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Research Article

Return to professional alpine skiing after a concomitant patellar tendon, ACL and MCL rupture in three athletes

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- Complex knee injury; Patellar tendon rupture; ACL rupture; Rehabilitation; Surgical technique; Alpine skiing

Abstract

Introduction: This study presents 3 professional alpine skiers with a simultaneous rupture of the Patellar Tendon (PT), Anterior Cruciate Ligament (ACL) and Medial Collateral Ligament (MCL) with a focus on the surgical techniques, functional outcomes and return to sports.

Material and Methods: Between 2013 and 2018, three professional alpine skiers (one female, two male) sustained a concomitant rupture of the PT and ACL, combined with an additional complete or partial tear of the MCL and either a lateral meniscal tear or an affection of both menisci. All patients underwent acute, single-stage surgery with PT and MCL repairs as well as ACL reconstruction. Clinical and functional assessments (Lysholm and Tegner scores) were performed 6, 12 and 24 months postoperatively.

Results: All three athletes returned to alpine skiing at the same professional pre-injury level. Postoperative functional scores at 6-month follow-up showed an average Lysholm score of 87 (range 67-100) and an average Tegner score of 8; at 12-month follow-up, the average Lysholm score was 91.7 (range 86-100) and the average Tegner score was 8; at 24-month follow-up, the average Lysholm score was 96.7 (range 94-100) and the average Tegner score was 8. The athletes returned to unrestricted snow training after 11 months (8-13 months) and returned to competition after 15.3 months (12-20 months).

Conclusion: For all three patients a return to professional alpine skiing was possible after this complex knee ligament injury. This rare injury was always associated with a meniscal tear. Therefore, advanced surgical techniques combining arthroscopic and open approaches are necessary. A single-stage treatment combined with accelerated rehabilitation is recommended for professional athletes to minimize the time to return to sports.

ABBREVIATIONS

PT: Patellar Tendon; ACL: Anterior Cruciate Ligament; MCL: Medial Collateral Ligament

INTRODUCTION

A concomitant rupture of the Patellar Tendon (PT), Anterior Cruciate Ligament (ACL) and Medial Collateral Ligament (MCL) is a serious and rare injury. To date, only 14 case reports with 17 patients with an average age of 30.6 years have been reported in the English scientific literature [1]. This injury typically occurs during sports, such as soccer, football, basketball and alpine skiing. Only four cases have been reported thus far in alpine skiers [1-3]. The initial diagnosis of this combined lesion is challenging and missed in up to 20% of cases [1]. Early MR imaging is mandatory to diagnose associated lesions, such as lateral (50%) and medial meniscal tears (46%) [1]. Six case studies documented the postoperative functional scores of only eleven knees [1,3-7], with a follow-up time ranging from 6 months to 4 years.

Concerning treatment, there is universal agreement for immediate PT repair because a delayed operation jeopardizes tissue healing and was found to be associated with atrophy of the quadriceps and a limited range of motion [6,8]. The timing of ACL reconstruction remains controversial. Some authors recommend one-stage treatment [5-7,9,10] that has the advantage of accelerated rehabilitation; others prefer a two-stage procedure with an interval of 40 days to 7 months [3,1-16] mainly because of technical difficulties such as extravasation during arthroscopy and because it potentially lowers the risk of arthrofibrosis.

We present 3 professional alpine skiers with a concomitant rupture of the PT, ACL and MCL, who have been treated with a one-stage procedure, focusing on operative techniques, functional outcomes after 24 months and return to sports.

MATERIAL AND METHODS

Patients, demographics, injury mechanism and injury type (Table 1)

Between 2013 and 2018, 3 professional alpine skiers (two males, one female; members of the International Ski Federation (Alpine Ski World Cup team or FIS European Cup national team)) were treated at our institution for a combined lesion of the PT, ACL and MCL after sustaining an injury during ski racing. The injury mechanism was similar in all three athletes, consisting of a deep flexion, internal rotation of the tibia and a sudden braking force on the tip of the ski from a snow bank. None of the three athletes had previously suffered from a major knee injury on the ipsilateral or contralateral side. The mean age at the time of injury was 23.3 years (20-26 years). Diagnostics included a clinical exam and MRI scan. All patients had either a lateral meniscal tear or an affection on both menisci.

One-stage surgery was performed within 24 hours following injury in all patients. Clinical and functional assessments (Lysholm and Tegner scores) were performed at 6, 12 and 24 months postoperatively.

Surgical technique (Table 2)

Preoperatively, an image intensifier was used to document the patellar height of the noninjured knee at 90° of flexion in a lateral view, and the image was saved on the screen. Intraoperatively, a lateral radiograph of the injured knee was taken to confirm the patellar height was identical before fixing the suture augmentation in all cases.

Patient 1: Through an anteromedial approach of approximately 15 cm, the PT was exposed first and showed a complete intraligamentous rupture within the distal third. Then, the preparation of the distally ruptured medial collateral ligament followed without addressing it yet. After harvesting the ipsilateral semitendinosus graft (4-stranded, femoral tunnel with a diameter of 7.5 mm, tibial tunnel with a diameter of 8 mm), arthroscopy was initiated without significant extravasation. A grade 3 chondral lesion of the medial femoral condyle (1 cm^2) was debrided, and a lateral vertical meniscal tear of the posterior horn was addressed with two all-inside sutures (Fast-Fix®, Smith & Nephew).

The ACL was then reconstructed arthroscopically using a single-bundle technique with a suspensory system for femoral fixation (Endobutton CL®, Smith & Nephew) and a bioabsorbable interference screw (8 x 28 mm) for tibial fixation (Mega Fix®, Storz). An additional extraarticular postfixation was performed with transosseous sutures (FiberWire®, no. 2).

The patella was reduced by a double cerclage with braided, non-absorbable, ultrahigh molecular weight polyethylene (FiberWire®, Arthrex, no. 5) through a single horizontal patellar

Table 1: Patient demographics and descriptions of the injury.

Patient	Gender	Side	Age at Injury	MCL	Menisci	Other Lesions
1	M	right	20	MCL (distal superficial layer)	Lateral (vertical tear posterior horn)	Grade 3 chondral lesion medial condyle (1 cm^2)
2	M	right	24	MCL (distal superficial and deep layer)	Lateral (radial) and medial (ramp lesion)	Distal fibula fracture (Weber C)
3	F	right	26	MCL (distal superficial and deep layer)	Lateral (vertical tear posterior horn/pars intermedia) and medial (vertical tear posterior horn)	None

Abbreviations: MCL medial collateral ligament

Table 2: Surgical techniques and functional outcomes.

Patient	1 stage vs 2 stages	Operation time (min)	Tourniquet pressure (mmHg); tourniquet time (min)	Patellar tendon repair	ACL recon-struction	ACL graft	Lysholm score			Tegner score		
							6 months	12 months	24 months	6 months	12 months	24 months
1	1	119	320; 119	direct suture, transosseous FiberWire 5 double loop	arthroscopic	4s-ST	100	100	100	8	8	8
2	1	211	320; 119	direct suture, transosseous FiberWire 5 double loop	open	QT	94	89	94	8	8	8
3	1	113	320; 108	direct suture, transosseous FiberWire 5 double loop	arthroscopic	4s-HT	67	86	96	8	8	8

Abbreviations 4s-HT: four-stranded semitendinosus graft, QT: quadriceps tendon graft

tunnel and a single horizontal tunnel through the tibial tuberosity followed by a direct suture of the PT stumps with an absorbable thread (Vicryl®, Ethicon, no. 3).

Finally, the superficial MCL was reinserted distally with two 2.9 mm soft anchors (JuggerKnot®, Zimmer Biomet).

The total operation time and tourniquet time was 119 minutes (320 mmHg).

Patient 2: As with patient 1, an anteromedial incision of approximately 15 cm was performed, which immediately revealed sight into the knee joint.

The ramp lesion of the medial meniscus was addressed with three vertical inside-out sutures, and the lateral radial tear was addressed with one horizontal inside-out suture (both FibreWire 2.0).

After harvesting a quadriceps tendon graft without a bone block (10 mm width x 5 mm depth x 70 mm length; Quad cut® Karl Storz, Tuttlingen, Germany), an arthroscopically assisted open ACL reconstruction and open patellar tendon repair were performed in identical manners to those performed on patient 1 (Figure 1 and 2).

Finally, the meniscofemoral ligament was reattached to the medial meniscus, and the superficial layer of the MCL was distally reinserted with two 2.9 mm soft anchors (JuggerKnot®, Zimmer Biomet) (Figure 3).

This patient also had a concomitant ipsilateral ankle fracture, which was subsequently treated in the same session by open reduction and fibular plating (Distal Fibula Plating System®, Zimmer Biomet).

The operating time (for both the knee and the ankle procedures) was 211 minutes, and the tourniquet time was 119 minutes (320 mmHg).

Patient 3: As with patients 1 and 2, an anteromedial incision was performed, which revealed a subtotal rupture of the patellar tendon. Then, the preparation of the distally avulsed medial collateral ligament followed. Both injuries had not yet been addressed. After harvesting an ipsilateral semitendinosus graft (4-stranded, femoral tunnel with a diameter of 8 mm, tibial tunnel with a diameter of 8.5 mm), arthroscopy was initiated without significant extravasation of intra-articular fluid. The lateral vertical meniscal tear was addressed with two vertical all-inside sutures (Fast-Fix®, Smith & Nephew) behind the hiatus popliteus and one inside-out suture in front of the hiatus. The longitudinal tear of the medial meniscus was addressed with two all-inside sutures (Fast-Fix®, Smith & Nephew) posteriorly and one inside-out suture in the pars intermedia.

Figure 1 Patient 2: "Open" ACL reconstruction using a soft tissue quadriceps tendon autograft. Extracortical graft fixation with a flip button.

Figure 2 Patient 2: A no. 5 FiberWire suture (Arthrex®) is looped through a transverse drill hole in the patella and a transverse drill hole through the tibial tuberosity.

Figure 3 Patient 2: Distal reinsertion of the superficial layer of the MCL with two 2.9 mm soft anchors (JuggerKnot®, Zimmer Biomet) at its distal avulsion underneath the pes anserinus.

Then, an arthroscopic ACL reconstruction and open PT repair were performed in identical manners to those performed on patients 1 and 2.

Finally, the deep MCL was reinserted close to the joint line with two 2.9 mm soft anchors (JuggerKnot®, Zimmer Biomet), and the superficial layer of the MCL was reinserted with two 1.6 mm ultrahigh molecular weight polyethylene anchors (FiberTak®, Arthrex) distally.

The operation time was 113 minutes, and the tourniquet time was 108 minutes (320 mmHg).

Early postoperative rehabilitation protocol

Following wound dressing, a knee immobilizer with a knee cooling system was applied in the operating room. The immobilizer was replaced with a hinged knee brace on post-op day one, allowing full extension and limiting flexion to 60°. No postoperative complications occurred, and wound healing was uneventful in all patients.

The patients were mobilized with partial weight-bearing for 6 weeks. Flexion was restricted to 60° for weeks 1-3 and to 90° for weeks 4-6. From the first postoperative day, a straight leg raise with active knee extension and isometric quadriceps activation was permitted. Full weight-bearing was permitted after 6 weeks. The out-patient criteria-based rehabilitation program was similar for all 3 patients.

RESULTS (TABLES 2 AND 3)

All patients reached a good or excellent final range of motion (140-150°/0°/0°). Postoperative functional scores at the 6-month follow-up showed an average Lysholm score of 87 (range: 67-100) and a Tegner score of 8. At the 12-month follow-up, the average Lysholm score was 91.7 (range: 86-100), and the average Tegner score was 8. At 24-month follow-up, the average Lysholm score was 96.7 (range: 94-100) and the average Tegner score was 8. The clinical examination at 12 months revealed a negative Lachman test result and a negative pivot shift test result in all patients. Finally, all three athletes returned to a professional level of alpine skiing. The athletes returned to unrestricted snow training after an average of 11 months (8-13 months) and to competition after an average of 15.3 months (12-20 months). Patients described the feeling of a "normal knee" after an average of 7-13 months.

DISCUSSION

Injury mechanism

To our knowledge, no case report of a concomitant injury of the PT, ACL and MCL in professional alpine skiers has been published thus far. In a systematic review by Chucchi et al., it was found that 4 out of 24 patients sustained the injury while skiing. 17 out of 24 patients had a concomitant rupture of the MCL [1]. Five injury mechanisms have been reported in the literature: landing after jumping, pivoting with the knee nearly in full extension and the foot planted, putting direct force on the knee, undergoing a valgus/external rotation trauma, and decelerating with the planted foot [1]. In our 3 athletes, the injury mechanism consisted of a deeply flexed position combined with a sudden braking force from a snow bank, which most closely corresponds to the mechanism of decelerating with a planted foot.

Diagnosis

All of our athletes had a ruptured distal MCL and a meniscal tear (one lateral, two lateral and medial), emphasizing the current literature of Cucchi et al. [1]. In our opinion, a preoperative MR diagnosis is crucial to detect all associated injuries.

Surgical technique

To date, no consensus on the surgical algorithm for this combined injury exists. However, our results support the data by Cucchi et al. [1] that a one-stage surgery might be an adequate treatment. Especially in professional athletes, we favor a one-stage treatment due to an accelerated rehabilitation process and a faster return to sports. None of our athletes experienced complications, including arthrofibrosis. All athletes reached full range of motion and could return to professional sports.

Koukoulias et al. [14] reported that a ruptured medial retinaculum makes the arthroscopic procedure impossible due to fluid extravasation; therefore, a two-stage treatment is recommended unless intraarticular procedures are performed by open surgery. After reviewing the MR images of patient 1, we expected an intraoperative traumatic arthrotomy, but surprisingly, after the surgical approach to the patellar tendon and MCL, no fluid extravasation occurred during the arthroscopy, and the ACL reconstruction and meniscal repair could both be performed arthroscopically. On the other hand, in patients 2, the joint capsule was disrupted, and the joint was fully exposed after the skin incision, which made a standard arthroscopic procedure impossible. This phenomenon may not be visible on preoperative MR images. Therefore, the surgeon should always be prepared to perform open ACL surgery and meniscal repair with the necessary surgical skills. Nevertheless, the scope may be used without fluid, especially for meniscal repairs.

Patellar tendon repair

Different techniques have been described for PT repair. Some authors perform an end-to-end suture reinforced by a wire loop cerclage and recommend hardware removal after 4-12 months [1, 9, 14], while others perform a direct suture combined with a suture sling [7,13,15-18]. Two cases of auto- or allograft

Table 3: Return to skiing and competition.

Patient	Return to practice on snow (months postoperatively)	Return to full snow training (months postoperatively)	Return to competition (months postoperatively)	Feeling of a "normal knee" (months postoperatively)
1	7	8	12	7
2	8	12	14	12
3	8	13	14	13

augmentation are also described in the literature [5,6]. A review by Kasten et al. [19] compared two augmentation methods (wire cerclage *vs* PDS cord). They found no significant difference in outcome between the two techniques. We prefer reinforcement by suture sling because this method does not require metal removal, has sufficient stability and does not cause harvest site morbidity.

ACL reconstruction

The graft choice for ACL reconstruction must be made individually. While an ipsilateral bone-patellar tendon-bone graft is not a choice in this situation [2], ipsilateral hamstring tendon grafts or quadriceps tendon grafts are both possible. Several studies have shown that there is no difference in outcomes of quadriceps-tendon grafts and hamstring-tendon grafts in primary ACL reconstruction [20,21]. Nevertheless, a survey among 221 experienced arthroscopic surgeons (AGA instructors) found that the majority of the surgeons is still using hamstring grafts (83.5%) in athletes and only 12% quadriceps tendon grafts [22].

Functional outcome and return to sport

Although a concomitant rupture of the PT and ACL is a devastating injury, individuals are able to recover fully and return to professional skiing at the elite level.

Comparable data on professional skiing athletes only exist for isolated ACL reconstruction. Csapo et al. showed that after ACL reconstruction, elite alpine skiers returned to competition within one year after surgery [23]. On average, our athletes returned to competition after 15.3 months, which is well explained by the severity of the injury.

Haida et al. recently reported that professional French alpine skiers between 1980 and 2013 even showed a higher mean performance level after an ACL rupture than before a rupture and that all skiers continued their career at a competitive level [24]. On the other hand, the incidence of a return to competitive sports one year after surgery varies between 33-92% in the literature [25-29]. Published Lysholm scores after isolated ACL reconstruction vary from 70.7 to 95.0 for quadriceps tendon grafts [30] and from 80 to 94 for hamstring tendon grafts [31-36]. These results are comparable with our data (Lysholm score of 87 after 6 months and 91.7 after 12 months). Nevertheless, different operation techniques and rehabilitation protocols hamper a direct comparison among these studies.

CONCLUSION

In summary, all three patients were able to return to competitive alpine skiing on a professional level after a combined lesion of the PT, ACL and MCL. This rare injury frequently occurs with meniscal tears. It is frequently associated with capsule disruption, making a strictly arthroscopic procedure impossible. It has been shown that a single-stage procedure is safe and effective, but it requires advanced skills of both arthroscopic and open surgical techniques.

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