Arthroskopische Therapie des Patellaspitzensyndroms

Wenn das Knie beim Springen schmerzt

P. Ogon, G. M. Salzmann, D. Maier, N. P. Südkamp

Wenn Sportler über Schmerzen unterhalb der Kniescheibe berichten, ist oft das sogenannte „jumpers knee“ Ursache der Beschwerden. Bei Versagen der konservativen Therapie wurden früher offene Verfahren im Bereich der Patellaspitze mit Sehnen- und Knochenentnahme durchgeführt. Heute kann das therapieresistente chronische Patellaspitzensyndrom mit arthroskopischen Techniken effektiv behandelt werden.

Das Patellaspitzensyndrom umschreibt ein Krankheitsbild, das durch eine Überlastung der Kniescheibensehne infolge wiederholter Zugbeanspruchungen hervorgerufen wird. Per Definition handelt es sich um eine chronische, schmerzhafte, degenerative Überlastungserkrankung des Kniescheibenstreckapparates am Knochen-/Sehnenübergang der Kniescheibenspitze. Die Bezeichnungen Springerknie, Kniescheibenspitzensyndrom, Patellar apicitis, Tendinitis patellae, Tendinosis patellae, Enthesiopathie der Patellarsehne und zu guter Letzt der am häufigsten verwendete Ausdruck „jumpers knee“ werden synonym zur Umschreibung der Pathologie verwendet.

Anatomie und Pathophysiologie

Die vierköpfige Streckmuskulatur des Oberschenkels endet sehnig an der Basis der Kniescheibe, die ihre wichtigste Funktion als größtes Hypomochlion des Körpers in der Umlenkung der Quadrizepssehne in die Patellasehne findet (Abb. 1). Von der Spitze der Kniescheibe aus läuft die Patellasehne zur Tuberositas tibiae, um hierüber die Kraft des Quadriceps femoris auf den Unterschenkel zu übertragen. Besonders hohen Belastungen ist die Patellasehne bei Sprungsportarten wie dem Skispringen, Volleyball, Fußball oder Basketball ausgesetzt. Dabei kommt es zu ruckartigen Zugbeanspruchungen der Sehne, die bei wiederholter Durchführung das Sehnengewebe überlasten und eventuell schädigen können. Eine genaue Analyse der jeweiligen Sportart sowie deren Belastung, speziell auf die Physiologie und Anatomie des entsprechenden Sportlers ausgelegt, gibt häufig Aufschluss über die Ursache und Entstehung des Patellaspitzensyndroms. Im Laufsport können Veränderungen der Belastung oder des Untergrundes, Änderungen des Laufstils oder der Laufschuhe Ursache für die Entwicklung eines Patellaspitzensyndroms sein. Auch der Wechsel von der Sporthalle auf den Rasen oder ein Wechsel im Kraft-/Ausdauerbereich können die Entstehung eines Patellaspitzensyndroms begünstigen. In der Literatur werden sowohl extrinsische als auch intrinsische Einflussfaktoren, die ein Patellaspitzensyndrom hervorrufen können, diskutiert. Zu den äußeren Einflussfaktoren gehört die Natur der Beschwerde verursachenden Tätigkeit an sich, während zu den inneren Einflussfaktoren das Alter des Patienten, das in der Regel über 15 Jahre beträgt, ein zugrundeliegender Patellahochstand (Patella alta), eine abgelaufene aseptische Knochennekrose der Tuberositas tibiae (Morbus Osgood-Schlatter), ein reduzierter Dehnungszustand der Muskulatur sowie mitunter eine vorliegende allgemeine Bandlaxität zählen.

Das pathologische Korrelat der Enthesopathie lässt sich direkt am Sehnen-Knochen-Übergang im Bereich der Patellaspitze finden. Die menschliche Anatomie, gerade im Bereich von Sehnenansatzzonen, gestaltet sich aufgrund des Zusammenspiels von straffem Bindegewebe in Richtung Sehne sowie einer mineralisierten Faserknorpelzone in Richtung Knochen besonders komplex. Verschiedene Arbeiten beschrieben Mikrorupturen mit konsekutiver inkompletter Heilung innerhalb der Sehne als Ausgangspunkt der Pathologie. Der degenerative Prozess im Sinne einer mukoiden, hyalinen oder fibrinoiden Nekrose lässt sich mikroskopisch direkt am Sehnen-Knochen-Übergang identifizieren. Im weiteren Verlauf können hier Pseudozysten bis hin zur partiellen oder (seltenen) totalen Sehnenruptur auftreten. Typische Zeichen der Infektion konnten demgegenüber jedoch nie identifiziert werden.

Das klinische Bild

Klinisch präsentiert sich die Überlastungs-Symptomatik in belastungsabhängigen Schmerzen im Bereich der Kniescheibenspitze. In Abhängigkeit der Progredienz der Erkrankung kann der Schmerz zum Belastungsbeginn vorliegen und nach der Aufwärmphase wieder verschwinden, während er in der Phase nach der Belastung erneut auftritt. Im fortgeschrittenen Stadium bleibt der Schmerz während der gesamten Belastung. Im Endstadium schmerzt der Kniescheibenansatz nicht nur während der sportlichen Tätigkeit, sondern permanent auch im Alltag, zum Beispiel beim Treppensteigen. Stichartige Schmerzen bei bestimmten Winkelzuständen des Kniegelenkes unter Belastung beschreiben eine typische Klinik. Auffällig ist vor allem der hartnäckige Cha-

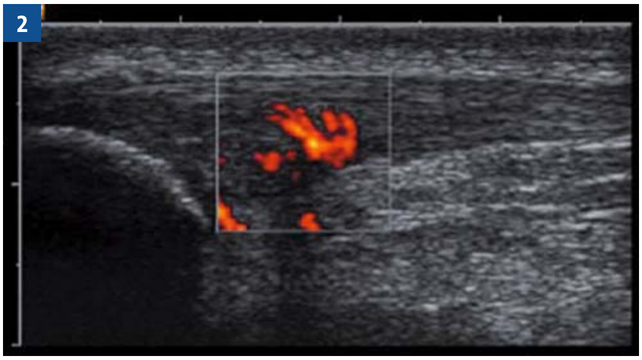


Abb. 1: Sagittales Kernspintomogramm eines Kniegelenks. Gut zu erkennen in dieser Schnittebene sind die Quadrizepssehne, die Kniescheibe (Patella) sowie die Patellasehne inklusive ihrem Ansatz an der Tuberositas tibiae. Im Bereich der Patellaspitze lässt sich eine pathologische Signalanhebung erkennen (typisch bei einem Patellaspitzensyndrom).

Abb. 2: Sonogramm des Kniegelenks eines Patienten mit Patellaspitzensyndrom. Es zeigen sich, vergleichbar dem Kernspintomogramm, pathologische Befunde im Bereich der Patellaspitze.

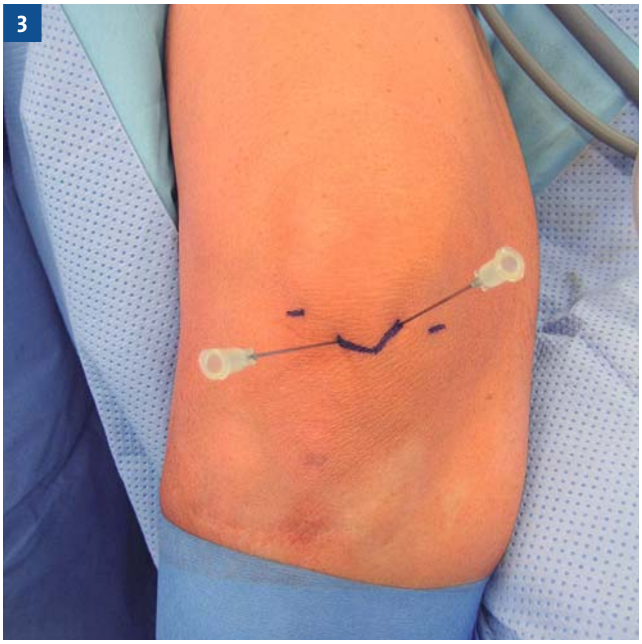
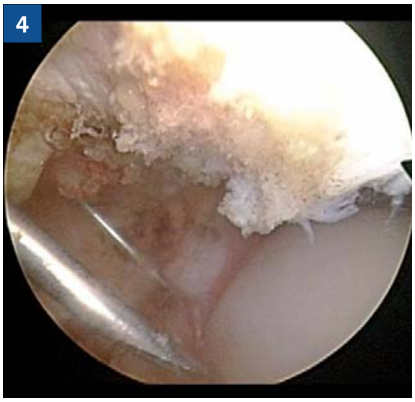


Abb. 3: Außenansicht eines Kniegelenks kurz vor Beginn der Arthroskopie. Direkt präoperativ wird in Zusammenarbeit mit dem Patient die schmerzhafte Stelle im Bereich der Patellaspitze mit einem Stift markiert. Im Bereich der Markierung werden dann zur exakten intraartikulären Lokalisation der relevanten Pathologie zwei Kanülen eingebracht.

Abb. 4: Intraartikuläre Ansicht eines Kniegelenks mit einliegenden Kanülen, die zuvor an der schmerzhaften Lokalisation der Patellaspitze eingebracht wurden. Deutlich erkennbar sind die synovitischen Veränderungen im Bereich der Patellaspitze.

Abb. 5: Intraartikuläre Ansicht eines Kniegelenks mit einliegender Kanüle sowie einem elektrothermischen Gerät zur Denervierung der Patellaspitze im schmerzhaften Bereich.

Abb. 6: Intraartikuläre Ansicht eines Kniegelenks nach erfolgreicher Denervierung der Patellaspitze ohne Resektion von Sehnengewebe, Knochen oder Knorpel.



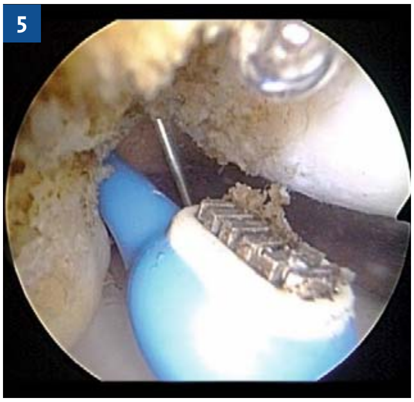


Foto: P. Ogon; G. Salzmann, Freiburg (alle Abbildungen) rakter des Beschwerdebildes. Oft handelt es sich um ein chronisches, über viele Monate bis Jahre anhaltendes Krankheitsbild mit beschwerdearmen Phasen, aber immer wieder auftretenden Beschwerden nach Belastungsspitzen. Während der klinischen Evaluation imponiert in der Regel wegweisend ein Druckschmerz sowie eine Schwellung über der Kniescheibenspitze. Typisch ist aber auch eine schmerzhafte Extensionsbewegung des Unterschenkels gegen manuellen Widerstand. Eine Rötung oder ein Erguss sind dagegen seltenere Anzeichen. Mithilfe des Klassifikationssystems von Blazina lässt sich das vorliegende Krankheitsstadium vergleichbar klassifizieren: Während Stadium 0 bei Schmerzfreiheit vorliegt, handelt es sich bei Schmerzen nach intensiver körperlicher Belastung um Stadium 1. Stadium 2 ist beschrieben mit Schmerzen bei Beginn der sportlichen Aktivität, Stadium 3 mit Schmerz während der sportlichen Aktivität, Stadium 4 mit nicht-akzeptablem Schmerz während der sportlichen Aktivität und Stadium 5 mit Schmerzen bei Aktivitäten des täglichen Lebens.

Zur kompletten Diagnostik der Erkrankung gehören neben dem klinischen Bild vor allem die bildgebenden Verfahren Magnetresonanztomografie (Abb. 1) und Sonografie (Abb. 2). Im Ultraschallbild lassen sich typischerweise eine Sehnenverdickung sowie vor allem hypoechogene Strukturen erkennen, die im Kernspintomogramm exakt lokalisiert und charakterisiert werden können. Zugleich können durch Anwendung der Magnetresonanztomografie potenziell bestehende Begleitpathologien hoch sensitiv ausgeschlossen werden. Durch viele Studien ist aber belegt, dass sowohl sonografische als auch kernspintomografische Zeichen des Patellaspitzensyndroms nicht zwangsläufig auf eine Symptomatik hinweisen müssen. Auch das klinische Bild und das postoperative Ergebnis ist häufig unabhängig von den im Sonogramm oder Kernspintomogramm noch nachweisbaren Veränderungen.

Therapie

Jede initiale Therapie des „jumpers knee“ ist nicht-operativ. Zur konservativen Behandlung zählen nicht-steroidale anti-inflammatorische Substanzen, Sportkarenz oder Modifikation der sportlichen Tätigkeit, Physiotherapie, Dehnung der Quadrizeps- und ischiocruralen Muskulatur sowie Kryotherapie. Wir empfehlen zusätzlich eine peritendinöse Anwendung von lokalen Steroiden, wobei die maximale Injektionsanzahl nicht mehr als drei betragen sollte, um eventuellen iatrogenen Sehnenrupturen vorzubeugen. Persistieren die Beschwerden unter der konservativen Therapie sollte eine operative Intervention in Betracht gezogen werden.

Die klassische offene Therapie des Patellaspitzensyndroms gilt heute als obsolet, da durch moderne arthroskopische Techniken in praktisch allen Fällen Beschwerdefreiheit erreicht werden kann. Verschiedene Arbeiten beschreiben einen Anteil von insgesamt circa 10 % der betroffenen Patienten, die sich im Verlauf der Erkrankung einer operativen Therapie unterzogen. Auch wenn im Leistungssport häufig zu einer frühen arthroskopischen Therapie tendiert wird, empfehlen wir vor einer eventuellen Operation – wenn möglich – einen mindestens sechsmonatigen konservativen Therapieversuch. In der Literatur sind multiple offene, minimal invasive und arthroskopische operative Verfahren zur Behandlung des Patellaspitzensyndroms beschrieben. Davon soll hier die von *Ogon und Kollegen* (Literatur beim Verfasser) beschriebene Technik demonstriert werden. Indiziert ist diese Technik vor allem bei Patienten, die sonografisch keine Anzeichen für eine Nekrose oder Ruptur im Bereich der insertionsnahen sowie proximalen Patellasehne aufweisen. Vor dem operativen Eingriff wird die klinisch symptomatische Stelle der Sehne auf der Haut markiert (Abb. 3). Der operative Eingriff beginnt immer mit einer diagnostischen Arthroskopie über das standardisierte anterolaterale Portal. Danach werden zwei Kanülen im Bereich der symptomatischen Region zur genauen intraartikulären Lokalisation der führenden Beschwerdesymptomatik eingeführt (Abb. 3, Abb. 4). Mithilfe eines zweiten medialen Arbeitsportals wird zunächst mittels elektrothermischer Instrumente (Abb. 5) die immer in diesem Bereich vorhandene Synovitis entfernt, das Paratenon entlastet und dann der untere knöcherne Patellapol denerviert (Abb. 6). Während des gesamten Eingriffs wird weder Knochen- noch Sehnenmaterial abgetragen. Alle bisher mit dieser Technik operierten Leistungssportler konnten auch ohne Entfernung von Knochen- und Sehnenanteilen postoperativ ihr ursprüngliches hohes Leistungsniveau wieder erreichen. Das postoperative Behandlungsschema erlaubt die schmerz-und schwellungsabhängige sofortige volle Belastung sowie freie Beweglichkeit des operierten Kniegelenks. Damit ist der häufig betroffene Sportler sehr früh dazu in der Lage, zu seinem initialen Leistungsniveau zurückzukehren.

In einer eigenen Studie wurden insgesamt 15 Patienten, die jeweils unter einem chronischen Patellaspitzensyndrom Blazina Grad 3 und 4 litten, unter Verwendung der oben beschriebenen Technik operativ behandelt und prospektiv nachuntersucht. Insgesamt 14 Patienten konnten erfolgreich zu ihrer initialen sportlichen Tätigkeit zurückkehren, während sich der Blazina Score im Mittel 41 Monate nach dem Eingriff auf durchschnittlich 0,4 Punkte reduzierte. 13 der 15 Patienten waren bereits drei Monate nach dem Eingriff komplett beschwerdefrei.

Fazit

Das Patellaspitzensyndrom ist für den aktiven Sportler eine einschneidende Erkrankung des Bewegungsapparates. Die primäre Therapie erfolgt zunächst konservativ. Bei Symptompersistenz, mit Rücksicht auf die richtige Diagnostik sowie Indikationsstellung, ist die arthroskopische Intervention letztlich ein elegantes und vor allem effektives therapeutisches Mittel zur Behandlung des „jumpers knee“. Sie erlaubt dem Leistungssportler, auch kurz nach der operativen Therapie sein ursprüngliches Leistungsniveau wieder zu erreichen.

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Arthroscopic patellar release allows timely return to performance in professional and amateur athletes with chronic patellar tendinopathy

Article *in* Knee Surgery Sports Traumatology Arthroscopy · May 2018

DOI: 10.1007/s00167-018-4985-4

Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-018-4985-4

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Arthroscopic patellar release allows timely return to performance in professional and amateur athletes with chronic patellar tendinopathy

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Received: 5 October 2017 / Accepted: 23 April 2018

Abstract

Purpose Return to sports rates in amateur and professional athletes with chronic patellar tendinopathy following arthroscopic patellar release are unpredictable. The present study aims to analyse the effectiveness of arthroscopic patellar release in professional compared to amateur athletes.

Methods A total of 34 amateur and 20 professional athletes with chronic patellar tendinopathy, refractory to conservative treatment, were studied prospectively and underwent arthroscopic tendon release at the inferior patellar pole. Impact of grouped sports on clinical and functional outcome, subjective patient satisfaction and return to sports rates were assessed. Additionally, preoperative MRI-scans of the knee were evaluated and correlated with clinical outcome.

Results In 40 patients (74.1%) arthroscopic patellar release resulted in complete recovery and return to preinjury exercise levels. Full return to sports was achieved after a median of 3.0 (range 0.5–12.0) months. Functional outcome measures VISA-P (Victorian Institute of sport assessment for patella) and modified Blazina scores improved significantly from pre- to postoperatively (VISA-P: 48.8 vs. 94.0 pts., respectively, $p < 0.0001$; Blazina: 4.47 vs. 0.5, respectively, $p < 0.0001$).

Conclusion As rapid recovery and timely return to sports are crucial for professional athletes, arthroscopic patellar release should be considered after failed conservative treatment.

Level of evidence IV.

Keywords Anterior knee pain · Patellar tendinitis · Jumper's knee · Professional/amateur athletes · Return to sports

Introduction

Chronic patellar tendinopathy is a major cause of morbidity in athletes participating in sports with high demand on the knee extensor mechanism. Prevalence of chronic patellar tendinopathy in jumping sports, such as elite basketball or volleyball players reaches up to 40% [22]. Male athletes are more exposed to chronic patellar tendinopathy than female [7, 24]. Sport-specific loading characteristics, age, body stature and body-weight are risk factors for the development of chronic patellar tendinopathy [24]. Eccentric training has become first line treatment of chronic patellar tendinopathy, resulting in satisfactory outcomes [6, 15]. In cases of unresponsive conservative therapies operative treatment might become necessary [13, 20]. Open and arthroscopic surgical modalities have been shown to effectively treat the symptoms of chronic patellar tendinopathy [3, 19]. This is of particular interest for professional athletes depending on a rapid recovery and early return to sports. Return to competition in professional athletes suffering from chronic patellar tendinopathy has been studied in detail [19]. However, studies comparing recreational to professional athletes are rare with little attention towards sports specific outcomes following arthroscopic patellar release. To our knowledge, current evidence on performance levels of sports participation following arthroscopic treatment of chronic patellar tendinopathy is minimal. Moreover, the influence of different sports on return to sports rates and rehabilitation times has not been studied in detail.

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Published online: 27 May 2018

The aim of the present study was to investigate effectiveness and clinical outcome in amateur and professional athletes having undergone arthroscopic treatment of chronic patellar tendinopathy due to failed conservative treatment. It was hypothesized that patellar tendon release relieves pain and dysfunction in athletes due to resection of locally inflamed tissue.

Materials and methods

In total, 54 amateur and professional athletes that underwent arthroscopic patellar release at the inferior pole due to chronic-refractory patellar tendinopathy were included in this prospective, single-centre study between 1998 and 2010. Inclusion criteria were age > 18 years, amateur or professional athlete and a minimum of 6 months of conservative treatment. Treatment strategies prior to arthroscopic patellar release included eccentric physiotherapy, oral non-steroidal anti-inflammatory drugs, extracorporeal shockwave therapy, and a maximum of three ultrasound-guided peritendinous corticosteroid injections at the inferior patellar pole. Injection of either local anaesthetics or corticosteroids led to temporal pain relief in all patients. Follow-up visits were scheduled 2 days, 6 and 12 weeks after surgery. A standardized retrospective follow-up assessment of time and ability to return to sports took place for all patients in August 2016.

Prior to the initial surgery, a standardized clinical examination of the knee was performed by the senior author including assessment of the range of motion (ROM), patellar stability together with functional assessment. Maximum pain sensation was identified at the inferior pole of the patella in all cases. Radiographic assessment included conventional radiographs (anteroposterior/lateral knee views and axial patellofemoral views). Ultrasonography (GE Vingmed Ultrasound AS, Trondheim, Norway) was performed using a 6–15 MHz linear multi-frequency probe for all patients. Magnetic resonance imaging (MRI) of the symptomatic knee joint excluded intra- and extra-articular co-pathologies. The images were acquired in a 1.5-T magnet (Magnetom, Siemens Medical Systems, Iselin, NJ). Sections were performed with 3-mm section thickness. Patients presenting with partial rupture of the proximal patellar tendon and concomitant intra- or extra-articular knee joint pathologies (i.e., patellofemoral malalignment/maltracking as well as acute meniscal tears and ligamentous injuries) were excluded from this study. Further exclusion criteria were chondral lesions: prior to the introduction of the International Cartilage Repair Society (ICRS) scoring system in 2003 all patients with minor and major cartilage lesions were excluded from the study [1]. After initiation of ICRS classification chondral lesions were differentiated and lesions greater than first degree were excluded from this study. Additional exclusion criteria were detraction of sports performance and/or sports cessation for reasons other than patellar tendinopathy (e.g., secondary injuries of the affected extremity).

Surgical procedure

All surgeries were performed by the same orthopaedic surgeon. The surgical procedure was performed as previously described [18]. Taken together, the skin of the inferior patellar pole was marked according to the preoperatively assessed symptomatic anatomic region. Then, the anteromedial portal was placed about 1.5 cm higher and slightly more medial compared to a standard approach. Intraoperatively, synovial hypertrophy surrounding the inferior patellar pole was typically detected. A needle was inserted at the medial and lateral borders of the skin initially marked defining the symptomatic area. An arthroscopic ablation probe (AAP; OPES; Arthrex, Naples, FL, USA) was utilized to release the inferior patellar pole.

Patients were discharged at the day of surgery or at the first postoperative day. Postoperative follow-up was recommended as described before [14].

Evaluation of clinical and functional outcome

All initial as well as follow-up examinations were performed by the senior author. Subjective pain sensation was noted on a nominal scale (0–10) where 0 described no and 10 maximum pain. The Victorian Institute of Sport Assessment questionnaire for patients with patellar tendinopathy (VISA-P) and the modified Blazina score served as functional outcome scores [4, 8]. VISA-P score results were categorized in excellent (91–100 points), good (81–90 points), satisfactory (71–80 points) and unsatisfactory (70 points). The modified Blazina score functions as a pathology-specific outcome measure including five stages according to symptoms occurring at different levels of sports/activity (0 = no pain, 1 = pain after intense sports activity, 2 = pain at beginning of and after sports activity, 3 = pain during activity at a satisfactory level, 4 = pain during sports activity at a non-satisfactory level, and 5 = pain during daily activity). Athletes evaluated the affected knee's subjective function via SANE score [23]. Hereafter, patients were advised to document their maximum pain level during activity on a nominal scale. Return to sports was defined as the point in recovery when a patient was able to go back to playing sports or participate in an activity. The number of months until athletes were able to perform specific exercises was extracted. At follow-up, patients were asked to evaluate their return to performance compared to before onset of symptoms (pre-injury level). Based on a VAS those ranged from 0 to 100% (0% no return to sport; 100% return to initial performance level without limitations). Also based on a VAS scale from

0 to 100%, athletes' subjective evaluation of activity levels prior to surgery was assessed in comparison to follow-up.

Preoperative MRI evaluation

MRI evaluation was performed according to a standardized algorithm including the presence of bone marrow edema (BME) of the inferior patellar pole, infrapatellar bursitis, and thickening of the proximal patellar tendon. BME of the inferior patellar pole was defined as distinct, focal enhancement compared to a normal surrounding bone signal. Furthermore, infrapatellar fat pad (IFP) edema was documented if the infrapatellar fat pad's signal intensity revealed detectable increase compared to normal fat tissue. Neither BME nor IFP were quantified in size or volume. Infrapatellar bursitis was determined as pathological fluid collection within the infrapatellar bursa. If the patellar tendon's proximal portion displayed a non-harmonic swelling compared to the distal part of the tendon, exceeding an AP-diameter > 7 mm, patellar tendon thickening was recorded [17].

Ethical approval

The study was approved by the local Ethics Committee of the University of Freiburg (Protocol Number 584/16) and informed consent was obtained from all participating patients before surgery.

Statistical analysis

Subgroup analyses were performed based on performance levels (professional vs. amateur athletes), individual sports exercised (running, soccer, handball, cycling, track and field athletics, alpine skiing, bodybuilding, gymnastics, volleyball) and type of exercise (endurance, start/stop, high-impact, low-impact). Running and cycling were considered endurance exercises; soccer, handball and volleyball start/stop exercises; alpine skiing, gymnastics, track and field athletics and body building were considered high-impact exercises. Group data were compared using the Chi-square test and Mann–Whitney *U* test. Statistical analysis was performed using SPSS software, version 20.0 (IBM, Armonk, NY). The significance level was set at $p < 0.05$. Bonferroni corrections were performed where appropriate. All data were initially tested for normal distribution using the Kolmogorov–Smirnov test. The Wilcoxon signed rank test and Mann–Whitney *U* tests were used to compare preinjury and postoperative values of the study group.

Results

Preoperative data was available for 58 athletes. Two patients were excluded because of secondary knee surgery for pathologic conditions other than patellar tendinopathy (lateral meniscus tear, medial femoral osteochondral lesions, and medial femoral chondral lesion), one patient died in a skiing accident and one patient was lost to follow-up resulting in a total of 54 athletes analysed in this study (follow-up rate 93.1%). Detailed information on all patient characteristics included in this study is given in Table 1.

Activities were categorized into subgroups endurance (cycling and running), start/stop (soccer, handball and volleyball) and high-impact sports (alpine ski, gymnastics, track and field, body building). Endurance athletes were significantly older when compared to athletes participating in start/stop or high-impact activities ($p < 0.0001$ and $p = 0.0026$, respectively; Table 2).

Median time required to return to sports were 3.0 months (range 0.5–12.0) which did not differ significantly between professional and amateur athletes. Only one patient (1.9%) failed arthroscopic patellar release. Direct comparisons between pre- and postoperative activity levels and different types of sports can be found in Fig. 1.

Average preoperative SANE scores in professional athletes improved significantly from 45.0 points (± 16.1) to 89.8 (± 11.2) postoperatively ($p < 0.0001$). Significant improvements were observed for amateur athletes from 38.5 points (± 16.1) pre- to 90.4 (± 11.5) postoperatively ($p < 0.0001$). Comparing professional athletes and amateurs, neither pre- nor postoperative scores differed significantly ($p = 0.0803$ and $p = 0.4151$, respectively). With regard to pain, however, professional athletes experienced significantly more pain prior to surgery measured on a VAS when compared to amateurs (VAS 7.2 vs. 6.4, respectively; $p = 0.0445$). At the time of follow-up a significant

Table 1 Patient demographics

	Total cohort	Professional Athletes	Amateurs	*p* value
No. of patients	54	20	34	n.a
Sex (male/female)	43/11 (79.6/20.4)	14/6 (70.0/30.0)	29/5 (85.3/14.7)	n.s
Median age at surgery in years (range)	27.5 (16.0–52.0)	23.5 (19.0–39.0)	29.0 (16.0–52.0)	$p = 0.0053$
Median follow-up in years (range)	6.6 (2.0–18.0)	6.1 (2.0–9.6)	6.6 (2.0–18.0)	n.s

Demographic characteristics of the study population

Table 2 Exercise-specific characteristics

	Endurance	Start/stop	High-impact
No. of patients	29	26	13
No. of professional athletes (%)	4 (13.8)	7 (26.9)	8 (61.5)
Median age at surgery (range)	34.3 (21.5–52.4)	23.9 (16.5–37.4)	26.2 (− 19.8 to 39.5)
Median follow-up time (in years; range)	7.6 (2.4–11.3)	6.5 (3.1–17.8)	7.4 (2.6–12.6)
Median time to return to sports in months (range)	3.0 (0.5–12.0)	3.0 (2.0–10.0)	3.1 (1.0–11.0)

Endurance: cycling, running; Start/stop: soccer, handball, volleyball; High-impact: alpine skiing, gymnastics, T&F (track and field athletics), body building

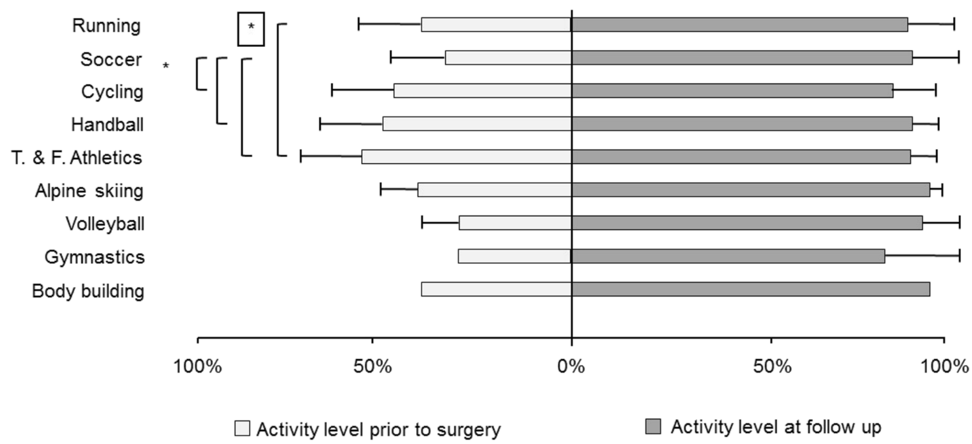

Fig. 1 Activity levels pre-/postoperatively stratified by type of sports. Preoperative activity levels differed significantly between soccer players when compared to cyclists ($p = 0.0156$), handball players ($p = 0.0098$) and track and field athletes ($p = 0.0019$). Runners were significantly less active preoperatively than track and field athletes ($p = 0.0240$). Postoperative activity levels, however, did not reveal any significant differences between different sports. (*$p \leq 0.05$)

reduction of pain was noted both for professional (VAS 0.9 ± 1.0; $p < 0.001$) and amateur athletes (VAS 0.7 ± 1.2; $p < 0.001$). Postoperative VAS scores did not differ significantly between professional and amateur athletes.

Overall, VISA-P scores significantly improved within the entire cohort from preoperative to follow-up ($p < 0.0001$). Direct comparison between amateur and professional athletes, however, did not reveal significant differences in VISA-P scores (Fig. 2).

Functional assessment of all patients at follow-up for Blazina score revealed a significant improvement compared to before surgery ($p < 0.0001$). Direct comparisons between pre- and postoperative results as well as amateur and professional athletes can be found in Fig. 2.

With four professional athletes that underwent knee surgery prior to arthroscopic patellar release at the same knee (20.0%), incidence of preoperative surgery was greater when compared to amateur athletes where two patients (5.9%) had undergone previous surgery. Chi-square test revealed significant connections between the level of sports performed preoperatively and the history of previous surgeries ($p = 0.0342$). However, patients with previous knee surgeries did not yield inferior clinical and/or functional outcome measures measured via VISA-P, modified Blazina or VAS score following arthroscopic patellar release.

A majority of 40 athletes (74.1%) reported that arthroscopic patellar release resulted in complete recovery and return to preinjury exercise levels. Detailed subgroup analyses between professional and amateur athletes can be found in Fig. 3.

In amateur athletes infrapatellar Hoffa edema was observed preoperatively in 14 (41.1%) cases compared to a majority of 17 (85.0%) professional athletes. These incidences differed significantly ($p = 0.0036$). Bone marrow edema, however, did not show different occurrence rates with 13 (39.4%) amateur and 12 (60.0%; n.s.) professional athletes.

Discussion

The main finding of this study was that a great majority of 74.1% of athletes reported that arthroscopic patellar release resulted in complete recovery and return to preinjury exercise levels. Five professional and five amateur athletes (18.5%) were able to return to sports with minor limitations. Professional athletes did not return to sports earlier than amateur athletes. This observation is surprising as on one hand side financial reasons and high expectations could make a speedy recovery and quick return to sports in professional athletes necessary. On the other hand a prolonged

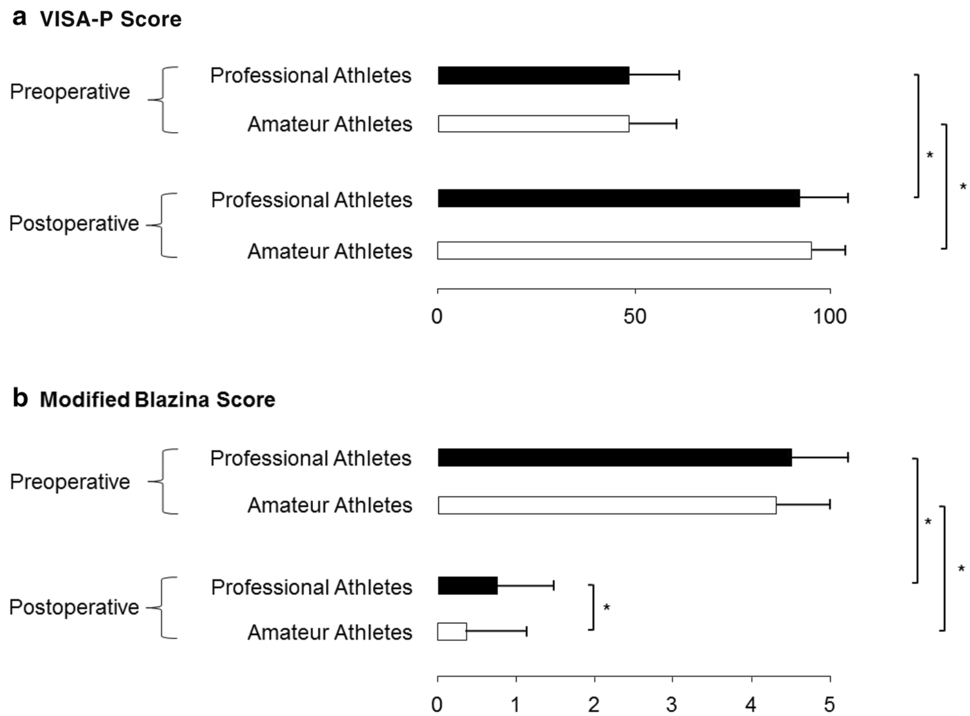

Fig. 2 Assessment of functional outcome parameters VISA-P (**a**) and modified Blazina scores (**b**). Significant improvements from pre- to postoperative were observed both for professional as well as amateur athletes ($p < 0.0001$). Direct comparison of score results between these two subgroups revealed significantly better postoperative Blazina score results in amateur when compared to professional athletes (0.4 ± 0.8 vs. 0.8 ± 0.8; $p = 0.0264$). *$p \leq 0.05$

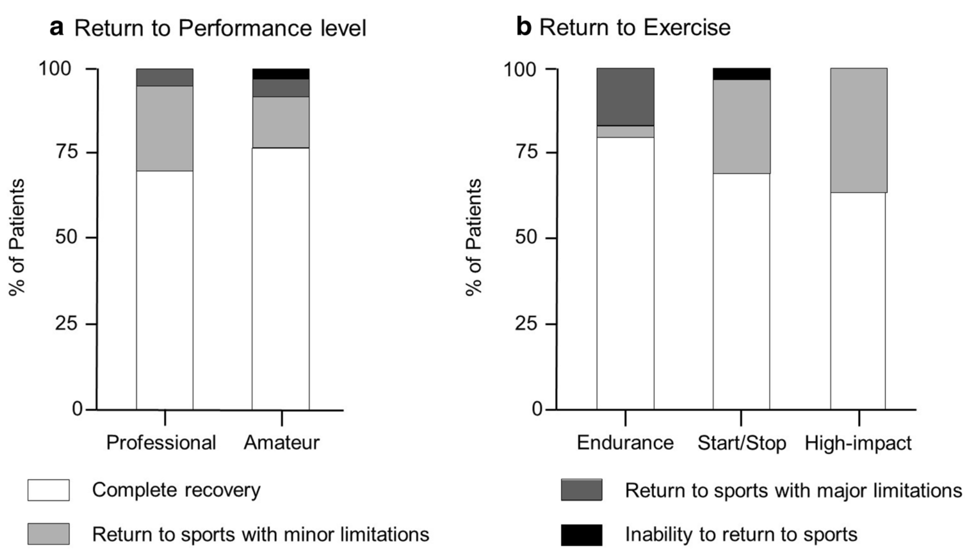

Fig. 3 Return to sports with regard to performance (**a**) and exercise levels (**b**). **a** A majority of 14 (70%) professional athletes reported complete recovery following arthroscopic patellar release. Five professional athletes (25%) were able to return to sports with only minor limitations while only one athlete reported major limitations at time of follow-up. A total of 26 (76.5%) amateur athletes reported complete recovery following arthroscopic patellar release with five (14.7%) athletes experiencing minor limitations. A total of two (5.9%) amateur athletes experienced major limitations at follow-up. Only one patient within this group was unable to return to his/her sport. **b** Return to exercise level: Endurance athletes showed the highest return to sports rates without limitations ($n = 23$; 79.3%). At the same time within this group the highest rate of persistent major limitations was found (18.9%). In total eight (61.5%) high-impact sport athletes experienced full recovery following arthroscopic patellar release while five (38.5%) athletes returned to sports with minor limitations. No significant differences between different exercise groups were observed

inability to perform on a professional level could be expected due to high demand as well as great training intensity and frequency. Pascarella et al., however, made similar observations in a cohort of professional athletes that underwent operative treatment for chronic patellar tendinopathy after failed conservative treatment [19]. Only professional athletes performing start–stop sports, no athletes performing high-impact or endurance sports were analysed. In this population

70% of the professional athletes could return to their sports without and 88% patients with minor or without pain.

Our study indicates that effectiveness of arthroscopic patellar release is not different in athletes participating in high-impact, endurance sports or start–stop sports. These findings are noteworthy as it is well known that contact sports put greater stress on the anterior knee joint making optimal postoperative muscular stabilisation necessary. Up to a 12-fold increased risk for knee osteoarthritis in high demand, pivoting athletes has been reported [3]. Because of the forceful, repetitive joint loading in impact sports, patella surgery in the high demand athlete's knee presents a significant therapeutic challenge and requires a postoperative result that can withstand the significant mechanical joint stresses generated during their sports activity [16].

Age did not appear to influence return to sport times in these subgroups with amateur athletes being significantly older than professionals. The absence of significant differences between professional and amateur athletes regarding time to return to sports could be explained by degenerative changes found in the patella tendon. Those typically include mucoid degeneration and collagen disorganization accompanied by hypercellularity and neovascularization [5]. However, inflammation predominantly affects adjacent tissues, but not the tendon itself. Focal synovitis around the inferior patellar pole and hypertrophy of the infrapatellar (Hoffa) fat pad represent pathognomonic findings [2, 21] in chronic patellar tendinopathy. This is supported by our observation where preoperative MRI-scans of the knee joint showed that the occurrence of Hoffa edema of the knee joint was significantly greater in professional athletes. This could be associated with greater damage, greater training intensity or prolonged duration of symptoms. Even though in the present study professional athletes were significantly younger at the time of surgery than amateur athletes, it is likely that degenerative changes at this age could be similarly pronounced. The lack of significant differences in return to sports times could, therefore, have a biological explanation. Inflammatory processes in the patella tendon and consecutive healing in this age group might need the same amount of reparative processes resulting in comparable return to sports times. There is good evidence that tendons do not degenerate with age as such, but a reduction in proteoglycans and an increase in crosslinks could make tendons stiffer and less capable of tolerating load [9, 10, 12]. As a consequence, older athletes exposed to only moderate tendon loads should not necessarily have an increased risk of tendinopathy [11]. With this information at hand it is our recommendation to offer arthroscopic patellar release to professional athletes as early as possible prior to chronification of symptoms. With the low complication rate of the arthroscopic procedure in mind we would recommend surgery for cases of failed conservative treatment as early as 3 months after initiation of conservative treatment. This could possibly shorten return to sports times and prevent financial loss in professional athletes.

As a limitation of this study the lack of data regarding the interval between the onset of symptoms and the surgical intervention needs to be pointed out. Prolonged duration of symptoms has been associated with inferior outcome regardless of treatment modality [6]. This could be of critical relevance when determining the time point at which arthroscopic patellar release should be recommended to professional athletes in cases of failed initial conservative treatment.

Conclusion

Arthroscopic patellar release should be recommended to athletes suffering from chronic patellar tendinopathy with failed conservative treatment as return to sports and competitions are generally possible after 3–4 months, independent of their performance level or sports exercised.

Author contributions JMP: research hypothesis, data acquisition, analysis and interpretation of data, draft of manuscript. GL: data acquisition, analysis and interpretation of data, draft of manuscript. KI: study design, analysis and interpretation of data, revision of manuscript. DM: study design, analysis and interpretation of data, revision of manuscript. NPS: study design, analysis and interpretation of data, revision of manuscript. PO: research hypothesis and design of study, data acquisition, analysis and interpretation of data, draft of manuscript. All authors critically reviewed and approved the final manuscript.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with ethical standards

Conflict of interest Jan M. Pestka, Gernot Lang, Dirk Maier, Norbert P. Südkamp, Peter Ogon and Kaywan Izadpanah have nothing to disclose and declare no conflicts of interest.

Ethical standards The study was approved by our local institutional review board and informed consent was obtained from all patients before surgery. All studies have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Consent has been obtained to publish from the participant (or legal parent or guardian for children) to report individual patient data.

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