was unable to resume preinjury activity level because of significant pain and discomfort during such activities, alongside minor symptoms during activities of daily living), or "Poor" (patients was unable to resume preinjury activity level, alongside difficulties in activities of daily living owing to significant pain and discomfort during such activities). The local hospital ethics committee (Hospital NEO, Turku, Finland) approved the study protocol on 16 September 2016.

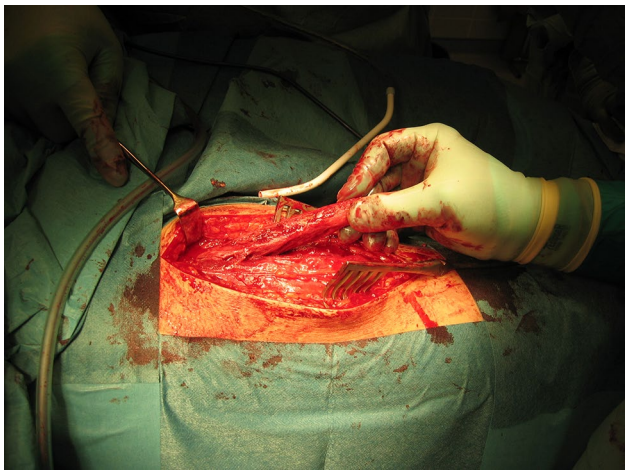

Fig. 2 The heterotopic ossified mass is peeled off from the vastus lateralis and surrounding muscle tissue

Statistical analysis

Descriptive statistics consisted of numbers with percentages for nonmetric variables, and medians with ranges or means with standard deviations for continuous variables. Student *t* test was used to compare between preinjury and latest follow-up means relating to Tegner activity level score. In addition, the following potential risk factors for inferior outcomes were compared between patients with "Good/Excellent" self-reported outcomes versus patients with "Fair/Moderate" self-reported outcomes: (1) age at injury

(years), (2) location of ossification ("thigh" vs. "nonthigh"), (3) time to surgery (months), and (4) size of ossified mass (cm length). Variables were checked for normality using the Shapiro–Wilk test. The Mann–Whitney nonparametric test was used for comparing continuous variables where the assumption of normality was rejected, and the Fisher exact test was used for comparing nominal variables. The p value to reject the null hypothesis was set at 0.05. Statistical analyses were performed using IBM SPSS-22 software package. Due to lack of data in the literature about any series of patients treated surgically for myositis ossificans, desired minimum sample size was based on previous largest series of patients treated nonoperatively for this condition which had between 19 and 26 cases [3, 14, 21].

Results

Of 57 athletes who underwent surgical excision of posttraumatic heterotopic ossifications between 1987 and 2015 by the senior author, 32 patients were categorized as isolated surgical excision of symptomatic mature posttraumatic myositis ossificans (Fig. 3). There were 30 (94%) men (Table 1). Median age was 23 years (range 18–45 years in 31 of the 32 athletes, and one 66-year-old recreational orienteering athlete). Soccer and ice hockey were the two most common types of sports, accounting for 24 (75%) cases. In 14 (44%) patients, the injury occurred during playing soccer, most commonly as a result of direct contusion to the thigh, and less common mechanisms in this sports included leg contusion and eccentric groin overload to the adductor muscles. In ten (31%) patients, the injury occurred during playing ice hockey with the exclusive mechanism of direct contusion to the thigh. Preinjury Tegner level was median 9 (range 6–10), of which 28 (94%) were involved in high-level sports corresponding to Tegner levels 8–10, such as professional soccer, ice hockey, and track and field athletics. In 27 (84%) patients, the thigh muscles (including anterior, posterior, posterolateral, lateral, and medial muscles) were involved. Mean interval between injury and surgery was 13 ± 7 months (range 6–35 months). In 16 (50%) patients, excised ossified mass length was ≥7-cm. The largest mass that was excised was 15 × 3 × 2 cm and involved the vastus lateralis muscle. Median follow-up was 2 years (range 1–20 years). Self-reported outcome at follow-up was rated as "Good/Excellent" in 26 (81%) patients. In five (16%) patients (one ice hockey, two soccer, one tennis, and one runner athletes) who rated their outcome as "Moderate" and one (3%) patient (soccer) with "Fair" outcome, postoperative radiographs and ultrasound showed only very subtle calcified spots at the area of excision but no substantial heterotopic bone regrowth at the area of the operation (other than remaining limited particles in two patients). Thirty patients (94%) were able to resume preinjury Tegner activity levels, although four (14%) of these patients reported decrease in their sports performance within the specific Tegner level, which included one professional ice hockey player who moved to a lower professional league, one soccer player, one tennis player, and one runner which reported minor symptoms during activities of daily living and therefore had "Moderate" outcome despite resuming preinjury Tegner levels of their sports activities. There was no significant difference between preinjury versus latest follow-up mean Tegner activity level in the entire cohort (9.0 ± 1.1 vs. 8.8 ± 1.2, $p = 0.2$). Comparisons between "Good/Excellent" versus "Fair/Moderate" outcome groups revealed nonsignificant differences for each potential risk factor tested, i.e. age, location of ossification, interval injury–surgery, and size of ossification (p = n.s. for all comparisons).

No postoperative infections, painful neuromas, or significant areas of loss of skin sensation were recorded, other than minimal insensitive areas at the periphery of skin incisions. There were no revision operations.

Discussion

The main finding of this study was that surgical excision of symptomatic mature posttraumatic myositis ossificans resulted in effective clinical improvements. The reproducibility of this operation is supported by the fact "Good/Excellent" outcomes were reported in 26 of 32 (81%) operated athletes. More specifically, preinjury Tegner activity level was maintained after surgery in 30 of 32 (94%) athletes, of whom 28 (94%) were involved in high-level sports corresponding to Tegner levels of 8–10, such as professional soccer, ice hockey, and track and field athletics. While there are no comparable series in the literature, sporadic case reports similarly showed effective clinical improvements following surgical excision of symptomatic myositis ossificans that involved the hamstrings and rectus femoris muscles [8, 22]. Altogether, these data support that when surgical intervention is indicated for chronic symptoms generated by mature myositis ossificans, effective results can be expected with low postoperative risks.

In 27 of 32 (84%) athletes, the ossified mass was located in a thigh muscle, corresponding to other descriptions of myositis ossificans that provoked chronic symptoms [7, 18, 21, 22]. As the thigh is the largest segment of the limbs with respect to surface area and muscle mass, it may have the highest likelihood to encounter a significant direct contusion that results in significant local haematoma leading to the formation of myositis ossificans. Moreover, large two-joint thigh muscles that cross the hip (i.e. hamstrings) and knee (i.e. Quadriceps group) are subjected to significant eccentric overload injuries as a second mechanism for muscle tear and

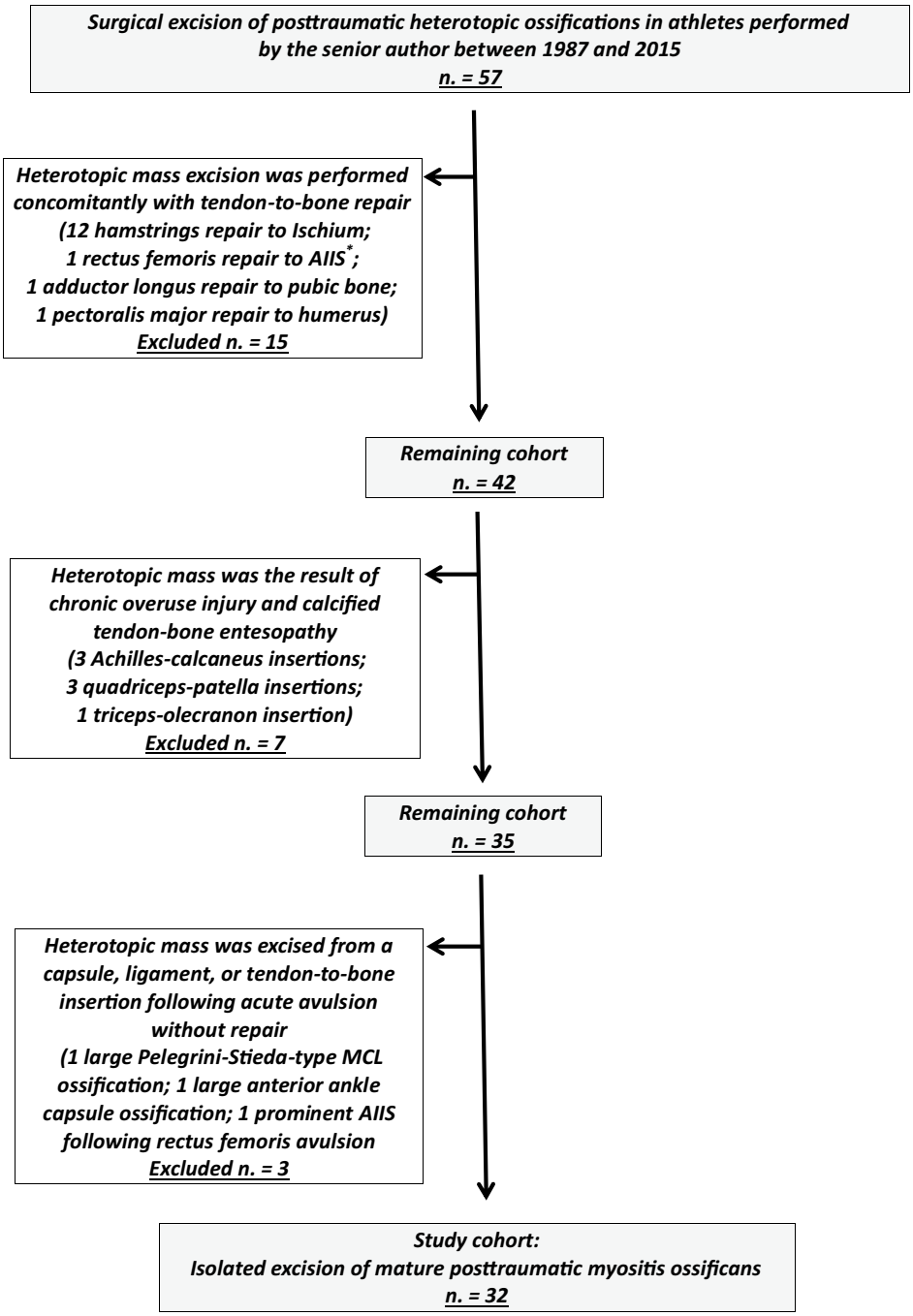

Fig. 3 Flow chart of study cohort. *, *AIIS* anterior inferior iliac spine

haematoma formation. In ice hockey, direct trauma has been shown to account for 80% of injuries encountered by players as opposed to overuse injuries which accounted for only 20% of the injuries [4]. Among the direct trauma injuries, thigh contusions were particularly common [4]. It is not surprising, therefore, that in this type of sport robust cushioning wear is used along the thigh and leg. This series shows, however, that this injury prevention measure cannot fully protect against the specific injury of significant muscle haematoma leading to the formation of myositis ossificans with chronic debilitating symptoms which may require surgical intervention. In soccer, cushioning thigh wear is not used, likely because of its potential to limit the players' mobility and agility. Leg protectors, however, are used in soccer, although these provide cushioning only to the anterior shin area, and may not be effective in preventing direct muscle contusions and haematomas along the upper anterolateral leg or the posterior calf, as demonstrated in some of the athletes in this series. In these circumstances, when severe muscle contusion occurs during a game, local icing with compression

Table 1 Patient demographics, injury, and surgery characteristics

Variable	
M/F (*n*. cases)	30/2
Age (Y) (median, range)	23, 18–66
Sports (*n*. cases)	
Soccer	14
Ice hockey	10
Orienteering	3
Running	3
Tennis*	1
Decathlon	1
Tegner activity level (median, range)	9, 6–10
Ossified mass location (*n*. cases)	
Thigh muscle	27
Leg muscle	3
Foot muscle	1
Arm muscle	1
Interval "injury–surgery" (M) (mean, range)	13 ± 7, 6–35
Size of excised ossified mass (cm) (range)**	(3 × 1)–(15 × 3×2)
Follow-up (Y) (median, range)	2, 1–20

n. number, *Y* years, *M* months

* In this case, contusion occurred during road traffic accident and not in sports

** In some cases, ossified particles size could clearly be measured only by length or by length and width, and not by thickness. This was the case for particles that were as thin as 5 mm and some that had significant irregularity in one or two dimensions

has been advocated by some investigators [5]. Prescribing indomethacin for 2–3 weeks should also be considered soon after the injury, because this may provide another secondary measure to decrease risk of late heterotopic mass formation [10, 18].

Preoperative planning of heterotopic mass size and location in this series was based primarily on plain radiographs. However, with modern imaging, low-radiation CTs are available [9] with the formation of three-dimensional reconstructions which enable more accurate assessment of heterotopic mass size, shape, and location relative to surrounding tissue. This was therefore suggested as the imaging of choice by several investigators [2, 20]. Greater precision in heterotopic mass characterization before surgery in this respect may have the potential for reduced risk of incomplete excision.

Serial postoperative radiographs were not performed routinely in this series, and therefore, the absence of heterotopic mass recurrence was not confirmed in all cases. Nevertheless, three principles which may have contributed to the favourable outcomes and reduced the risk of recurrence were applied and should be noticed: (1) excision of the heterotopic mass was never performed before 6 months from the acute injury in order to allow maturation of the ossified mass, as recommended [2, 6]; (2) care was applied during surgery for meticulous bleeding control and performing as atraumatic as possible soft tissue dissection to reduce risk of excessive operative site bleeding; and (3) indomethacin was routinely prescribed for 21 days after surgery, which has been previously shown to be effective medication in preventing new bone formation after surgical excision of muscular and tendinous excessive bone formation at the periphery of the hip joint with serial radiographs up to 2 years after surgery [9] or at the hamstrings with minimum 2-year follow-up and clinical evaluation [18].

In six of 32 (19%) patients, "Moderate/Fair" outcomes were recorded, but specific risk factors for inferior postoperative outcomes in this series could not be identified. This may be related to the multifactorial nature of sports functional demands in these cases. Factors which could only be suggested may include substantial scar formation in musculotendinous locations affecting tasks such as jumping and sprinting, nerve involvement in lesioned areas, and remaining ossified tissue, among others.

In this series, 94% of the patients were men, corresponding to other descriptions about posttraumatic heterotopic ossifications in athletes which showed male predominance [18, 21]. In ice hockey specifically, this corresponds to the fact "body checking" which provokes direct collisions between players is allowed only in men but is considered penalty in women [15]. Of note, this contradicts noncontact injuries such as knee anterior cruciate ligament tears which are more prevalent in female athletes [17], likely due to pronounced valgus knee alignment with decreased neuromuscular control [11].

Indications for and optimal timing of surgical excision of myositis ossificans are not well established and should be carefully selected. This can occur when persistent symptoms interfere with the athlete's ability to resume his/her sports level or when symptoms are significant enough to interfere with activities of daily living despite applying nonoperative treatment for adequate time frames. In the current series, nonoperative treatment comprised of physical therapy and activity modifications for more than 6 months. However, there is no consensus in the literature about which nonoperative treatment should be offered, and multiple alternatives have been suggested. These included, in addition to physical therapy [14], the modality of shock-wave treatment [3], and also therapeutic abstention with close monitoring of neovascularization within the muscle using Doppler ultrasound [21]. With shock-wave treatment, 13% of patients did not return to their preinjury level of activity [3]. Common to all of these treatment options was that majority of patients completed healing at 6–12 months after which return to sports was allowed [3, 14, 21]. This is in accordance with the clinical approach in the current series which referred to 6–12 months as minimum time frame after which surgical excision was suggested to athletes who failed return to

sports and were practically unable to resume their athletic activities. From a "return-to-sports criteria" perspective per se, there is lack of scientific data in relation specifically to myositis ossificans. The "closest" "return-to-sports criteria" in this respect which was elaborated related to hamstrings muscle injuries [1], which showed that a time interval of 6–9 months was the accepted upper limit for expected return to sports after severe tears. Thus, inability to resume sports level at this time frame can again be seen as "failure" of treatment which deserves considering further treatment options.

The favourable outcomes observed in this series after surgery apply specifically to myositis ossificans, particularly in the thigh muscles, and may not necessarily apply to other conditions that require surgical excision of heterotopic bone formations, such as those described in the excluded subgroups in this study. In fact, outcomes observed in the largest excluded subgroup in this study, which were 12 patients who had surgical excisions of heterotopic bone formations from the proximal hamstrings with concomitant repair of the hamstrings tendons to the ischium, showed, contrary to the 32 patients who had isolated myositis ossificans excision, significantly lower follow-up Tegner scores compared to preinjury scores (7.4 ± 1.1 vs. 8.5 ± 1.1, $p = 0.04$). This implies that every condition of heterotopic mass excision should be specifically addressed viewing its special characteristics, and surgical considerations should be based on the expected benefits of the specific surgery versus its potential risks. Among these conditions, it seems from this study that isolated excision of mature myositis ossificans is likely one of the most rewarding surgeries when chronic disabling symptoms favour operative intervention and this should therefore be considered a viable treatment option when nonoperative management fails.

Limitations of this series include the retrospective design, lacking systematic postoperative imaging to evaluate possible ossified mass recurrence, and lack of a control group. Nevertheless, with 84% of the cases involving thigh muscles and most having ossifications of 7 cm or larger, and with almost all patients men and three-quarters playing soccer or ice hockey, these shared characteristics support some homogeneity of the series and may allow for future comparisons of the current series versus similar populations treated by other strategies, such as shock-wave treatment [3].

Conclusion

In high-level athletes who present chronic disabling mature posttraumatic myositis ossificans that interfere with their sports career, surgical excision of the heterotopic mass results in effective clinical improvement with return to sports and minimal postoperative risks.

Compliance with ethical standards

Conflict of interest All authors declare that they do not have any conflict of interests related to this article.

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Ethical approval The local hospital ethics committee (Hospital NEO, Turku, Finland) approved the study protocol on 16 September 2016. It includes only retrospective data obtained from hospital databases and did not require any patient to sign informed consent form.

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