



# Retrograde fixation of the lesser trochanter in the adolescent: new surgical technique and clinical results of two cases

A. Otto<sup>1,2</sup> · I. J. Banke<sup>3</sup> · J. Mehl<sup>1,2</sup> · K. Beitzel<sup>1</sup> · A. B. Imhoff<sup>1</sup> · B. Scheiderer<sup>1</sup>

Received: 17 July 2018 / Published online: 10 December 2018  
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## Abstract

**Introduction** Avulsions of the lesser femoral trochanter are rare injuries in the adolescent population. An acute avulsion causes severe functional impairment with compromised hip flexion. Recent literature reports the superiority of surgical treatment for apophyseal avulsion fractures of the pelvis in adolescents. Unfortunately, there are no guidelines for an evidence-based treatment of lesser trochanter avulsions established. We present the cases of two adolescent athletes treated operatively.

**Materials and methods** Two adolescent males, 12 and 16 years old, suffered an avulsion of the lesser trochanter during soccer. They reported immobilizing groin pain with subjective impairment in daily activities and inability to perform sports. Surgical treatment with a new retrograde technique by applying an adapted mini-open anterior approach was performed. Intraoperatively, both cases showed an intact musculo-tendinous unit attached to the avulsed fragment.

**Results** Both patients showed excellent postoperative results and were satisfied with the clinical outcome. In the postoperative follow-up an adequate consolidation of the lesser trochanter was visible. No complications were postoperatively reported at final follow-up.

**Conclusions** The retrograde fixation technique has led to an excellent outcome without complications in two adolescents with acute lesser trochanter apophyseal avulsions. Further clinical use may support the value of this new surgical technique.

**Keywords** Lesser trochanter avulsion · Pelvis · Hip · Adolescent · Apophyseal avulsion fracture · Retrograde fixation technique

✉ A. Otto  
alexander.otto@tum.de

I. J. Banke  
ingo.banke@mri.tum.de

J. Mehl  
julian.mehl@tum.de

K. Beitzel  
beitzelknut@tum.de

A. B. Imhoff  
imhof@tum.de

B. Scheiderer  
bastian.scheiderer@tum.de

<sup>1</sup> Department of Orthopaedic Sports Medicine, Klinikum rechts der Isar, Technical University of Munich, Munich, Germany

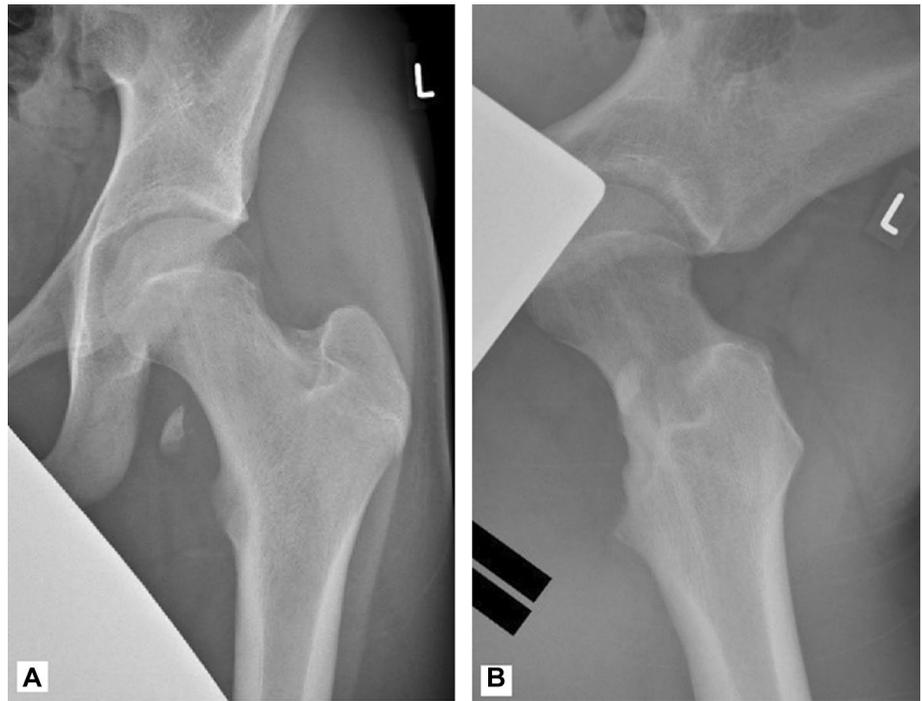
<sup>2</sup> Department of Orthopaedic Surgery, UConn Musculoskeletal Institute, University of Connecticut, Farmington, CT, USA

<sup>3</sup> Clinic of Orthopaedics and Sports Orthopaedics, Klinikum rechts der Isar, Technical University of Munich, Munich, Germany

## Introduction

Avulsions of the lesser femoral trochanter are rare injuries in the adolescent population, estimated only 1–2% of all apophyseal injuries of the pelvis [1, 17]. The second decade, around 14 ( $\pm 0.6$ ) years, has been reported as critical age for apophyseal avulsions of the lesser trochanter [1, 12, 17]. Up to 75% of the affected adolescents are male [1, 10, 12]. An acute complete avulsion of the minor trochanter causes severe functional impairment with compromised flexion of the hip [17]. For a standardized and evidence-based treatment, there are no guidelines in the literature established. Although, a recent review reports the superiority of operative treatment in adolescents with apophyseal avulsion fractures of the pelvis compared to conservative treatment [1]. An overall success rate of 88% with a return to sports of 80% after surgical intervention is described [1]. Furthermore, Willinger et al. recently published a new technique for surgical treatment of anterior superior iliac spine avulsions with an excellent outcome

**Fig. 1 a, b** Preoperative AP and axial hip radiographs of case #1: lesser trochanter avulsion with retraction (> 2 cm) to the level of the femoral neck



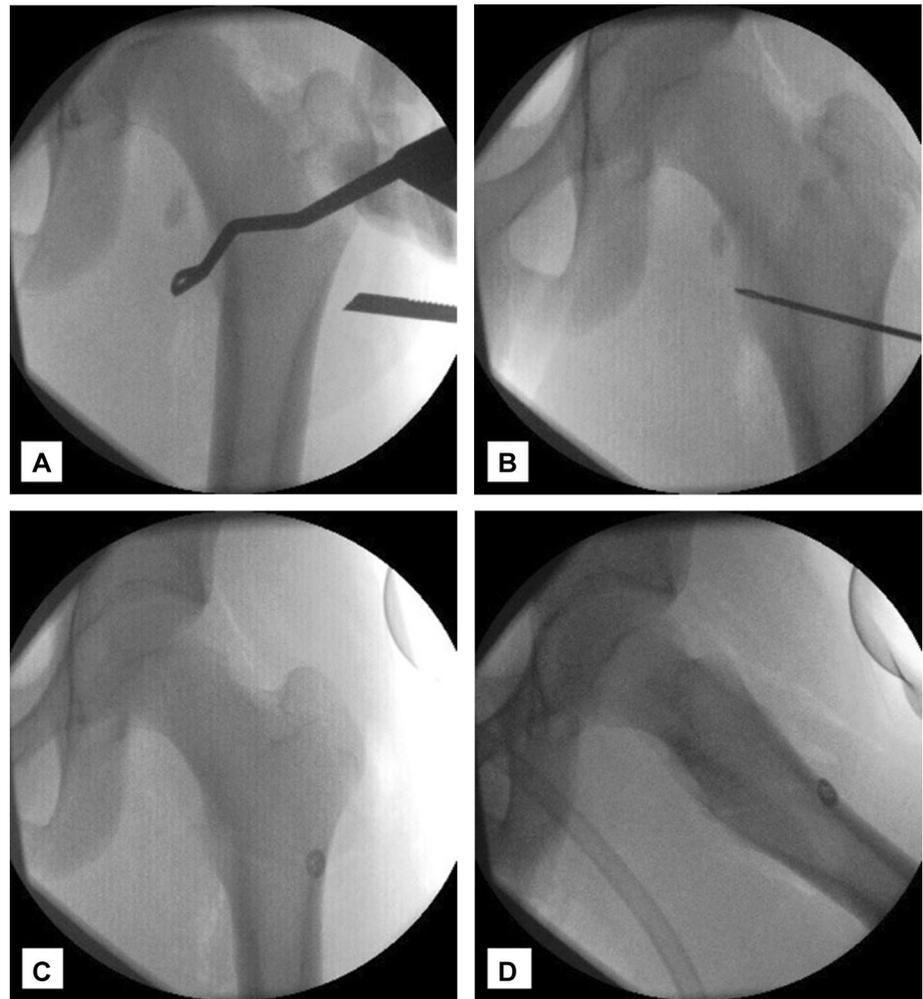
[16]. The reluctant position towards surgical treatment for lesser trochanter avulsions might be based on the difficulty to reduce the fragment safely through an anterograde fixation technique. The anatomical orientation as well as the proximity of the lesser trochanter to the femoral neurovascular structures makes surgical procedures extremely

challenging [13]. The anterograde reduction and screw fixation with the addition of a medial arthroscopic portal especially increases the risk of injury to the femoral neurovascular structures. Only a few operatively treated cases of lesser trochanter avulsion with different fixation techniques are documented [6]. Unfortunately, there is

**Fig. 2 a, b** Preoperative AP and axial hip radiographs of case #2: lesser trochanter avulsion with relevant retraction



**Fig. 3** a–d Intra-operative image converter documentation of case #1: **a** positioning aiming device; **b** drill placement in the centre of fracture bed; **c,d** fixed lesser trochanter using a Suture Button<sup>®</sup> in AP and axial view



no standardized surgical treatment for retracted avulsion injuries of the lesser trochanter. Open reduction and screw fixation is the most common surgical treatment for dislocated fractures. However, the applicability in avulsion cases is strongly limited due to fragment size. The objective of a successful surgical technique is stable reduction for consolidation with reconstitution of the iliopsoas muscle function and return to sports. Furthermore, excessive calcifications, as seen after conservative treatment, leading to impingement and preventable sequelae may be reduced [12].

Therefore, an innovative retrograde fixation technique with an adapted mini-open anterior approach was developed. The surgical principle of this reduction technique has already been successfully applied in the fixation of tibial eminence fractures with a trans-tibial suture cerclage [4]. This reliable operative technique uses an aiming device and non-dissolvable sutures held at the lateral femoral cortex by a metal button. Furthermore, this procedure allows a lateral exposure away from the femoral neurovascular structures and minimizes operative risks as well as invasiveness.

## Methods

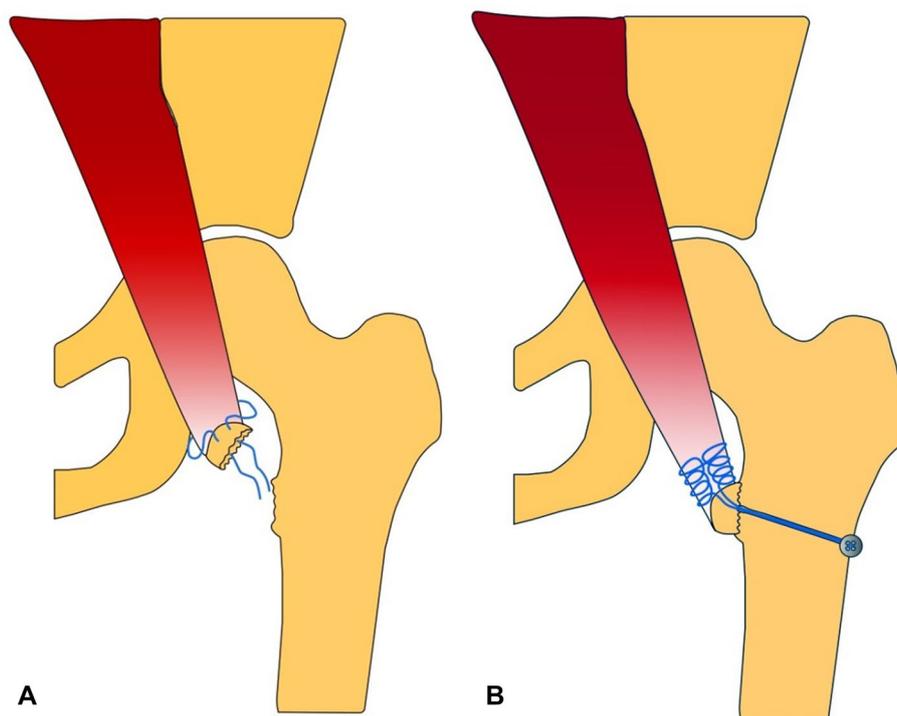
### Patients

Between May 2016 and May 2017 two patients reported to our outpatient clinic with an acute avulsion fracture of the minor trochanter. Both patients suffered this injury during soccer. They reported rushing groin pain instantly after kicking the ball. The operations were performed 20 and 23 days after the initial injury. Both patients underwent surgery in the same department with follow-up by the same investigator.

### Case #1

A 16-year-old male adolescent described immobilizing groin pain on the left side immediately after shooting during soccer. No prior injuries were noted leading up to aforementioned event. In the physical examination passive motion showed a physiologic range. Palpation below the left groin was painful. Active hip flexion strength was reduced to 4/5

**Fig. 4** **a** Schematic of a lesser trochanter avulsion (showing entwined trans-osseous Fibertape<sup>®</sup>-loop, only applied additionally in case #1); **b** scheme of a fixed lesser trochanter in case #1, using a Suture Button<sup>®</sup> (schemes illustrated with Adobe<sup>®</sup> Illustrator CC 2018, Version 22.0.1, Adobe Systems Incorporated, San Jose, CA/USA)



in comparison to the uninjured contralateral side. Radiographic imaging confirmed an avulsion of the left lesser trochanter with retraction of the bony fragment (Fig. 1). Due to the subjective impairment in daily activities (inability to climb stairs) and inability to perform sports in a young, active patient, we performed the subsequent procedure for minimally invasive reduction and fixation.

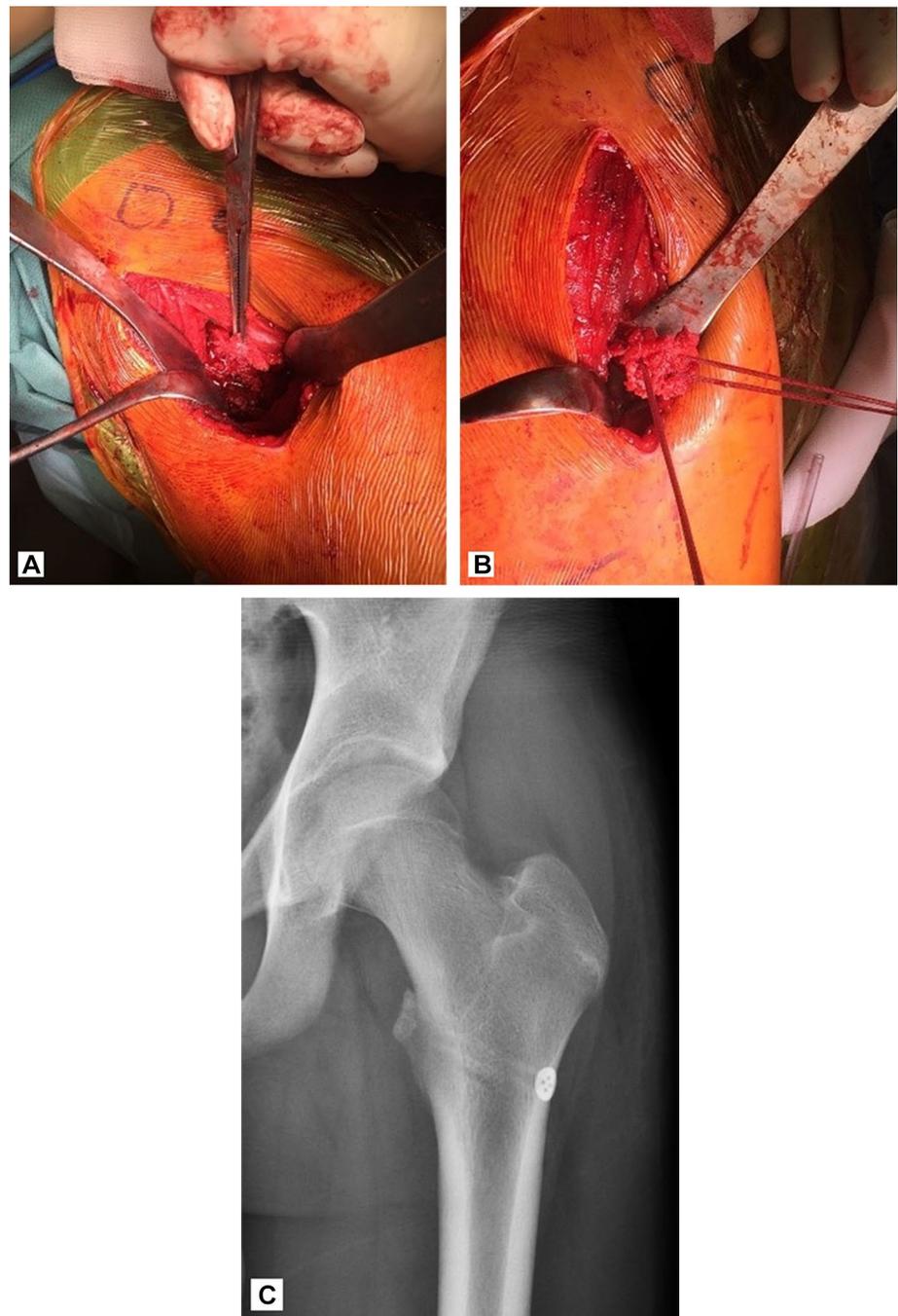
### Case #2

A 12-year-old boy depicted rushing groin pain on the right side after shooting during soccer. Four days prior to the above-mentioned event, he reported light groin pain on the ipsilateral side, but no prior injuries or adequate trauma was known. The passive range of motion was limited to a flexion of 90° with slightly reduced external and internal rotation due to pain. Palpation below the right groin triggered pain. Active hip flexion strength was painfully reduced 4/5 in comparison to the uninjured contralateral site. Radiographs confirmed an avulsion of the right lesser trochanter with a retracted bony fragment (Fig. 2). Due to the subjective impairment in daily activities (inability to climb stairs) and lost ability to perform sports in a young active patient with sporting demands, we recommended the subsequent procedure for minimally invasive reduction and fixation.

### Operative technique

The patient was placed in supine position and slight hip flexion to facilitate fragment reduction. A modified Smith-Peterson approach was utilized for exposure. Subcutaneous dissection to the fascia was performed under permanent protection of the lateral femoral cutaneous nerve. The Smith-Peterson interval was exposed through blunt dissection followed by retracting the tensor fasciae latae muscle laterally and the rectus femoris muscle medially. The medial retractor protected the femoral neurovascular structures in close proximity to the operation site. The ascending branch of the lateral femoral circumflex artery was identified and preserved. The lesser trochanter was further exposed until the fracture site was fully visible. After debridement of the fracture bed, the fragment was further mobilized through blunt scar tissue separation. In both cases the fracture fragment was anatomically reduced to the lesser trochanter and held in position without tension. For femoral drilling, an aiming device with an adjustable angle was used (Arthrex<sup>®</sup>, Naples, FL/USA). The entry point for the lateral approach to the lesser trochanter was determined by positioning the device with its tip in the centre of the fracture bed and aiming superiorly with 120° to the femoral shaft axis. A skin incision of 4 cm was followed by a split of the iliotibial tract in line with the fibres. The aiming device was readjusted and the drill guide was positioned against the lateral femoral cortex at an angle of 120° to the femoral shaft axis (Fig. 3a). The aiming device is designed with a stop at the desired target area, so injury to

**Fig. 5** **a** Mobilization of the lesser trochanter fragment in the Smith-Peterson interval in case #2; **b** trans-osseous augmentation of iliopsoas tendon in case #2; **c** postoperative AP radiography of case #1 showing adequate reduction



the femoral neurovascular structures is minimized. A cannulated 2.4-mm drill was positioned in the above-mentioned technique (Arthrex<sup>®</sup>, Naples, FL/USA) (Fig. 3b).

In case #1 the bony substance of the fragment had enough stability for trans-osseous placement of one #2 FiberWire<sup>®</sup> (Arthrex<sup>®</sup>, Naples, FL/USA) and one 2-mm FiberTape<sup>®</sup> (Arthrex<sup>®</sup>, Naples, FL/USA) (Fig. 4b). The Fibertape<sup>®</sup> entwined the tendon insertion near the bony fragment to compress it to the fragment bed (Fig. 4a). The FiberWire<sup>®</sup> augmented the iliopsoas tendon through four medial and

lateral locking stitches in a Krackow technique (Fig. 4b). The trans-osseus placed suture ends were shuttled to the lateral side of the femur. The lesser trochanter fragment was repositioned and through a four-hole titanium Suture Button<sup>®</sup> (Arthrex<sup>®</sup>, Naples, FL/USA) fixed against the lateral femoral cortex (Figs. 3a–d, 4b). A gap-free reduction of the former fragment was achieved (Fig. 3c, d).

In case #2 the bony substance of the fragment proved softer than the first case during trans-osseous placement of the sutures. Fixation was reinforced through tendon

**Table 1** Hip flexion strength (kg) measured in 0° flexion for the physiological side and the postoperative side (physiological side: phys., postoperative side: postop.; mean and standard deviation calculated with SPSS®, Version 25, IBM, New York, NY/USA) of case #1 and #2

	#1 phys.	#1 postop.	#2 phys.	#2 postop.
I	9.0	6.7	7.9	9.3
II	8.8	8.0	8.9	9.1
III	8.7	8.9	9.0	5.1
IV	9.1	9.6	6.8	6.7
V	8.6	8.0	6.9	6.8
Mean (standard deviation) (kg)	8.8 (±0.21)	8.2 (±1.09)	7.9 (±1.05)	7.4 (±1.78)

**Table 2** Hip flexion strength (kg) measured in 30° flexion for the physiological side and the postoperative side (physiological side: phys., postoperative side: postop.; mean and standard deviation calculated with SPSS®, Version 25, IBM, New York, NY/USA) of case #1 and #2

	#1 phys.	#1 postop.	#2 phys.	#2 postop.
I	10.8	11.7	5.9	8.2
II	10.7	10.4	7.1	7.8
III	11.0	9.4	7.1	6.7
IV	11.0	12.3	5.8	6.9
V	10.6	11.9	5.6	5.0
Mean (standard deviation) (kg)	10.8 (±0.18)	11.1 (±1.21)	6.3 (±0.74)	6.9 (±1.24)

augmentation with Fibertape® and appeared to be the safer approach since compression of the fragment during reduction and fixation might have led to a further fragmentation of the lesser trochanter (Fig. 5b). Two 2-mm Fibertape® were used for tendon augmentation in a locking Krackow-stitch technique as performed in case #1. The trans-osseous positioned tape ends were shuttled through the lateral side of the femur. A reduction of the fragment was performed and the fragment was fixed through the fracture bed using a Dog Bone Button® (Arthrex®, Naples, FL/USA) as abutment against the lateral femoral cortex. A gap-free reduction was accomplished (Fig. 5c).

### Postoperative protocol

For 6 weeks the patients were instructed to limit weight bearing to 20 kg and used a hip–knee hinged brace (Newport Easy®, ORMED GmbH®, Freiburg, Germany). The brace was set to limit flexion to 30°–90° with no possible ad-/

abduction or further extension. After 6 weeks the limitations were repealed.

### Evaluation

The postoperative evaluation included an open form regarding complaints during daily activities and sports as well as the Tegner Activity Score, Harris Hip Score and HOOS Score [2, 7, 14]. A comprehensive examination of the hip including muscle strength and iliopsoas function was performed. In comparison to the physiological contralateral hip, the flexion strength was measured with an isometric strength testing device. The ISOBEX® dynamometer (CURSOR AG, Bern, Switzerland) measures muscle force for 3 s (10 times per second) and determines the mean value. Diminishing the influence of other muscles, the testing was performed 5 times at the mid-thigh in 0° and 30° of hip flexion, while the patient was in supine position.

At follow-up standardized conventional radiography of the hip was conducted in AP and axial to evaluate consolidation of the lesser trochanter or postoperative calcifications.

### Results

In the postoperative course no adverse events such as meralgia paresthetica or lesser trochanter dislocation occurred. Case #1 was re-evaluated 13 months after the operation and the patient reported only minor complaints during sport activities without the need for pain medications. He currently was recovering from a fatigue fracture of the proximal, ipsilateral tibia after returning to sports 4 months after lesser trochanter repair. He intensified jogging from an average of 3 km per training session, 3 times per week to 5 km per session. Six months after operation a non-operative related stress fracture of the proximal tibia occurred. External physicians recommended limited weight bearing for 8 weeks and sport activities were restricted. At final follow-up, 13 months after surgery he was performing limited sport activities without jogging or running and reached a Tegner Score of 3. Concerning the hip, he stated a satisfactory postoperative course with pain reduction and recovery of muscle strength. A Harris Hip Score of 96 and a HOOS Score of 99.4 were determined at follow-up. A mean muscle strength of 8.2 kg in 0° hip flexion and 11.1 kg in 30° hip flexion were measured (Tables 1, 2). In comparison, the uninjured hip had no difference of more than 1 kg regarding muscle strength (Tables 1, 2). Adequate consolidation without any signs of calcification was observed in the follow-up radiography (Fig. 6a, b).

Case #2 was re-evaluated 6 months after surgery. He reported a satisfactory postoperative course with absence

**Fig. 6 a, b** Postoperative AP and axial hip radiographs 1 year after surgery of case #1



of pain or muscle deficiency. The postoperative rehabilitation was on the verge of transitioning to sport-specific training. He was able perform jogging and cycling once a week and reached a Tegner Score of 4. A Harris Hip Score of 100 and a HOOS Score of 95.0 were determined at follow-up. A mean muscle strength of 7.4 kg in 0° hip flexion and 6.9 kg in 30° hip flexion were measured (Tables 1, 2). In comparison, the uninjured hip had no difference of more than 1 kg regarding muscle strength (Tables 1, 2). Adequate consolidation without any signs of calcification was observed in the follow-up radiograph (Fig. 7a, b).

## Discussion

Our most important finding is that a safe and secure fixation of the lesser trochanter is accomplished through the introduced technique. No adverse events or intraoperative lesions to the femoral neurovascular structures occurred, despite their close proximity. Notably, the retrograde mini-open assisted fixation allows preservation of the neurovascular structures. Furthermore, a safer zone for surgery is created in comparison to the published anterograde fixation technique [6]. Excellent hip function was reported in the

subjective questionnaires postoperatively. The objective muscle strength measurements confirm an equivalent level in comparison to the uninjured contralateral side. No signs of relevant calcifications were observed in the postoperative radiographs. Our results are supported by a current review regarding apophyseal avulsion fractures of the pelvis in adolescence, reporting the superiority of surgery in comparison to conservative treatment with an overall success rate of 88% and a return to sports of 80% [1].

Due to the low patient number and our short, individual follow-up without a conservative control group, a further statistical analysis is not possible and our results are limited. However, the low patient number is reflecting the incidence of lesser trochanter apophyseal lesions [1, 17]. The different follow-up span is due to a delay of the postoperative control, since a strictly sports-related stress fracture of the proximal tibia occurred after a regular rehabilitation. Nevertheless, the collected data allow a comparison, since a reference to the physiological contralateral hip was possible. Furthermore, an objective tool with a high reliability and reproducibility was used for muscle strength evaluation [8].

No iatrogenic fractures of the femur were observed in the postoperative follow-up. We state the risk of such an event is low, since a minimally invasive technique, using a 2.4-mm

**Fig. 7 a, b** Postoperative AP and axial hip radiographs 1 year after surgery of case #2



drill was applied. This is supported by a current biomechanical study, which analysed the risk of fracture after drilling at or below the level of the lesser trochanter [15].

No lesions to the femoral neurovascular structures were observed during follow-up. In the arthroscopic approach by Khemka et al., a medial portal was essentially required [6]. An arthroscopic approach with a medial portal aimed at the fragment for anterograde fixation is, in our opinion, highly demanding and bears the risk of iatrogenic injury to the obturator, femoral neurovascular structures as well as medial femoral circumflex artery [5, 11]. This is due to the orientation and level of the lesser trochanter itself and the retraction of the fragment, forcing the surgeon to work outside the described arthroscopic “safe zone” or “triangle” [3, 4, 11, 13]. Since the lesion lies extra-articular, the capsule is needed to be incised during an arthroscopic approach [6]. Consequently, the capsular resistance is reduced and the procedure is mainly performed in soft tissue. This bears the risk of a compartment-syndrome due to the extruded arthroscopic fluid. A medial portal for hip arthroscopy might be applied by some surgeons in a standardized arthroscopy [5]. However, especially in the setting of a lesser trochanter avulsion we advise to not use this portal, though in general, arthroscopic approaches to hip pathologies are excellent techniques with low complication rates [9]. The indications

for hip arthroscopy may likely expand in the future as surgical technique and technologies continue to improve, but for lesser trochanter avulsion we do not recommend an arthroscopic approach due to aforementioned reasons.

## Conclusion

The retrograde fixation technique has led to an excellent outcome without complications in two adolescents with lesser trochanter apophyseal avulsions. Based on our clinic experience, this surgical treatment can be highly recommended for acute, retracted lesser trochanter avulsions in patients with relevant impairment of daily activities and sports. Further clinical use and a possible application in complex fractures including the lesser trochanter may support the value of this new surgical technique.

**Funding** There is no funding source concerning this study/report.

## Compliance with ethical standards

**Conflict of interest** I.J. Banke, K. Beitzel are consultants for Arthrex®. A.B. Imhoff is a consultant for Arthrex® and Arthrosurface®. Remaining authors confirm no conflict of interest concerning this study/report.

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