

# Arthroscopic Reduction and Fixation of a Lesser Trochanter Avulsion Nonunion



Alex G. Dukas, M.D., M.A., Taylor L. King, B.S., Temitope F. Adeyemi, M.P.H., and Travis G. Maak, M.D.

**Abstract:** Identifying and treating avulsion fractures of the pelvis and proximal femur in adolescent athletes has become increasingly more important as the rate of competitive sports participation has grown. The majority of these fractures can be treated conservatively, with most returning to full activity. Surgical treatment of these injuries has been traditionally indicated for >2 cm displacement, painful nonunion, symptomatic exostosis formation, or persistent pain and symptoms. Lesser trochanter avulsion injuries are extremely rare and literature outlining their surgical treatment lacking. We present our method of arthroscopic reduction and fixation of lesser trochanter avulsion nonunions.

As competitive sports participation increases in adolescent athletes, it is essential that orthopaedic surgeons identify and treat injuries about the pelvis and proximal femur appropriately. In the skeletally immature, the tendinous insertions about the pelvis and femur have a greater ability to resist tensile load than the apophysis, resulting in an avulsion fracture at this site when the tendinous insertion unit is overloaded by forceful muscle contraction.<sup>1-4</sup>

Acute lesser trochanter avulsions are relatively rare and typically treated with conservative measures consisting of nonsteroidal anti-inflammatories, rest, and a brief period of protected weight bearing, with gradual return to sport.<sup>3</sup> With this approach, the literature supports that the majority of patients have good outcomes and return to normal activity.<sup>5-11</sup>

However, there are reports of significant reduction in their sporting ability, chronic cramps, grinding

sensation, and hip stiffness.<sup>12,13</sup> Conservative treatment can result in sequelae such as nonunion, symptomatic heterotopic ossification, impingement, or painful pseudarthrosis.<sup>14</sup> A recent meta-analysis reported that complications of conservative management of pelvic avulsion fractures in skeletally immature can occur in 17% of cases.<sup>15</sup>

Although the large majority of these patients can be successfully treated conservatively, there are rare occurrences of painful pseudarthrosis and nonunion. In these uncommon circumstances, open treatment has significant associated morbidity. Arthroscopic techniques have the benefit of less morbidity, faster recovery, and greater patient satisfaction.<sup>16,17</sup> We present our technique for all-arthroscopic fixation of a symptomatic lesser trochanter avulsion nonunion.

## Presentation

In the acute setting, patients often report immediate onset of anteromedial thigh and groin pain with decreased function. As often with other pelvis apophyseal avulsion fractures, the patient is often engaged in a sporting activity such as gymnastics, football, or even ballet, which involves running, jumping, or cutting and results in a forceful and eccentric contraction to the hip.<sup>2,6,18</sup> They often are unable to continue in their event or sport acutely. The condition is more common in male athletes.<sup>8</sup> Pain and disfunction often causes an antalgic gait with ambulation.<sup>2</sup> Systematic reviews have shown the average age range is from 12 to 15 years and differential diagnosis should include slipped capital femoral epiphysis, Perthes disease, and acute hip septic arthritis. Appropriate measures to rule out these

From the Department of Orthopaedic Surgery, University of Utah Orthopaedic Center (A.G.D., T.F.A., T.G.M.) and School of Medicine (T.L.K.), University of Utah, Salt Lake City, Utah, U.S.A.

The authors report the following potential conflict of interest or source of funding: T.G.M. is a paid speaker for Arthrex, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received June 13, 2019; accepted August 12, 2019.

Address correspondence to Travis G. Maak, M.D., Associate Professor, Department of Orthopaedics, University of Utah Orthopaedic Center, 590 Wakara Way, Salt Lake City, UT 84108. E-mail: [travis.maak@hsc.utah.edu](mailto:travis.maak@hsc.utah.edu)

© 2019 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/19760

<https://doi.org/10.1016/j.eats.2019.08.002>



**Fig 1.** Anteroposterior radiograph demonstrating left hip lesser trochanter avulsion fracture.

diagnoses should be taken as necessary, based on clinical judgment.<sup>15</sup>

Acutely, findings of the physical examination will demonstrate tenderness to palpation over the lesser trochanter, groin pain with resisted hip flexion, and pain with passive hip extension. There may be objective weakness measured with hip flexion strength; however, it may be minimal.<sup>15</sup>

Imaging required is usually a standard series of anteroposterior (AP) pelvis, hip, and lateral images. In our office setting, the standard hip series includes AP



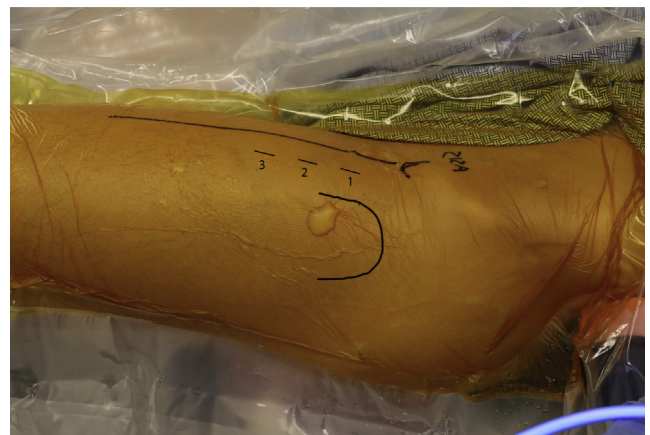
**Fig 2.** Injury magnetic resonance imaging T2 coronal sequence demonstrating lesser tuberosity fragment displaced superiorly.

pelvis, hip, modified Dunn lateral, and false profile. Often, the avulsion is apparent mostly on the AP radiograph (Fig 1). In patients who go on to having chronic pain or concern for nonunion and are indicated for possible surgical intervention, we prefer to obtain advanced imaging. Magnetic resonance imaging of the effected hip will provide a more detailed evaluation of displacement and also will enable the physician evaluate the position and integrity of the associated iliopsoas tendon (Fig 2). If there is a portion still attached to the femur, this may have to be released intraoperatively. Computed tomography is used to evaluate the bony detail further. We find computed tomography necessary to identify the extent of nonunion, and it is helpful in the setting of concerning nonunion after considerable nonoperative treatment.

### Indications

Treatment for most lesser trochanter avulsion fractures is largely supportive, with a period of rest and activity modification and with a rehabilitation that focuses on maintaining range of motion and beginning gentle strengthening at 2 to 3 months with the focus on return to play after 3 months.

Surgical treatment can be considered in those who do not respond to considerable treatment. In our practice, we continue conservative management for at least 6 months before pursuing more advanced workup for nonunion. Surgical consideration can be given to those who continue to have considerable pain and dysfunction for durations that exceed 6 months. Classic surgical indications of these injuries have been traditionally indicated for >2 cm displacement, painful nonunion, symptomatic exostosis formation, or persistent pain and symptoms.<sup>13,14,19,20</sup> However, more recent literature has retrospectively reviewed outcomes and have found



**Fig 3.** The patient is supine on a hip arthroscopy table without traction. Three portals are used—central, proximal, and distal. The central portal is the main viewing portal, whereas the proximal and distal are working portals.



**Fig 4.** Left hip, patient in supine position. Viewing from the central portal with a 70° arthroscope the first step is identification of the psoas tendon and bony fragment (\*). This is done by using a full radius 5.0 shaver to resect the psoas bursa.

that 2 cm of displacement may portend to a greater rate of painful nonunion or pseud arthrosis.<sup>15,21</sup>

### Technique

All work was performed at the University of Utah. The patient is positioned supine on a hip arthroscopy table with the foot in neutral rotation (Smith



**Fig 5.** Left hip, patient in supine position. Viewing from the central portal. A radiofrequency ablator is introduced through the distal portal and further used to dissect the fibrous nonunion and undersurface of the lesser trochanteric fragment (\*).

& Nephew, Andover, MA). Traction is not necessary; however, it is our preference to use an arthroscopy table, as it allows for full fluoroscopic evaluation of the surgical field (Video 1).

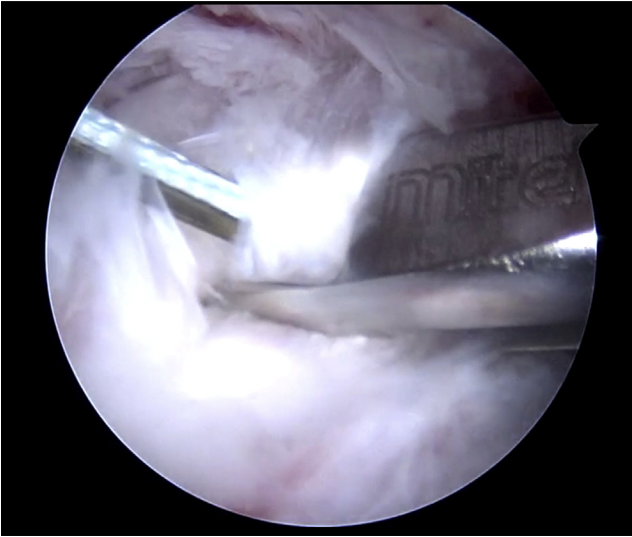
The mid-axial reference line is delineated, and the femoral neurovascular bundle is palpated to ensure the location is medial to the mid-axial reference line. Three portals are used: the central, proximal, and distal. The proximal portal is located similar to a standard mid-anterior portal (Portal 1 in Fig 3). The central and distal portals are positioned 4 cm and 8 cm distal to the proximal portal, respectively, all in parallel and 2 to 3 cm lateral to the mid-axial line (Portal 2 and 3 in Fig 3).

Using fluoroscopic guidance, the proximal portal is established using a spinal needle introduced and directed to the lesser trochanter. The portal is established using a blunt trochar using palpation and fluoroscopy to ensure placement in the correct position and trajectory. The arthroscope is then introduced and the lesser trochanter visualized. The central and distal portal is then established using a spinal needle followed by guidewire and blunt trochar under arthroscopic visualization. The arthroscope is then switched to the central portal, where it is maintained for the duration of the procedure while the proximal and distal portals are for instrumentation.

After establishment of all portals is confirmed, attention is turned to fully identifying the psoas tendon and lesser tuberosity fragment. A radiofrequency ablation wand and straight 5.0-mm dissecting shaver are used to delineate and resect psoas bursa to improve



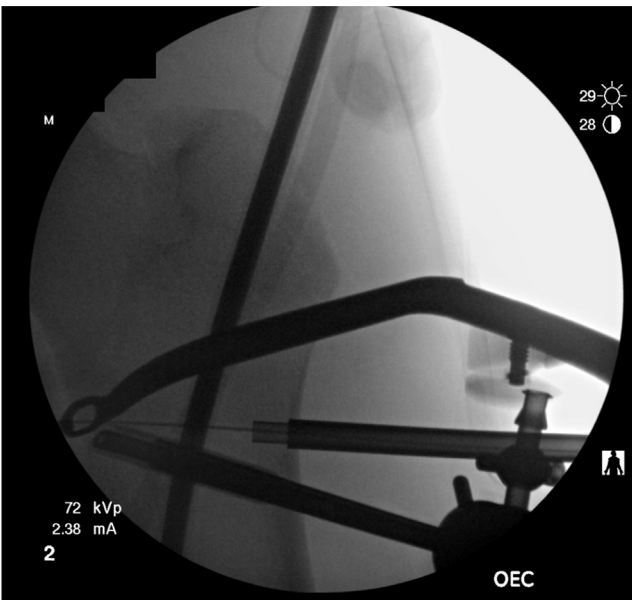
**Fig 6.** Central viewing portal, left hip, patient in supine position. An arthroscopic grasper is brought through the proximal portal, testing the mobility of the fragment to be reduced to the anatomic location. It should reduce down easily without significant tension.



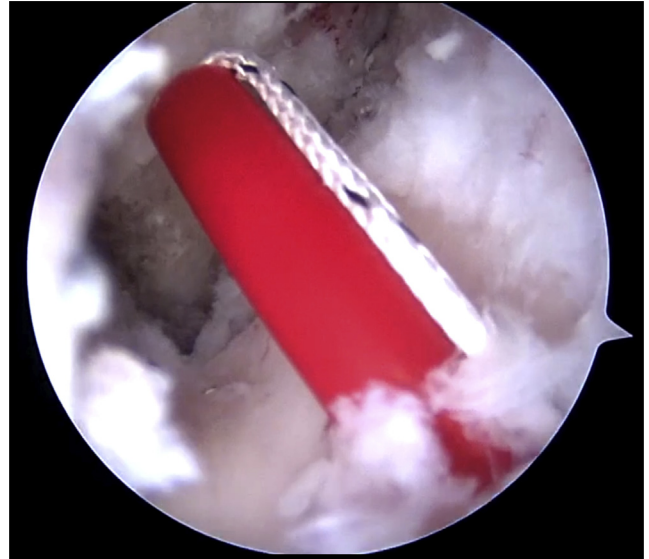
**Fig 7.** Central viewing portal, left hip, patient in supine position. A suture passer is used to place a luggage tag type suture in the tendon of the psoas tendon immediately proximal to the bony fragment. We find that two #2 high-strength sutures are adequate.

visualization (Figs 4 and 5). Carefully proximal dissection is performed until the distal aspect of the avulsion fragment is encountered.

The fragment and attached tendon are then further mobilized to allow reduction to the lesser trochanter without compromise of the tendinous attachment. An arthroscopic grasper is used through the distal portal to

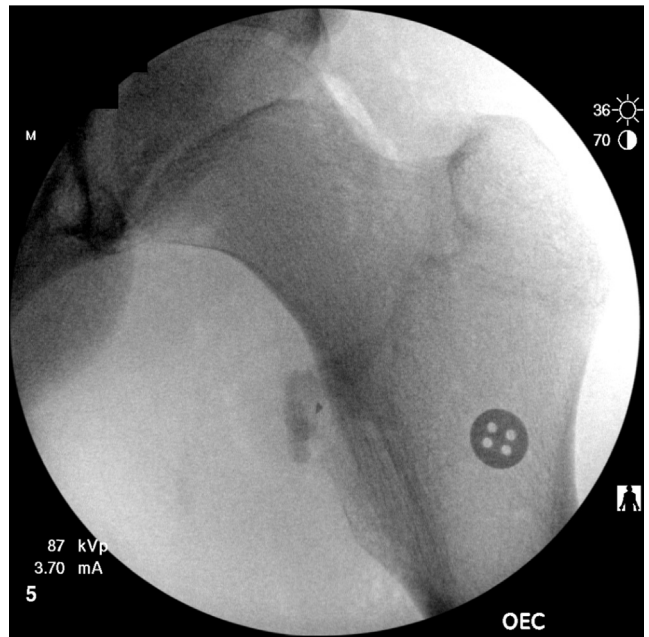


**Fig 8.** Central viewing portal, left hip, patient in supine position. An anterior cruciate ligament drill guide is placed through the proximal portal and guide cannula introduced through a stab incision laterally. Note the step design of the cannula, which is able to be malleted into the drill hole. This allows easy passage of a passing suture.



**Fig 9.** Left hip, patient in supine position. Endoscopic view from the central portal demonstrating placement of a suture passer through bed of nonunion site. These sutures are then used to shuttle the previously placed psoas tendon sutures out laterally to be tied over a button.

apply traction on the fragment and tendon to confirm adequate release and anatomic positioning to the lesser trochanter (Fig 6). A bone-cutting shaver was used to decorticate the non-union, lightly on the fragment while more aggressively on the lesser trochanter bed of the proximal femur. Care should be taken to avoid notching the surrounding cortex during debridement to minimize future fracture risk.



**Fig 10.** Left hip, patient in supine position. Fluoroscopic image of final fixation construct and anatomic reduction of lesser trochanter fragment.

**Table 1.** Classification of Avulsion Fractures of the Lesser Trochanter in Adolescents

Type	Avulsion Description	Treatment Recommendation
Type 1	Non-displaced	Nonoperative
Type 2	Displacement $\leq 2$ cm	Nonoperative
Type 3	Displacement $> 2$ cm	Nonoperative
Type 4	Symptomatic non-union or painful exostosis	Surgical intervention to be discussed

A disposable cannula is placed into the proximal portal (Trim-it Cannula; Arthrex Naples, FL) to allow ease of suture placement. Next, a self-retrieving suture passer (Scorpion; Arthrex) is used to pass two #2 high-strength sutures (FiberWire and TigerWire; Arthrex) in a luggage-tag configuration (Fig 7).

Focus is then directed on the creation of a transfemoral tunnel for transosseous fixation. The aiming arm of an anterior cruciate ligament femoral guide is introduced through the proximal portal over a sled to the distal aspect of the lesser trochanteric bed. A 3-cm incision directly lateral to the femur is then made. The iliotibial band is identified and longitudinally split with blunt dissection of the underlying vastus lateralis to the lateral cortex at a level directly lateral to the lesser trochanter. The anterior cruciate ligament drill guide sleeve is advanced to the lateral femoral cortex and a 2.4-mm drill advanced medially through the lateral cortex and into the previously prepared bed of the lesser trochanter under fluoroscopic and arthroscopic visualization. We find it beneficial to use a cannula that is designed to be malleted into the aforementioned drill hole and stay in place. This allows easy ability to feed a suture passer through the cannula without spending time to find the previously placed drill hole while retracting soft tissues (Fig 8). The guide pin sleeve is then gently malleted into the lateral femur to maintain the tunnel position and facilitate suture passage while the drill is removed (Arthrex).

A FiberStick (Arthrex) is then inserted through the sleeve and retrieved arthroscopically through the

proximal portal (Fig 9). This is used to pass the previously placed psoas tendon sutures through the transosseous tunnel to the lateral aspect of the femur. Once retrieved, placing tension on these sutures allows anatomic reduction of the fragment. Reduction is confirmed with direct arthroscopic and fluoroscopic visualization. The sutures are secured through a 4-hole titanium button placed on the lateral aspect of the femur (Fig 10). The iliotibial band incision and portal incisions are then repaired and closed according to the surgeon's preference.

## Rehabilitation

Following the procedure, follow-up occurs at 2, 6, 16, 24 weeks then 1 year postoperatively. Routine office radiographs are obtained at 6, 16, 24 weeks and the 1-year mark. Radiographic union is usually observed around the 16-week visit. Initially, patients are kept toe-touch weight bearing with crutches for 6 weeks. Formal physical therapy commences at 8 weeks. At the 3- to 4-month visit, patients are allowed to return to play and perform strenuous activities to tolerance.

## Discussion

Avulsion fractures of the lesser trochanter in the skeletally immature are exceedingly rare, representing  $< 1\%$  of hip injuries and 1.8% to 3% of all avulsion injuries to the hip and pelvis.<sup>1,15,19,22</sup> The mechanism of the injury in this age group, similar to other avulsion injuries, is result of forceful muscle contraction and occurs more commonly in male patients.<sup>8</sup>

McKinney et al.<sup>3</sup> presented a classification scheme for acute avulsions of the lesser trochanter with treatment recommendations of each type (Table 1). According to their classification scheme, avulsions  $> 2$  cm are treated with nonoperative therapy and only Type 4, symptomatic nonunions, are considered for operative fixation. Other reports in the literature argue for fixation of fragments  $> 2$  cm.<sup>21,23,24</sup> This has been supported by more recent studies showing that a displacement greater than 20 mm increases nonunion by 26 times.<sup>25</sup>

**Table 2.** Pearls and Pitfalls

### Pearls

- Ensure to place portals far enough apart to allow to easier triangulation.
- Take time to ensure fibrous tissue and bursa are fully resected, and define bony edges of the lesser trochanteric fragment aides in assessment of reduction.
- Place a suture proximal to bony fragment in the Psoas tendon aides in control of fragment.
- Use of an anterior cruciate ligament guide allows precise placement of the transfemoral drill hole.
- Use generous fluoroscopy during procedure to ensure fragment is reduced in proper position as well as lateral suture button in proper position on lateral femoral cortex.

### Pitfalls

- Avoid aggressive preparation of the lesser trochanter bed as overt notching of the femoral cortex in the subtrochanteric region may risk fracture.
- Avoid excessive pump pressures to curb extravasation into compartment and soft tissues.
- Allow partial or touch down weightbearing during initial 6 weeks as non-weight bearing may place tension on the repair site.

**Table 3.** Advantages/Disadvantages

## Advantages

- Arthroscopic fixation is minimally invasive and less morbid than traditional open procedures.

## Disadvantages

- Technically demanding procedure.
- Potential risks include damage to major neurovascular structures, heterotopic bone formation, loss of fixation, and persistence of symptoms.
- Arthroscopic lesser trochanter fixation is a procedure that is lacking long-term, evidence-based studies. Therefore, there may be long-term complications that have not yet been determined.

With the aforementioned condition being exceedingly rare, it is understandable that there is a paucity of literature with most articles describing case reports or small case series.<sup>2,18,26</sup> However, a recent systematic review and meta-analysis by Eberbach et al. details the largest collection of outcomes.<sup>15</sup> Their review of 14 publications and analysis of 596 patients challenges the treatment dogma for these injuries. Surprisingly, their findings advocate for operative intervention with decreased displacement threshold of 15 mm. They state the overall success is greater in the operative group, citing better function in high-demand activities and greater rates of return to sport. They also report complication rates of 17% in the conservative group and 19% for the operative group. Our patient's initial displacement of 18.5 mm would be indicated for primary fixation according to their recommendations. However, it could be argued the 15 mm they cite is based off of Ferlic et al.'s experience with ischial tuberosity fractures, and it may not be correct to extrapolate this to all other pelvic avulsion fractures such as lesser trochanter fractures.<sup>21</sup>

Recently, Khemka et al.<sup>12</sup> published their experience with treating displaced lesser trochanter avulsions with arthroscopically assisted fixation. Two of the patients presented with acute injuries and one in the chronic setting. All patients had displacement of >2 cm. Follow-up ranged from 12 to 36 months, with all patients demonstrating excellent healing, and the 2 acute patients were able to return to high-impact activities. One patient did have transient anterior femoral cutaneous nerve symptoms that resolved within 2 weeks of procedure.

Although Khemka et al. did make an argument that displaced avulsion fragments are concerning for nonunion, loss of strength secondary to muscle shortening, symptomatic malunion, or development of ischiofemoral impingement, this is not commonly found on review of the literature. In a recent retrospective study, Ruffing et al.<sup>8</sup> looked at lesser trochanter fractures in adolescents who presented to their Level I Trauma center over a 6-year period and found only 5 cases. All patients were treated conservatively and returned to high-level sports without any reported deficiencies. They did find that 1 patient had objective weakness but no subjective deficit.

Although we are not arguing for more aggressive treatment of lesser trochanteric avulsion fractures, there is a rather high incidence of complications resulting from nonoperative treatment of these fractures.<sup>15</sup> Addressing these complications surgically is not benign, and open surgical treatment carries a significant morbidity (Tables 2 and 3). Arthroscopic techniques afford minimal soft-tissue disruption and morbidity, all the while allowing the patient to recover faster. We feel it is valuable that the treating physician be aware of treatment strategies for such patients as we present an arthroscopic technique to successfully treat a nonunion of lesser trochanter.

## References

1. Dimon JH. Isolated fractures of the lesser trochanter of the femur. *Clin Orthop Relat Res* 1972;82:144-148.
2. Homma Y, Baba T, Ishii S, Matsumoto M, Kaneko K. Avulsion fracture of the lesser trochanter in a skeletally immature freestyle footballer. *J Pediatr Orthop B* 2015;24:304-307.
3. McKinney BL, Nelson C, Carrion W. Apophyseal avulsion fractures of the hip and pelvis. *Orthopedics* 2009;32:42.
4. Salter RB, Harris WR. JBJS Classics—injuries involving the epiphyseal plate. *J Bone Jt Surg* 1963;45:587-622.
5. Key JA, Conwell HE. *The management of fractures, dislocations and sprains*. St. Louis: Mosby, 1961.
6. Metzmaker JN, Pappas AM. Avulsion fractures of the pelvis. *Am J Sports Med* 1985;13:349-358.
7. Rossi F, Dragoni S. Acute avulsion fractures of the pelvis in adolescent competitive athletes: Prevalence, location and sports distribution of 203 cases collected. *Skeletal Radiol* 2001;30:127-131.
8. Ruffing T, Rückauer T, Bludau F, Hofmann A, Muhm M, Suda AJ. Avulsion fracture of the lesser trochanter in adolescents. *Injury* 2018;49:1278-1281.
9. Saluan PM, Weiker GG. Avulsion of the anterior inferior iliac spine. *Orthopedics* 1997;20:558-559.
10. Torode I, Zieg D. Pelvic fractures in children. *J Pediatr Orthop* 1985;5:76-84.
11. Papacostas NC, Bowe CT, Shaffer Strout TD. Lesser trochanter avulsion fracture. *J Emerg Med* 2013;45:256-257.
12. Khemka A, Raz G, Bosley B, Ludger G, Al Muderis M. Arthroscopically assisted fixation of the lesser trochanter fracture: A case series. *J Hip Preserv Surg* 2014;1:27-32.
13. Sundar M, Carty H. Avulsion fractures of the pelvis in children: A report of 32 fractures and their outcome. *Skelet Radiol* 1994;23:85-90.
14. Ganz R, Slongo T, Turchetto L, Massè A, Whitehead D, Leunig M. The lesser trochanter as a cause of hip

- impingement: Pathophysiology and treatment options. *HIP Int* 2013;23:S35-S41 (suppl 9).
15. Eberbach H, Hohloch L, Feucht MJ, Konstantinidis L, Südkamp NP, Zwingmann J. Operative versus conservative treatment of apophyseal avulsion fractures of the pelvis in the adolescents: A systematical review with meta-analysis of clinical outcome and return to sports. *BMC Musculoskelet Disord* 2017;18:162.
  16. Sauerbrey AM, Getz CL, Piancastelli M, Iannotti JP, Ramsey ML, Williams GR. Arthroscopic versus mini-open rotator cuff repair: A comparison of clinical outcome. *Arthroscopy* 2005;21:1415-1420.
  17. Youm T, Murray DH, Kubiak EN, Rokito AS, Zuckerman JD. Arthroscopic versus mini-open rotator cuff repair: A comparison of clinical outcomes and patient satisfaction. *J Shoulder Elbow Surg* 2005;14:455-459.
  18. Quarrier NF, Wightman AB. A ballet dancer with chronic hip pain due to a lesser trochanter bony avulsion: The challenge of a differential diagnosis. *J Orthop Sport Phys Ther* 1998;28:168-173.
  19. Rajasekhar C, Kumar KS, Bhamra MS. Avulsion fractures of the anterior inferior iliac spine: The case for surgical intervention. *Int Orthop* 2001;24:364-365.
  20. Vazquez E, Kim TY, Young TP. Avulsion fracture of the lesser trochanter: An unusual cause of hip pain in an adolescent. *CJEM* 2013;15:123-125.
  21. Ferlic PW, Sadoghi P, Singer G, Kraus T, Eberl R. Treatment for ischial tuberosity avulsion fractures in adolescent athletes. *Knee Surg Sport Traumatol Arthrosc* 2014;22:893-897.
  22. Theologis TN, Epps H, Latz K, Cole WG. Isolated fractures of the lesser trochanter in children. *Injury* 1997;28:363-364.
  23. Kassarian A, Martel-Villagrán J, Bueno-Horcajadas Á. Hip and Pelvis. In: Ribes R, Vilanova JC, eds. *Learning Musculoskeletal Imaging (Learning Imaging)*. Berlin, Heidelberg: Springer, 2010;157-178.
  24. Spencer-Gardner L, Bedi A, Stuart MJ, et al. Ischiofemoral impingement and hamstring dysfunction as a potential pain generator after ischial tuberosity apophyseal fracture non-union/malunion. *Knee Surg Sport Traumatol Arthrosc* 2017;25:55-61.
  25. Schuett DJ, Bomar JD, Pennock AT. Pelvic apophyseal avulsion fractures. *J Pediatr Orthop* 2015;35:617-623.
  26. Fink LE, Gerald W, Morris J, Mansfield LA. Case report. *J Fam Pract* 2017;66:691-694.