



## Isolated femoral avulsion of the popliteus tendon: a systematic review of the literature

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**The popliteus tendon is an important part of the posterolateral corner of the knee. Isolated injuries to the posterolateral corner are very rare, as most injuries occur in multiligamentous knee trauma. Purely isolated popliteus tendon injuries are even more rare. There is very little evidence for treatment of isolated popliteus tendon avulsion injuries. The aim of this systematic review is to report on all publications regarding isolated popliteus tendon avulsion injuries and hopefully provide some guidance for future treatment algorithms. A systematic review of the literature was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Studies were included if they documented isolated popliteus tendon avulsion injuries. Exclusion criteria were studies with popliteus injuries in combination with other knee ligamentous injuries and popliteus tendon injuries other than femoral avulsion injuries. Twenty-eight studies were included which mentioned in total 38 patients with isolated popliteus tendon avulsion injuries. 24 patients (63%) were treated operatively. 3 (8%) patients were diagnosed arthroscopically but did not receive any surgical treatment. 9 patients (24%) were treated conservatively. In two publications, there was no mention of treatment. We found no clear recommendations in the literature for treatment of this rare injury.**

**Keywords:** popliteus tendon, avulsion, posterolateral corner.

### INTRODUCTION

The three main structures of the posterolateral corner are the fibular (lateral) collateral ligament (LCL), the popliteus tendon (PT) and the popliteofibular ligament (PFL). Isolated injuries to the posterolateral corner are very rare, as most injuries occur in multiligamentous knee trauma<sup>1-4</sup>. Only 12% of all posterolateral corner injuries are purely isolated injuries<sup>5</sup>. Purely isolated popliteus tendon injuries are even more rare, with only 10% of popliteus tendon injuries being reported as isolated. There remains large heterogeneity in high level evidence guiding treatment algorithms for posterolateral corner injuries<sup>6</sup>. There is even less evidence for treatment of isolated popliteus tendon avulsion injuries. The aim of this systematic review is to report on all publications regarding isolated popliteus tendon avulsion injuries and hopefully provide some guidance for future treatment algorithms.

### MATERIAL AND METHODS

A systematic review of the literature was performed according to the Preferred Reporting Items for System-

atic Reviews and Meta-Analyses (PRISMA). The study was registered with the PROSPERO database (ID: 383945). Two reviewers (S.H and P.D) independently searched the PubMed and OVID databases for articles concerning isolated popliteus tendon injuries. The following search terms were used with a variation of combinations of these term: “popliteus” AND “popliteal” AND “posterolateral” AND “avulsion” AND “fracture” AND “rupture” AND “pediatric” AND “injury” AND “tear”. Language of the study, age of the patients and mechanism of injury were not exclusion criteria. Studies were included if they documented isolated popliteus tendon avulsion injuries. Exclusion criteria were studies with popliteus injuries in combination with other knee ligamentous injuries and popliteus tendon injuries other than femoral avulsion injuries. All types of studies were included from case reports to reviews. Initially 85 studies were evaluated and after screening for duplicates (n=28) and after implementing the exclusion criteria, 28 studies were included in this review. These articles were reviewed for number of patients, age of the patients, mechanism of injury, presence of a bony fragment, clinical

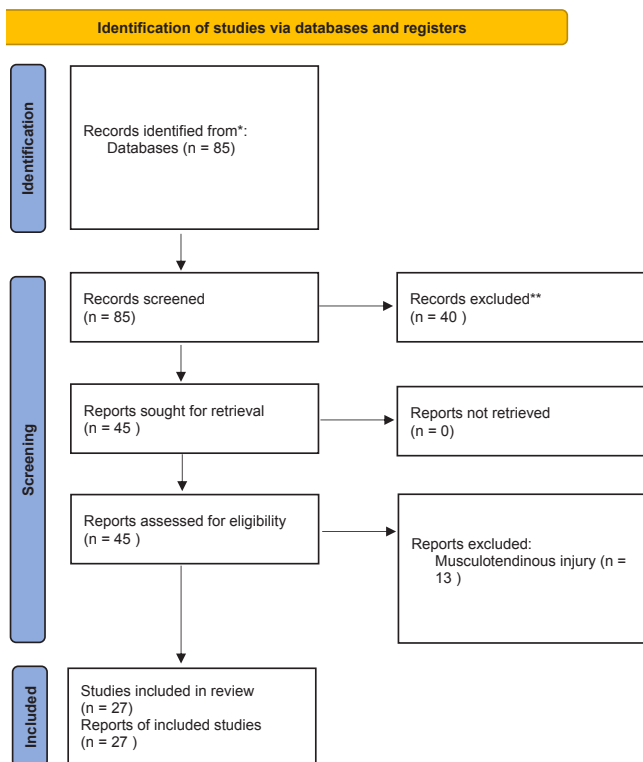


Figure 1. — Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of the current study.

examination, treatment, outcome and follow-up. The search process is depicted in Figure 1.

## RESULTS

In the 28 included studies a total of 38 patients were included. The mean age of the patients was 15.5 years old (range 11-74 years). Seven patients (18%) were female and 31 (81%) were male patients. The mean follow-up time was 7 months (range 2-216 months). In all but 8 patients, the cause of the injury was sports. Haemarthrosis was present in 32 (89%) of cases, but was not mentioned three times. Other symptoms mentioned included lateral knee pain, reduced range of motion and inability to bear weight. Interestingly, in only 4 cases (10%) there was instability on ligamentous testing of the posterolateral corner. Ligamentous testing was not mentioned in 2 cases. In 30 patients (79%) there was mention of a bony avulsion injury. 24 patients (63%) were treated operatively. 3 (8%) patients were diagnosed arthroscopically but did not receive any surgical treatment. 9 patients (24%) were treated conservatively. In two publications, there was no mention of treatment.

Some authors advise operative repair of isolated popliteus tendon avulsions without further mentioning

instability or presence of a fragment<sup>7-16</sup>. Others advise conservative treatment if no instability is present<sup>7-19</sup>. One authors clearly states that in absence of instability, conservative treatment is an option but repeat clinical examination is a must<sup>20</sup>. Only one author suggests performing a computed tomography scan in patients to better delineate the fragment and investigate the amount of displacement<sup>21</sup>. Annear et al. are the first to publish a treatment algorithm for isolated popliteus tendon avulsions<sup>22</sup>. They propose a conservative treatment with a long knee brace and early weight bearing and range of motion exercises for 3 months with delayed repair if this fails after 3 months. In this algorithm they do not include a difference between a bony avulsion or a pure tendinous avulsion, nor do they include findings of a clinical examination.

There were no complications mentioned in the operative group in any study. In the nonoperative group, there were two complications: a valgus deformity and a nonunion of a bony fragment which had to be excised.

In the following section we discuss the different reports of patients with an isolated popliteus tendon avulsion. Table I provides an overview of the studies included in this review.

As early as 1985 Naver et al. report on a 20 year old male athlete who sustained a popliteus tendon avulsion injury diagnosed during arthroscopy as a completely avulsed popliteus tendon which had already retracted and a chondral fracture of the lateral femoral condyl at the level of the popliteus tendon insertion<sup>23</sup>. The chondral fracture was resected via open manner and the retracted popliteus tendon was left unreconstructed and unrepaired. The patient returned to normal activities.

In 1988 Rose et al. describe a case of a 23 year old man sustaining an isolated popliteus femoral avulsion injury while pushing a car<sup>24</sup>. There was significant haemarthrosis. The popliteus tendon was repaired via an open approach. There was no osteochondral fragment. The patient rehabilitated well.

Gruel et al. report on two cases of popliteus tendon avulsions<sup>25</sup>. Both cases were in teenage athletes and in both cases there was significant hemarthrosis and a chondral fracture. No attempt at repair was made. The patients did well.

Burstein et al. present a case of a 24 year old male athlete who sustained a popliteus avulsion injury during a football game<sup>26</sup>. There was significant haemarthrosis. An MRI revealed severe oedema in the popliteus muscle belly, but could not convincingly show a tendon avulsion. The diagnosis was made during arthroscopy and the treatment was conservative. There was no osteochondral fragment. The patient recovered well.

**Table I.** — Overview of the studies included in this systematic review.

Author (year)	Cases	M/F (age)	OCF	Swelling	Sports	Surgery	Instability	FU (months)
Naver et al. ('85)	1	M (20)	+	+	Football	Dx Arthro	-	?
Rose et al. ('86)	1	M (23)	-	+	Pushing a car	Repair	+	12
Gruel et al. ('90)	2	M (16) F (15)	+	+	Skiing Football	Fragment removal	-	30
Burstein et al. ('90)	1	M (24)	-	+	Football	Dx Arthro	-	3
McConkey ('91)	1	F (13)	+	+	Fall from height	Repair	-	7
Mirkoupoulos ('91)	1	M (11)	+	+	Basketball	Repair	-	48
Garth et al. ('92)	2	2M (12&14)	+	+	Football Wrestling	Repair	-	20
Westrich et al. ('95)	1	F (21)	-	Not mentioned	Car accident	Repair	-	7
Nakhostine et al. ('95)	4	3M 1F (mean 17)	+	+	Rugby Iceskating Waterskiing	Repair	-	35
Llipos-Miro et al. ('99)	1	M (24)	-	+	Car accident	Repair	+	6
Guha et al. ('03)	1	M (23)	-	+	Football	Dx Arthro	-	12
Murray et al. ('04)	1	F (74)	-	-	No trauma	Debride	-	3
Wheeler et al. ('08)	4	4M (13-14)	+	+	Football Rugby Car accident	Nonop	-	2
Sileo et al. ('09)	1	M (15)	-	+	Football	Repair	-	6
Mariani et al. ('09)	1	M (31)	-	-	Football	Repair	-	2
Vu et al. ('09)	1	M (13)	+	Not mentioned	Football	No mention	No mention	No mention
Von Heideken et al. ('11)	1	M (12)	+	+	Skiing	Repair	+	44
Thapa et al. ('12)	1	M (12)	+	+	Football	No mention	No mention	No mention
McKay et al. ('14)	2	2M (12)	+	+	Dodgeball Dirt bike	Nonop	+	24 6
Avery et al. ('12)	1	M (13)	+	+	Football	Nonop	-	18
Chheda et al. ('15)	3	2M (18&30) 1F (16)	+	+	Manhunt No trauma Walking	Nonop Repair Excision	-	6,5 No mention
Liu et al. ('16)	2	M (16) F (11)	+	+	Football Sledding	Repair	-	3
Algazwi et al. ('19)	1	M (16)	+	+	Soccer	Nonop	-	3
Koukoulis et al. ('20)	1	M (12)	-	+	Soccer	Repair	-	24
Blackwell et al. ('22)	1	M (31)	+	Not mentioned	Lacrosse	Excision	-	216
Pengas et al. ('22)	1	M (14)	+	+	Soccer	Repair	-	60

M, male; F, female; OCF, osteochondral fragment; FU, follow-up; Dx Arthro, diagnostic arthroscopy; nonop, non operative treatment.

McConkey et al. describe for the first time the association between a popliteus tendon avulsion injury and a small bony avulsion fracture seen on radiography of the knee<sup>7</sup>. The injury occurred in a 13 year old female and the avulsed fragment was fixed with two screws. There was minimal haemarthrosis. It is the first report in the literature which clearly states that in case of a bony avulsion near the lateral femoral condyl visible on radiography of the knee, open reduction and fixation of

the fragment is indicated to preserve popliteus tendon function and prevent impingement of the fragment in the lateral gutter.

Mirkopoulos et al. present a case of an 11 year old who injured his knee playing basketball<sup>8</sup>. He sustained a femorally avulsed popliteus tendon, with a small flake of bone visible on radiography of the knee. There was a mild effusion. The popliteus tendon was avulsed with a large osteochondral fragment which was fixed with a

screw and washer via an open approach. The authors advise fixation of this fragment.

Westrich et al. report on a 21 year old female who sustained an isolated popliteus tendon avulsion during a car accident<sup>27</sup>. The diagnosis was made with MRI and subsequent arthroscopy. The patient exhibited increased external rotation of the tibia during examination under anesthesia. The fragment was fixed with a small lateral approach.

Nakhostine et al. present 4 cases of isolated popliteus tendon avulsions<sup>9</sup>. All occurred in young patients (mean age 17) and during sports activities. The diagnosis was made arthroscopically in all cases and all patients were treated with open fixation of the osteochondral fragment. In none of the cases was there rotatory instability. The authors advise fixation of the osteochondral fragment to retain function of the popliteus tendon.

Llopis-Miro et al. report on a 24 year old man who sustained a popliteus tendon avulsion during a car accident<sup>10</sup>. A small flake of bone was visible on radiography of the knee, but on arthroscopy no osteochondral fragment was noted. The patient had an increase in external rotation of the tibia. The popliteus tendon was reattached and the authors suggest this approach versus a conservative approach.

Guha et al. present a 23 year old male who sustained a popliteus tendon avulsion during a football game. Clinical examination did not reveal an increase in external rotation. The diagnosis was suggested on MRI scan and confirmed during arthroscopy. There was no osteochondral fragment. The popliteus tendon was completely retracted and not visualised during arthroscopy. No attempt at repair was made and the patient recovered well.

Murray et al. describe a case of a 74 year old woman who sustained a spontaneous popliteus tendon rupture which was diagnosed during arthroscopy<sup>28</sup>. The avulsed tendon blocked extension of the knee and the proximal stump was resected to regain full extension.

Wheeler et al. describe 4 cases of adolescent patients who sustained an isolated popliteus tendon injuries during sporting events<sup>29</sup>. All cases demonstrated a small radiographic flake of bone. They were all treated conservatively and did well.

Sileo et al. present a case of a 15 year old male who injured his knee during a football game and sustained an isolated popliteus tendon injury<sup>30</sup>. Six months after his injury, conservative management had failed and he continued to complain of pain posterolaterally. Clinical examination 6 months after trauma did not reveal a positive dial test. Initial MRI did not reveal an avulsion injury, but repeat MRI 6 months later did. Operative

repair of the popliteus tendon was performed and the patient recovered well.

Mariani et al. describe a 31 year old male who sustained a partial intrasubstance tear popliteus tendon injury during a soccer game<sup>31</sup>. After 4 weeks the patient continued to complain of pain, but no instability was found during clinical examination. The diagnosis was made during arthroscopy and treatment consisted of open debridement. The patient recovered well.

Vu et al. report on a 13 year old boy who was diagnosed with a popliteus tendon avulsion on radiography (with a small flake of bone visible) and on MRI<sup>32</sup>. It was a football injury. There was no mention of clinical examination or treatment.

Von Heideken et al. published 6 cases of bony posterolateral corner injuries in adolescents<sup>11</sup>. In only one of these patients, the fracture involved only the popliteus tendon insertion. This patient exhibited an increased external rotation of the knee compared to the contralateral side. All patients, but one, were treated surgically. The conservatively treated patient later developed a growth disturbance due to growth plate disturbance. Due to this devastating complication, the authors dig deeper into the proximity of this fracture to the physal line. They classify this injury as a type 6 physal injury, with a risk of physal growth disturbance. They also mention that the risk of growth plate disturbance may be higher in case of involvement of the LCL femoral insertion, due to a closer proximity to the growth plate than the popliteus tendon femoral insertion.

Thapa et al. mention a case of a 12 year old boy with an osteochondral fracture visible near the lateral femoral condyl on radiograph and MRI, representing a popliteus tendon avulsion injury with an acute hemarthrosis<sup>33</sup>. They do not mention further clinical examination or treatment.

McKay et al. report on two cases of isolated popliteus tendon avulsions in 12 year old males, which occurred during sporting events<sup>17</sup>. In one case there was significant swelling of the knee, but not in the other case. Clinical examination showed stable knee exam and both radiography and MRI of the knee demonstrated an isolated popliteus tendon avulsion injury with osteochondral fragment. The authors carefully suggest that in absence of ligamentous instability, treatment may be conservative.

Avery et al. describe a 13 year old male who sustained a isolated bony popliteus tendon avulsion during a football game<sup>18</sup>. There was significant swelling of the knee, but the knee appeared stable on clinical examination. The authors clearly state that in isolated

popliteus tendon avulsions, operative treatment is not to be recommended because of potential perioperative complications.

Chheda et al. present three unusual case of popliteus tendon avulsions occurring in chronic osteochondral lesions of the posterolateral femoral condyl<sup>12</sup>. In all three cases ligamentous examination was normal and the fragment exhibited signs of an acute presentation of a chronic lesion. In one case the fragment was fixed, in the second case the fragment and lesion were treated conservatively and in the last case, the fragment was excised. They concluded that this fragment was caused by an unhealed osteochondritis dissecans and that minor trauma caused the partially healed fragment to become slightly unstable. The authors mention that in case of a viable fragment, repair may be advocated.

Liu et al. report two cases of isolated bony popliteus tendon avulsion injuries, visible on both radiography and MRI of the knee<sup>13</sup>. The first case was in an 11 year old female who injured her knee whilst sledding and the second case in a 16 year old male with an injury due to football. Both cases exhibited haemarthrosis but a negative dial test. They both had a larger osteochondral fragment and this was fixed with a mini-open arthrotomy and a suture anchor repair. The authors suggest an operative approach for these lesions to prevent potential long-term complications and instability.

While not truly presenting a case, Gilmer states that double row suture anchor repair of these lesions may be preferential to screw fixation as screw fixation in this region has the potential to penetrate the intercondylar notch<sup>14</sup>. He also states that repair may be beneficial over (late) reconstruction due to lower morbidity of the procedure.

Annear et al. are the first to publish a treatment algorithm for isolated popliteus tendon avulsions<sup>22</sup>. They propose a conservative treatment with a long knee brace and early weight bearing and range of motion exercises for 3 months with delayed repair if this fails after 3 months. In this algorithm they do not include a difference between a bony avulsion or a pure tendinous avulsion, nor do they include findings of a clinical examination.

Algazwi et al. present a 16 year old male who sustained an isolated popliteus tendon avulsion injury playing soccer<sup>19</sup>. The patient had a small flake of bone visible near the lateral femoral condyle. There is not mention of a clinical examination or haemarthrosis. The patient was treated conservatively and recovered well. The authors mention that these lesions can be treated conservatively when no signs of instability are present during clinical examination.

Koukoulis et al. publish a case of a 16 year old male who sustained an isolated popliteus tendon avulsion during a soccer match<sup>20</sup>. He presented with haemarthrosis and lateral knee pain. Initial clinical examination revealed no signs of instability, but follow up clinical examination showed a positive dial test. Subsequent MRI showed an isolated popliteus tendon avulsion without bony involvement. The popliteus tendon was reattached fully arthroscopically with a suture anchor and the patient recovered well. The authors conclude that repeat examination is necessary because initial investigation may reveal a stable knee due to guarding and haemarthrosis. They also conclude that in case of instability on examination, repair is necessary.

Arner et al. describe their technique for open popliteal tendon repair in isolated cases and advise repair for restoring anatomy and prevent future injury<sup>15</sup>.

Blackwell et al. report on a 31 year old male patient who 18 years prior sustained a bony isolated popliteus tendon avulsion injury of the left knee that was treated conservatively<sup>21</sup>. The patient exhibited signs of locking of the knee, with a mobile fragment near the lateral femoral condyl. The fragment was excised and the patient recovered well. The authors state that it is still unclear when operative management of isolated popliteus tendon avulsion injuries is indicated. They mention that a computed tomography (CT) scan may be indicated to better delineate the size and morphology of the fragment and the amount of displacement. If conservative management is advised, close follow up is necessary.

Pengas et al. describe a 14 year old male who sustained a bony avulsion of the popliteus tendon while playing soccer<sup>16</sup>. The knee showed considerable haemarthrosis, but was stable on examination. Under anesthesia, the knee showed a block to maximal flexion due to the bony fragment. The fragment was fixed with anchors and the patient recovered well. The authors conclude that early surgical repair of these injuries may lead to a more predictable outcome and conservative treatment may risk future instability, altered knee kinematics and the risk of growth disturbance.

Garth et al. describe two cases of a bony avulsion of the popliteus tendon<sup>34</sup>. One case was in a 12 year old male who sustained the injury during a football match and the other in a 14 year old male who injured himself during a wrestling match. In both cases there was no instability, but severe haemarthrosis. In both case the fragment was fixed.

The following publications were not included in the study as they did not meet the inclusion criteria but are

worth mentioning. Bowditch et al. and Geissler et al. both publish cases of isolated popliteus muscle injury with posterior tibial nerve impairment<sup>35,36</sup>. Quinlan et al. also report a musculotendinous injury of the popliteus muscle<sup>37</sup>. Salzler et al. describe an arthroscopic repair of an avulsed popliteus tendon, but in a multiligamentous injury case<sup>38</sup>. Koong et al. publish a case report of a musculotendinous injury of the popliteus tendon which was treated conservatively<sup>39</sup>. Kramer et al. do not present a study on isolated popliteus tendon injuries, but investigate pediatric patients with isolated collateral (medial and lateral) ligament injuries<sup>40</sup>. In three of these patients there was a combination of a lateral collateral ligament tear and a popliteus tendon tear. One patient was treated surgically and the other two conservatively. All patients recovered well. Newcomb et al. present a case of a 14 year old female who sustained a musculotendinous injury of the popliteus tendon who recovered well with conservative treatment<sup>41</sup>. Kovack et al. present a case of a periosteal avulsion of the femoral side of the posterolateral corner of the knee in an adolescent patient, but it involved also the femoral insertion of the LCL<sup>42</sup>. The fragment was fixed with a screw and washer. Jae Yo Hoo et al. present a case of a small radiographic flake of bone near the lateral femoral epicondyl in 55 year old man, which turned out to be an avulsion fracture of both the popliteus tendon and LCL in a multiligamentous case<sup>43</sup>. It is the first case in the literature describing this type of injury, but was not included in our review because it was not an isolated popliteus tendon injury.

## DISCUSSION

This systematic review on isolated popliteus tendon avulsion injuries confirms that no clear consensus regarding treatment of this injury exists. Ligamentous instability during clinical examination is rare in these injuries, however few studies have a long follow-up (mean follow-up 7 months) and progressive instability may be an issue in these injuries. Some authors advise operative repair of isolated popliteus tendon avulsions without further mentioning instability or presence of a fragment<sup>7-16</sup>. Others advise conservative treatment if no instability is present<sup>17-19</sup>. One authors clearly states that in absence of instability, conservative treatment is an option but repeat clinical examination is a must<sup>20</sup>. Only one author suggests performing a computed tomography scan in patients to better delineate the fragment and investigate the amount of displacement<sup>21</sup>. Annear et al. are the first to publish a treatment algorithm for isolated popliteus tendon

avulsions<sup>22</sup>. They propose a conservative treatment with a long knee brace and early weight bearing and range of motion exercises for 3 months with delayed repair if this fails after 3 months. In this algorithm they do not include a difference between a bony avulsion or a pure tendinous avulsion, nor do they include findings of a clinical examination. There were no complications mentioned in the operative group in any study. In the nonoperative group, there were two complications: a valgus deformity and a nonunion of a bony fragment which had to be excised.

The popliteus tendon is a component of the posterolateral corner of the knee. Isolated injuries to the posterolateral corner are very rare, as most injuries occur in multiligamentous knee trauma<sup>1-4</sup>. Only 12% of all posterolateral corner injuries are purely isolated injuries<sup>5</sup>. Isolated popliteus tendon avulsion injuries are even more rare. One of the functions of the popliteus tendon is to act as a stabiliser for external rotation of the knee and as a secondary stabiliser to varus stress<sup>44</sup>. Sectioning of the popliteus tendon in human cadavers, causes a significant increase in external rotation and reconstruction of the popliteus tendon does reduce again this increase<sup>44</sup>. Avulsion injuries of the popliteus tendon may occur as a result of hyperextension of the knee with either a varus force or a tibial external rotation force to the knee<sup>22</sup>. Diagnosis of isolated popliteus tendon injuries is not always easy. Some authors report an accuracy of MRI imaging of the popliteus femoral tendinous insertion of 90%<sup>45</sup>. Others have found a sensitivity of only 82% and also a limited sensitivity of the dial test<sup>46</sup>. In case of a displaced osteochondral lesion, diagnosis can be easily made during arthroscopy, but in case of a tendinous avulsion injury the diagnosis is not always so easy<sup>46</sup>. Feng et al. found that in 48 patients of femoral peel-off lesions of the posterolateral corner, 21% had an isolated popliteus tendon peel off<sup>46</sup>. In this type of injury, sensitivity of both MRI and clinical examination was lowest compared to combined injuries with an LCL peel-off.

There remains large heterogeneity in high level evidence guiding treatment algorithms for posterolateral corner injuries<sup>6</sup>. There is even less evidence for treatment of isolated popliteus tendon avulsion injuries. In isolated low-grade combined posterolateral corner injuries, conservative treatment has been suggested. However treatment was usually based on the Hughston classification which only involved varus instability. The two main classification systems used to classify injuries to the PLC are the Hughston classification<sup>47</sup> and the classification proposed by Fanelli and Larson<sup>48</sup>. Isolated injuries to the popliteus tendon complex (with

an intact LCL) are classified as Fanelli type A injuries, but they are classified as an injury to both the popliteus tendon and the popliteofibular ligament. Most reviews conclude that isolated grade 1-2 injuries (Hughston classification) can be treated conservatively<sup>49-53</sup>. However regarding isolated Fanelli type A injuries with significant increase in external rotation of the knee, few recommendations can be found in the literature. In a sheep model, Scherer et al. investigated the effect of an isolated popliteus tendon injury<sup>54</sup>. Initially clinical examination was negative, but after one year there was an increase in posterolateral instability, suggesting stretching or loss of compensation of other posterolateral structures in the event of an absent/nonfunctional popliteus tendon. As mentioned by Zhang et al. an injury distal to the PFL at the musculotendinous junction of the popliteus tendon ensures still a working mechanism for the aruate complex/PFL<sup>55</sup>. A femoral avulsion of the popliteus tendon might reduce the ability of the PFL to resist external rotation of the knee due to a lack of tensioning effect of the popliteus tendon. Isolated lesions to the PFL do not lead to significant increase in external rotation, but isolated lesions to the popliteus tendon (femorally avulsed) do lead to increase in external rotation<sup>56</sup>. LaPrade et al. state that avulsion of the popliteus tendon off of the femoral insertion leads to laxity of the popliteomeniscal fascicles and the popliteofibular ligament<sup>57</sup>. Despite the obvious important role of the popliteus tendon, no clear algorithm in the literature was found for treatment of isolated popliteus tendon avulsion injuries.

In a recent expert consensus statement it was mentioned that a new classification is needed for PLC injuries including the structures that are injured and the type of injury (avulsion or midsubstance)<sup>58</sup>. Considerable controversy existed in this consensus statement regarding the role of conservative treatment in PLC injuries. The statement does mention that repair is only valid in bony avulsions and reconstruction in other cases.

In a recently proposed new classification, Weiler et al. propose cautiously that in isolated injuries to the popliteofibular complex, isolated reconstruction may be considered<sup>59</sup>. Bony avulsions are also included in their classification, but are not separately mentioned in their treatment protocol in these injuries.

Identifying the site of injury to the popliteus tendon as either a femoral avulsion or a musculotendinous injury is very important<sup>60</sup>. Musculotendinous popliteus injuries are far more common than avulsion injuries<sup>61,62</sup>. The location, the presence of an avulsed tendon with a bony fragment, the severity of the tendon retraction,

and related menisco-ligamentous injury are essential to select the mode of surgery. Some authors conclude that the presence of an osseous fragment is favourable for repair in contrast to pure tendinous injuries<sup>63</sup>.

Since this injury is rare, randomised controlled trials comparing operative versus conservative treatment will be difficult to pursue. We advise perhaps pursuing an expert consensus statement using the Delphi Consensus Method. We propose taking the following factors into consideration for a treatment protocol: presence of a bony fragment, amount of displacement of the fragment, instability on clinical examination, minimal follow-up time, need for CT scan.

## CONCLUSION

This is a systematic review of isolated popliteus tendon avulsion injuries. This injury is rare with only 38 confirmed cases in the literature. Though 63% of these patients were treated operatively, there is no clear consensus in the literature regarding treatment. Some authors advise conservative treatment, while others recommend operative treatment. We advise perhaps pursuing an expert consensus statement using the Delphi Consensus Method. We propose taking the following factors into consideration for a treatment protocol: presence of a bony fragment, amount of displacement of the fragment, instability on clinical examination, minimal follow-up time and need for a computed tomography scan.

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