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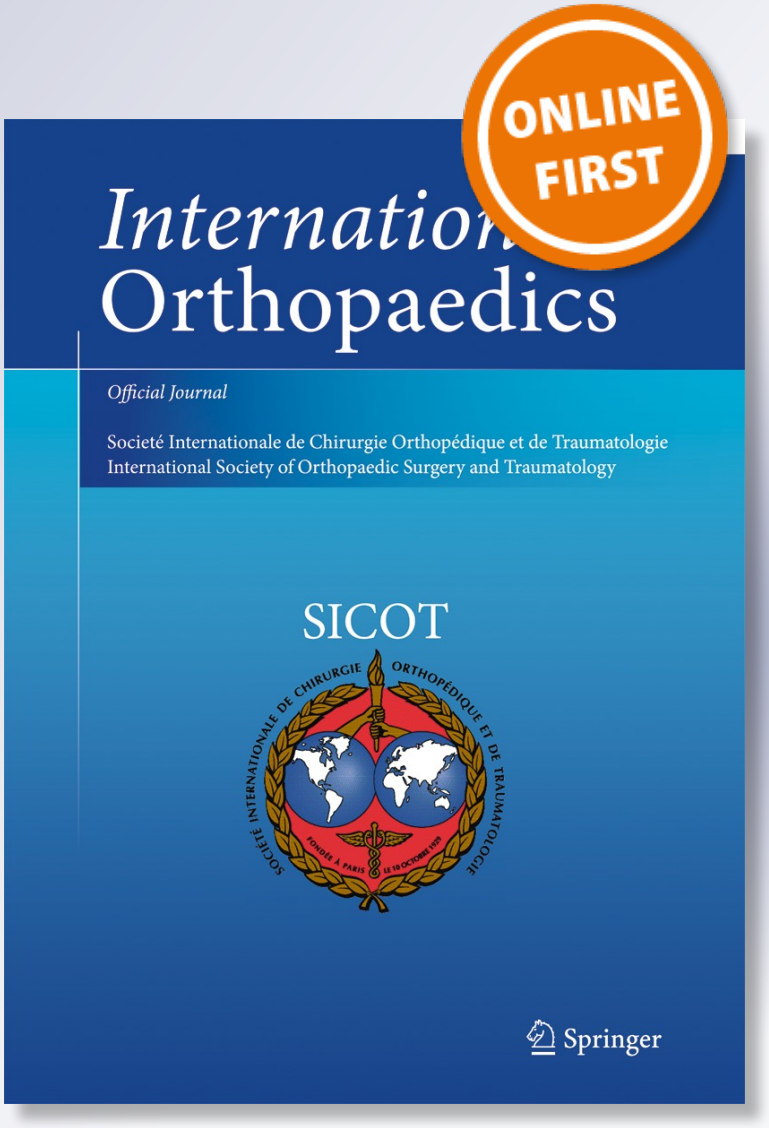

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ORIGINAL PAPER

Acute and chronic menisco-capsular separation in the young athlete: diagnosis, treatment and results in thirty seven consecutive patients

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Abstract
Purpose Menisco-capsular separation (MCS) is an avulsion type of injury of the medial and/or lateral meniscus and is defined as detachment of the meniscus from its capsular attachment. The aims of this study were to show the results of arthroscopic all-inside menisco-capsular repair in a large number of consecutive patients with acute or chronic MCS, emphasise the advantages of this safe treatment option and stress the superiority of the treatment on the basis of thorough physical examination of the knee joint over magnetic resonance imaging (MRI) diagnosis in MCS.
Methods We evaluated data of patients treated between October 2011 and July 2012. Inclusion and exclusion criteria were defined and demographic variables evaluated. All patients were examined physically and with MRI. Knee arthroscopy was performed and the MCS repaired through all-inside menisco-capsular repair. Postoperative treatment was standardised. Patients were followed up for at least 24 weeks.
Results Thirty-seven athletes (12 women, 25 men) were evaluated. Only in six patients was MCS detected on MRI. In all patients, MCS was diagnosed via physical examination. Arthroscopic treatment led to significant ($p<0.01$) improvement. There were no complications reported postoperatively.
Conclusion Isolated MCS is not as rare a meniscus pathology after trauma in young athletes as could be expected after reviewing current literature. It is occult on MRI scans in most of the cases and should therefor be taken into consideration in patients with acute or chronic tenderness at the level of the joint line and negative MRI scans. Thorough physical examination has higher diagnostic value than MRI alone, as shown in this study. Treatment of MCS using all-inside nonabsorbable sutures, as described in this study using Ultra FasT Fix®, is effective if performed by an experienced surgeon.

Keywords Menisco-capsular separation · MCS · All-inside repair · Physical examination

Introduction

Menisco-capsular separation (MCS) is an avulsion type of injury of the medial and/or lateral meniscus and is defined as detachment of the meniscus from its capsular attachment [6, 25, 30]. Medial MCS is more frequent than lateral MCS and most often occurs in combination with other ligament injuries [30]. The majority of medial lesions is due to the relative rigid fixation of the medial meniscus to the tibia by the meniscotibial ligament (coronary ligament). This is important for the role the meniscus plays in restraining posterior translation of the medial femoral condyle on the tibia [5, 16, 2]. Patients with MCS can show relatively unspecific signs of pain, instability and joint effusion. In particuar, medial MCS can be associated with other ligamentous injuries [30]. Generally, isolated MCS is known to be an uncommon entity, which is often not or with difficulty diagnosed on MRI scans [4, 3, 34, 9]. If treated operatively, the detached meniscus can be sutured back to the capsular structures with various techniques. This treatment often leads to significant pain relief and allows the reattached meniscus to heal [15, 11]. Studies reporting on the uncommon entity of isolated MCS are rare and limited to case

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series with low treatment numbers. To the best of our knowledge, only one retrospective case report describes the treatment of MCS with all-inside repair, and that report assessed a low number of patients [15].

The aims of this study were to: (1) show the outcome of arthroscopic all-inside menisco-capsular repair of acute or chronic MCS in a significant number of consecutive patients, (2) emphasise the advantages of this treatment option and (3) stress the superiority of the treatment on the basis of thorough physical examination of the knee joint over MRI diagnosis in MCS. The primary hypothesis of this study was that arthroscopic all-inside menisco-capsular repair is a recommendable treatment option for patients with MCS. The secondary hypothesis was that clinical evaluation is superior to imaging techniques in the diagnosis of MCS.

Materials and methods

Data of patients treated between October 2011 and July 2012 was evaluated retrospectively. Ethical approval was obtained from the local ethics committee according to the Declaration of Helsinki (EK 13-141-VK). Inclusion criteria were female and male athletes <45 years with acute or chronic medial or lateral knee pain unresponsive to conservative treatment (e.g. activity modification, physiotherapy) and injury sustained during sports. Exclusion criteria were additional ligamentous instability of the knee and no arthroscopic evaluation. Patients with acute injury presented less than three months after trauma, and chronic injuries were defined as unresponsive to conservative treatment for greater than three months. Patients were carefully examined physically for clinical meniscus pathology. Symptoms of tenderness on palpation of the medial or lateral joint line were indicative. Additionally, the following meniscus-specific tests were done: McMurray's test, Steinman 1 and 2 tests, Payr sign and Böhler's meniscus sign. A positive result in these tests was rated as indicative for MCS. All patients had recent MRI scans available (not older than four weeks). Sequences included sagittal, axial and coronal fast-spin-echo images performed with and without fat suppression. All MRI scans were interpreted by experienced musculoskeletal radiologists.

Knee arthroscopy was performed by the senior author. All patients were prepped and draped in a leg holder for single-sided knee arthroscopy under regional or general anaesthesia. After physical examination under anaesthesia, all patients were scoped via an anterolateral portal. An anteromedial portal for instrumentation was then created under image guidance, and a standard diagnostic arthroscopy was performed. Thereafter, meniscal attachments were examined using a standard arthroscopic probe. The MCS was identified through insertion of the probe into the lesion between the joint capsule and the meniscus and by showing the respective meniscus instability. MCS length was described by its extension into the three different regions of the meniscus (anterior, intermediate, posterior). The entire menisco-capsular junction of the meniscus was probed to identify possible multiple locations of MCS. In case of acute MCS, the lesion was first debrided with a 4.5 full-radius shaver, and the meniscus avulsion was treated with nonabsorbable 2–0 all-inside sutures (Ultra FasT Fix®, Smith&Nephew, Andover, USA) in a horizontal configuration. The number of sutures needed during the surgery was documented. In cases of chronic MCS with uncertain blood effusion at the meniscocapsular junction, bleeding was induced by needling with a spinal needle or an arthroscopic meniscus rasp.

After the operation, the knee was placed in a brace allowing limited range of motion (ROM) (0–60° for medial and 10–60° for lateral MCS). Patients used crutches and partial weight bearing for a minimum of four weeks and thereafter began full weight bearing of the affected leg. Isometric physical activity was started on the first day, and guided physiotherapy was introduced one week postoperatively. Stitches were removed ten days after the procedure.

A recommended graded protocol for limited sports activities included running at four months and restrictions for squatting and high-level and stop-and-go sports for six months (e.g. soccer, American football, hockey, etc.). Patients were followed up for at least 24 weeks, until they gained full knee function and could unrestrictedly return to their sport.

The following variables were obtained for each patient: gender, age at operation, acute (less than three months) or chronic (greater than three months) pain, sports activity leading to injury, diagnosis on MRI, location of meniscal tear, length of MCS, number of sutures needed, pre-operative and postoperative pain score using the visual analogue scale (VAS), duration of arthroscopic reconstruction, need for drainage after surgery, complications or adverse events postoperatively, pre-operative and postoperative evaluation of the objective part of the International Knee Documentation Committee (IKDC) score introduced by Hefti et al. [12, 13], duration of hospital stay, time to return to sports and duration of follow-up.

All data were statistically analysed using IBM SPSS 21.0 for Macintosh©. Standard descriptive statistics included frequency, mean and standard deviation of variables. For statistical comparison, a *t* test was applied in metric variables and a chi-square test in nominal variables. A statistically significant difference was considered to be present at a p value <0.05.

Results

In this nine-month period, 37 consecutive patients presented at the senior author's office with persistent pain and tenderness over the medial and/or lateral joint line. No patient had a complete tear of the anterior cruciate ligament (ACL), but in

25 patients, the ACL revealed an acute or chronic overstretch injury (sprain grade 1 [21]) or partial tear (sprain grade 2 [21]) during arthroscopy, which did not require ACL repair at the time of the operation. In each of these patients a MCS was diagnosed by physical examination and by completion of the aforementioned diagnostic tests (McMurray's test, Steinman 1 and 2 tests, Payr sign, Böhler's meniscus sign). Patient demographic data is shown in Table 1.

Thirteen patients had 1.5-T and 18 had 3-T MRI scans. Signs of MCS (e.g. meniscus avulsion, perimeniscal fluid) on MRI scans were found in only six patients (16.2 %). In 31 patients, MRI scans (1.5 T: n=13,;3 T: n=18) revealed no MCS and were interpreted as being negative for meniscus pathology. There was no difference in detection rate between 1.5-T and 3-T scans. ACL overstretch injury was seen on MRI in four cases (1.5 T: n=1; 3 T: n=3). Due to the small number of patients, no statistical comparison was performed. During arthroscopy, 25 ACL overstretch injuries were diagnosed. These were limited to the anteromedial bundle in 14 cases (37.8 %), the posterolateral bundle in nine (24.3 %) and both bundles in two (5.4 %). No ACL required reconstruction and were stable when healed. In 86.5 % (n=32) of patients, the medial meniscus showed the MCS, in 8.1 % (n=3) the lateral meniscus and in 5.4 % (n=2) both menisci (Fig. 1).

In the majority of patients showing injury to the medial meniscus, the posterior part (76.5 %, n=26) was affected. In 14.7 % (n=5), the interomedial part was injured, and in 8.8 % (n=3) the MSC was in both the posterior and the interomedial part of the medial meniscus. In patients with injury to the lateral meniscus, the posterior part was injured in 80.0 % (n=4) and the interomedial part in 20.0 % (n=1), also showing injury to the popliteomeniscal fascicles. The popliteal hiatus appeared normal in all cases.

For lesion repair, a single suture was sufficient in 29 cases (78.4 %), two were required in six (16.2 %) and three were used in two (5.4 %) to reattach the meniscus to the joint

Table 1 Patient demographics

Variable	Subcategory	No. (%)
Gender	male	12 (32.4)
	female	25 (65.6)
Age	24.2±12.2 years	
Pain	acute	24
	chronic	13
Reason	american football	6 (16.2)
	soccer	5 (13.5)
	running	5 (13.5)
	skiing	5 (13.5)
	hockey	3 (8.1)
	tennis	2 (5.4)
	cheerleading	2 (5.4)
	badminton	2 (5.4)
	climbing	2 (5.4)
	rugby	1 (2.7)
	snowboarding	1 (2.7)
	not rememberable	4 (10.8)
Injury mechanism	twisting and pivoting	32 (86.5)
	jump landing	5 (15.6)
MRI findings	positive	6 (16.2)
	negative	31 (83.8)
Side of MCS	medial	32 (86.5)
	lateral	3 (8.1)
	both	2 (5.4)
Location of MCS	medial posterior: 27 (73.0 %)	lateral posterior: 4 (10.8)
	medial intermediate: 5 (13.5 %)	lateral ntermediate: 1 (2.7)
	medial both: 3 (8.1 %)	lateral both: 0
Number of sutures	1	29 (78.4)
	2	6 (16.2)
	3	2 (5.4)

MRI magnetic resonance imaging, *MCS* meniscocapsular separation

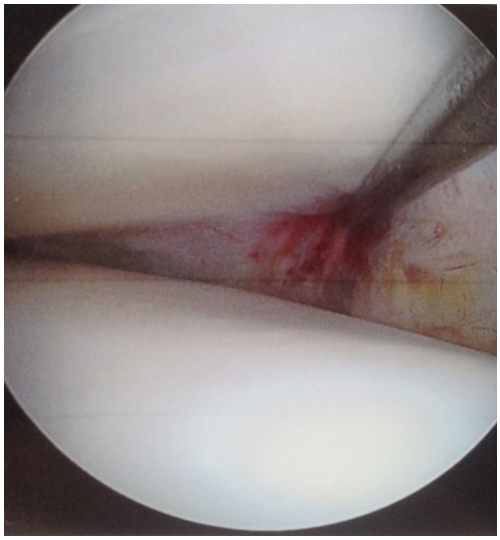

Fig. 1 Intra-arthroscopic image showing an a meniscocapsular separation (MCS) of the medial meniscus in a left knee. The standard arthroscopic probe is hooked into the gap of the MCS from underneath

capsule. Operation duration was 22.9 (13–31) minutes on average using the Ultra FasT Fix® for reattachment (Figs. 2 and 3). We treated 64.9 % (n=24) of patients in an ambulatory setting, and they were able to go home the same day of the procedure. The remaining 35.1 % (n=13) stayed for one night at the hospital. In four cases (10.81 %), a drain was applied intra-operatively, which was removed on the first postoperative day.

Pre-operative VAS scores were between 0 and 5 in 64.9 % (n=24) and between 6 and 10 in 35.1 % (n=13). Postoperatively, VAS values were zero in 73.0 % (n=27), 1 in 21.6 % (n=8) and 2 in 5.4 % (n=2). The difference between pre-operative and postoperative VAS values was highly significant (p<0.01; Fig. 4). Pre-operative objective IKDC score was was assessed. In 21.6 % (n=8) of patients, knee function was classified as nearly normal (group B), in 64.9 % (n=24) as abnormal and in 13.5 % (n=5) as severely abnormal.

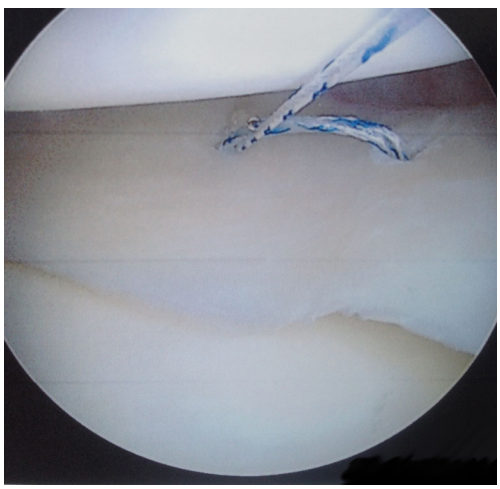

Fig. 2 Intra-arthroscopic image showing reattachment of the medial meniscus in a left knee using Ultra FasT Fix®

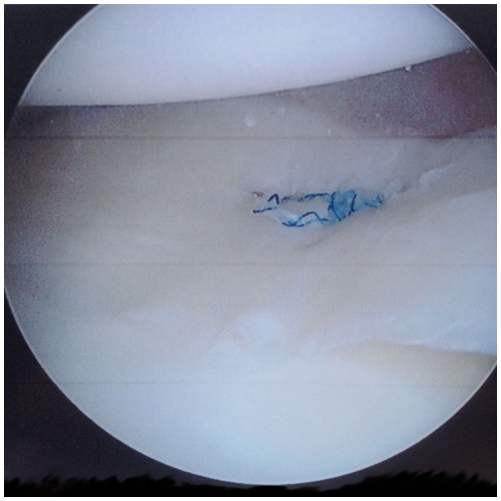

Fig. 3 Intra-arthroscopic image showing final result after reattachment of the medial meniscus using Ultra FasT Fix®

Postoperative IKDC scores were classified as normal in 91.9 % (n=34; group A), as nearly normal in 8.1 % (n=3; group B). The difference between pre-operative and postoperative IKDC values was highly significant (p<0.01; Fig. 5).

Patients were followed up for 24.7 (24–28) weeks. Of 37 patients, 18 (48.7 %) showed slight swelling of the knee joint postoperatively; in no case did postoperative infection occur. No other complications or adverse events prolonging treatment were reported and in no case was re-operation necessary.

Limited ROM lasted on average 5.8 (4–7) weeks, partial weight bearing was maintained for 5.9 (5–7) weeks and after 27 (21–32) weeks, all patients were able to return to their respective sports activities at the same level as prior to injury.

Discussion

Studies reporting isolated MCS are rare in the literature and are usually additionally limited to case series with low treatment numbers. Our study represents the first report of 37 consecutive patients who underwent arthroscopic all-inside meniscocapsular repair after isolated acute or chronic MCS. Additionally, this study shows that the arthroscopic all-inside repair of MCS is a very reliable technique. The MCS is an injury best diagnosed through physical examination by an experienced surgeon. Typically, this injury is found in young athletes who twist their knee in noncontact activities. Symptoms can develop acutely, or chronically over months and even years after the initial injury. Although injuries to the meniscus per se are frequent, MCS has been described as a rare injury and is often not detected on MRI scans alone [4, 3, 34, 25, 24, 9].

Rubin et al. [25] described that the positive predictive value of MRI in the diagnosis of MCS is 9 % medially and 13 % laterally. De Maeseneer et al. [3] showed that, especially for

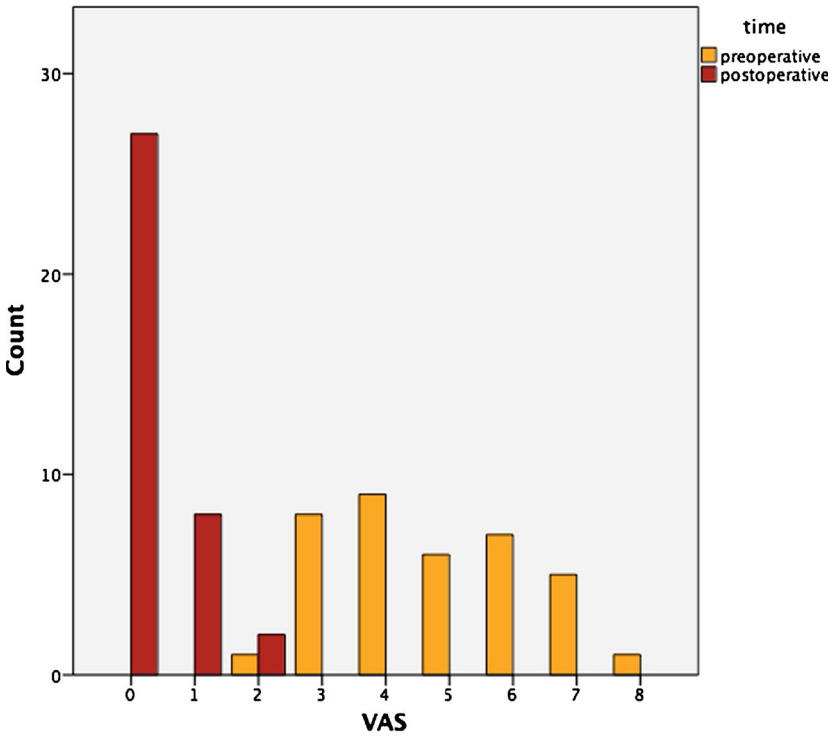

Fig. 4 Comparison of visual analogue scale (VAS) scores pre-operatively (*orange*) and postoperatively (*red*)

identifying the deep layer of the medial collateral ligament, which comprises the meniscofemoral and meniscotibial (coronary) ligament, is especially difficult to differentiate on MRI. In negative or questionable MRI scans, knee arthroscopy can thus detect occult MCS, which then can be treated operatively or nonoperatively. Therefore, arthroscopy is the gold standard by which to diagnose MCS in cases of symptomatic patients with doubtful MRI.

De Maeseneer et al. [4] summarised the various pitfalls in evaluating MRIs with questionable MCS, especially as the

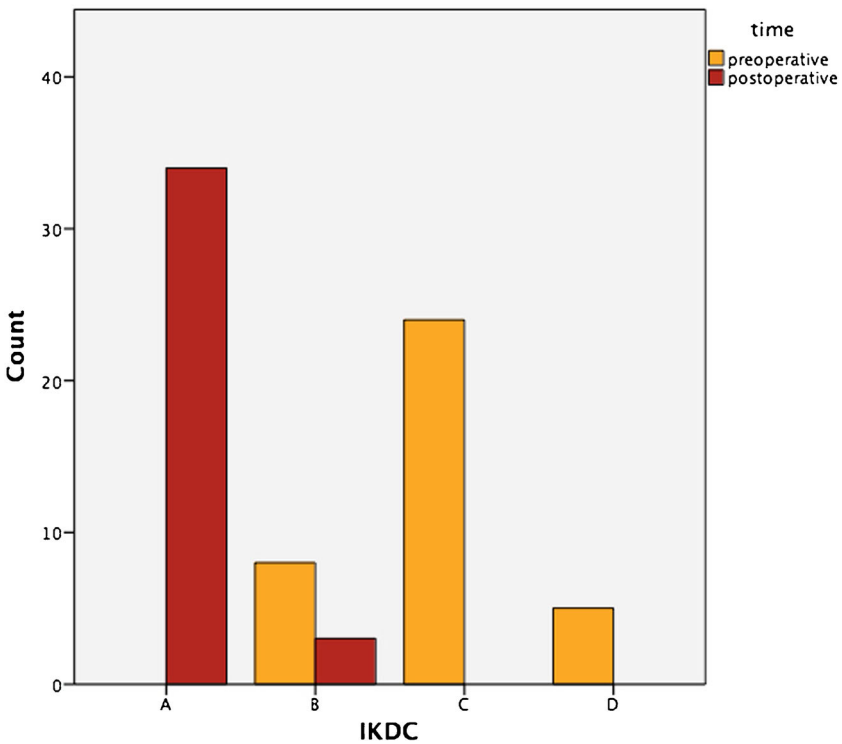

Fig. 5 Comparison of International Knee Documentation Committee (IKDC) scores pre-operatively (*orange*) and postoperatively (*red*)

reasons for the presence of perimeniscal fluid and an irregular meniscal outline—being the two most important signs—are various. Additionally, a layer of fat can lie between the superficial and deep portions of the medial collateral ligament, appearing to be almost the same as fluid on T2-weighted fast-spin-echo sequences [3]. In this context, we emphasise the high relevance of physical examination as the first and most effective diagnostic tool in this population of patients with questionable or negative MRI scans, despite clinical symptoms. It must also be noted that there is no specific test for MCS and its correct diagnosis, and thorough clinical examination is mainly depending on surgeon experience.

MRI scans, although evaluated by experienced musculoskeletal radiologists, were negative in 31 of the 37 patients (83.78 %) reported in this study. Although scans were performed in 13 cases using a 1.5-T scanner and in 18 using a 3-T scanner, there was no difference in detection rate between those two modalities. Overall, this is in line with existing literature [15]. It must be noted, however, that a specific comparison in MCS detection rate on 1.5 vs 3 T does not yet exist to our knowledge.

In all cases in this study, thorough clinical examination led to the diagnosis of MCS and the decision to perform arthroscopy as the next step. During arthroscopy, MCS was verified in all patients. MCS was delimited from a coronary ligament tear. In such cases, insertion of the arthroscopic probe between the joint capsule and the meniscus, as well as proof of meniscus instability, are the things to look for. Local synovitis, minimal effusion and a defect at the menisco-capsular junction when probing the meniscus provide proof of MCS and are regularly found during arthroscopy. MCS location detected during arthroscopy, however, is equivalent to the location of meniscal tears reported in other studies [33], which suggests approximately the same injury mechanism. Patients in that study were treated using all-inside menisco-capsular repair.

An important finding of this investigation is the great benefit of knee arthroscopy in such patients. If the patient is eligible, it is the surgical therapy of choice for meniscal tears alone or in combination with injuries to the ACL [8, 28, 27, 1, 14, 17, 29]. The method applied in this study has been described as a reliable technique of meniscal repair in radial tears [10, 18, 8], but no descriptions yet exist of its application in MCS treatment.

In this study, we showed the fast and safe application of the Ultra FasT-Fix® for reattaching the MCS. Also, hospital stay can be minimised to ambulant treatment or a maximum of one night, which is an interesting aspect. To date, this treatment method for MCS has not been described in the literature. However, this method results in a very low number of complications or adverse events. In the study reported here, temporary swelling was the only side effect after operation, and all outcome parameters improved over the follow-up period in every patient diagnosed and treated for acute or chronic MCS. Therefore, arthroscopy seems to be reasonable option after an index injury and symptomatic clinical correlation, even if MRI is negative. Day surgery can be recommended in light of the complication-free results of this study.

Although acute MCS might heal spontaneously [30], this protocol with arthroscopy and meniscus refixation can be recommended to sufficiently restore menisco-capsular anatomy. In another of our case series (unpublished data), three young patients with a history of twisting knee injury but without any pathological signs on MRI were treated conservatively for greater than four months and developed complete intra-articular dislocations of the posterior horn of the medial meniscus as a result of an initial MCS. It could therefor be hypothesised that MCS healing failure can lead to avulsion of the posterior horn of the medial meniscus due to loss of fixation. It is therefor of utmost importance for meniscal health and knee-joint integrity that MCS be adequately treated.

This study further reveals the high diagnostic value of arthroscopy in a population of patients with persistent medial or lateral knee pain and joint-line tenderness but negative MRI scans. This is in accordance with Hetsroni et al. [15] and Rubin et al. [25], who found very low positive predictive value for MRI diagnosis of MCS. We therefore note that in our study, a diagnostic arthroscopy per definition (arthroscopy without an intervention) was not performed in any patient in our population. All arthroscopies included MCS repair with sutures and refixation of the meniscus.

Compared with previous case reports, this study describes a relatively high number of patients with isolated acute or chronic MCS within a relatively short time period of nine months. This might be explained by the high case load of the senior author, who is specialised in arthroscopic knee surgery and frequently exposed to patients with meniscus pathology. In this context, we additionally point out the high frequency of patients who came to the office for a second opinion. Most patients were previously seen by other specialists, who relied on negative MRI and did not initiate further diagnostic or therapeutic measures. In six of our patients, even crystalloid cortisone with or without local anaesthetics was injected by primary care physicians for attempted pain reduction.

Injuries leading to MCS during sports are mostly of a pivoting nature. This concurs with the overall reasons for meniscal injuries during sports, showing especially the danger of American football, soccer and skiing [7, 20, 26]. The distribution of the type of sport leading to MCS in our study confirms this. Also, the gender distribution depicted in this study is congruent with previous studies [20]. There exist several publications describing the greater vulnerability women have for knee injuries because of their different soft tissue characteristics, especially that of capsular attachments, and different anthropometric characteristics of bone morphology and joint congruency [15]. Also, poorer jump-

landing techniques, greater valgus moment of the knee, more internal rotation of the hip and greater knee-joint loading could lead to a higher incidence of knee-joint trauma in female athletes [22]. However, taking into consideration that more men than women take part in regional sports and that more men than women report to a clinic because of knee injuries [20], the distinguishing morphologic features between men and women do not actually influence the rate of injuries to the knee.

The significant difference between VAS score and the objective IKDC score pre- and postoperative evaluation shows the positive effect of correct diagnosis and arthroscopic treatment of MCS. Pain is the main symptom of patients with isolated MCS and the primary reason for consulting a doctor. It therefor should be noted that all patients treated in this study were pain free postoperatively. This is in accordance with the cases reported by Hetsroni et al. [15] and Haas et al. [10].

Although no patient in this study showed any knee instability, in 25 of them, the ACL revealed an acute or chronic stretch injury (sprain grade 1–2 [21]), which did not require ACL repair at the time of the operation. Although MRI is the gold standard in diagnosing ACL tears, these overstretch injuries were only identified in four cases by MRI, showing a signal alteration in the ligament. The small number allowed no statistical comparison between the two modalities performed. However, Park et al. [23] reported no statistically significant difference between 1.5 and 3 T in the diagnosis of ACL tears. Additionally, Van Dyk et al. [32] noted that it is quite difficult to differentiate a stable from an unstable ACL injury using MRI. In particular, detecting chronic injury to the ACL may be challenging using MRI, as the ACL may look normal in course and continuity, as scarring to the PCL or the roof of the intercondylar notch obscures correct diagnosis [31, 19]. This may be the reason for the low number of cases with stable overstretch injury to the ACL reported in this study. Moreover, correct MRI diagnosis of a grade 1 sprain of the ACL has scarcely been discussed in the literature.

ACL injuries (sprain grades 1–2) in our patients did not influence joint stability. It could therefor be stated that mechanical factors leading to complete ACL tears and MCS seem to differ substantially. This is not in accordance with other authors, who frequently found complete ACL tears in patients with acute MCS. Although no patient in our case series developed knee instability at follow-up, both surgeon and patient should be aware that an additional ACL injury might lead to subsequent instability.

The duration of postoperative treatment in this study is comparable with recommendations mentioned in similar studies, as is the time until patients were able to return to their respective sports [7, 15, 18, 10, 29].

Limitations

A limitation of this study is patient selection. Our study design was retrospective, and no control group was used; this would be a good option for a follow-up study. As all patients were athletes with regular training, they were in higher risk group for acquiring meniscal injury [15, 26, 20]. The primary aim of our study was not to show MCS frequency in the average population but to show the efficiency of all-inside meniscal repair and the importance of physical examination in its correct diagnosis. For the same reason, follow-up information concerning long-term complications were not evaluated. However, as all patients were professional athletes, quick recovery was the main treatment objective. Also, although no other scoring system (e.g. Tegner score, Marx activity scale) was used, the VAS and objective IKDC scores proved that MCS repair using the method described herein was successful.

It is important to again note that no patient in this study had significant ligament injuries. Therefore, classic symptoms and patients' physical evaluation were sufficient for the diagnosis MCS. In more complex injuries of the knee involving ligament trauma, it would certainly be more difficult to recognise MCS using clinical examination only. However, in such cases, arthroscopic ligament repair would be the primary treatment option, allowing simultaneous evaluation and treatment of meniscus tears or MCS.

Conclusion

Isolated MCS is a more frequent meniscus pathology after trauma in young athletes than could be expected looking at current literature. It is occult on MRI scans in most cases and should therefor be taken into consideration in patients with acute or chronic tenderness at the level of the joint line and negative MRI scans. Thorough physical examination has higher diagnostic value than MRI alone, as shown in this study. In selected patients with a history of knee-twist injury and persistent pain or tenderness over the knee-joint line, knee arthroscopy and arthroscopic examination of the meniscocapsular region should be performed. Treatment of MCS by all-inside nonabsorbable sutures, as described in this study using Ultra FasT Fix®, is effective if performed by an experienced surgeon.

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