

Superior Pole Sleeve Fracture of the Patella

A Case Report and Review of the Literature

F. Keith Gettys,^{*†} MD, Robert J. Morgan,[‡] MD, and James E. Fleischli,[§] MD

From the [†]Department of Orthopaedic Surgery, Carolinas Medical Center, Charlotte, North Carolina, [‡]Resurgens Orthopaedics, Atlanta, Georgia, and [§]OrthoCarolina Sports Medicine Center, Charlotte, North Carolina

Keywords: patella; sleeve fracture; upper pole; children

Patellar fractures in children are uncommon and represent 1% of all pediatric fractures.^{1,14,19,20} Of all patellar fractures, less than 2% occur in skeletally immature patients, and over half of these are sleeve fractures.¹⁴ Most reported cases of sleeve fractures involve the inferior patellar pole. There is a particularly high male predominance of this injury, with a ratio of 5:1.¹⁸ The sleeve fracture was first described in 1979 by Houghton and Ackroyd¹³ as an avulsion of a small subchondral osseous fragment from the distal pole of the patella together with an extensive sleeve of cartilage and retinaculum pulled from the main body of the patella.^{1,9,13} To our knowledge, there have been 13 cases reported in the literature of sleeve fractures involving the superior pole of the patella. In reviewing the literature, there is a lack of information pertaining to long-term results. The present case report is of a superior pole sleeve avulsion fracture in an otherwise normal athletic boy, treated operatively and seen back for a 3-year follow-up. The patient and his family were informed that data concerning the case would be submitted for publication, and the study was approved by our institutional review board.

CASE REPORT

A 10-year-old boy was referred by his pediatrician the day after he slipped while jumping off a diving board and sustained a severe eccentric load to his right knee. He described feeling a “pop” and had immediate pain and swelling to his knee. He was unable to bear weight on his right lower extremity.

On examination, a moderate joint effusion was present. The patient had tenderness to palpation at the superior

*Address correspondence to F. Keith Gettys, MD, 1025 Morehead Medical Drive, Suite 300, Charlotte, NC 28204 (e-mail: keithgettys@gmail.com).

The authors declared that they had no conflicts of interest in their authorship and publication of this contribution.



Figure 1. Lateral knee injury radiograph. Arrow points to periosteal sleeve fragment.

pole of the patella, with a palpable defect of the quadriceps tendon. He was unable to actively extend his knee or perform a straight-leg raise. Any attempts to do so resulted in severe pain. The knee was stable ligamentously with negative Lachman, pivot-shift, and posterior drawer test results. No instability was present with varus or valgus stress with the knee at 0° and 30° of flexion. The leg was neurovascularly intact.

Plain radiographs of the knee (Figure 1) revealed a periosteal sleeve avulsion injury to the superior pole of the patella. Additionally, some soft tissue swelling was present. Magnetic resonance imaging (MRI) confirmed an avulsion fracture of the superior aspect of the patella (Figure 2).

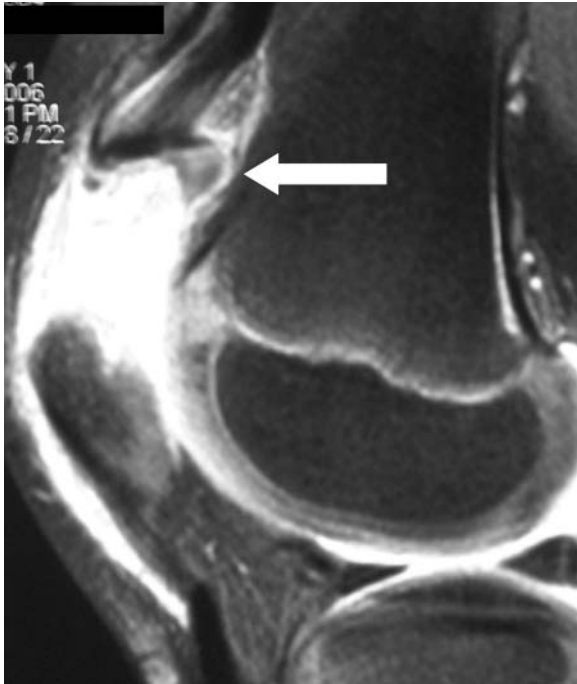


Figure 2. Sagittal T2-weighted magnetic resonance image. Arrow points to superior avulsed cartilage attached to periosteal sleeve.

Four days later, under general anesthesia, the patient underwent open reduction and internal fixation of the patellar fracture through an anterior approach with repair of the quadriceps tendon avulsion. At surgery, a large superior cartilaginous fragment with minimal peripheral ossification was noted attached to the quadriceps tendon. A significant portion of the articular surface was attached to this fragment. Another lateral fracture fragment was noted with a significant amount of the articular surface attached (Figure 3). The remainder of the patella was intact. Two No. 2 FiberWire sutures (Arthrex, Naples, Florida) were placed in the quadriceps tendon from proximal to distal using a modified Bunnell stitch. The sutures were passed through the superior cartilaginous fragment using a cutting needle. Bone tunnels were made at a corresponding location on the inferior patella fragment, and the sutures were passed. With the knee in extension, the sutures were tied over a bony bridge at the inferior aspect of the patella. The lateral fracture fragment was reduced, and two 2.7-mm screws were used to secure this fragment to the intact inferior aspect of the patella (Figure 4).

The patient was immobilized with a playmaker knee brace (DonJoy, Vista, California) locked in extension for 4 weeks. Physical therapy began at 4 weeks postoperatively. At 8 weeks postoperatively, plain radiographs showed healing of the patellar fracture (Figure 5). The patient had regained full knee range of motion, while quadriceps atrophy remained. At his 4- and 6-month follow-up visits, full, painless knee range of motion was again present with full quadriceps strength. He started

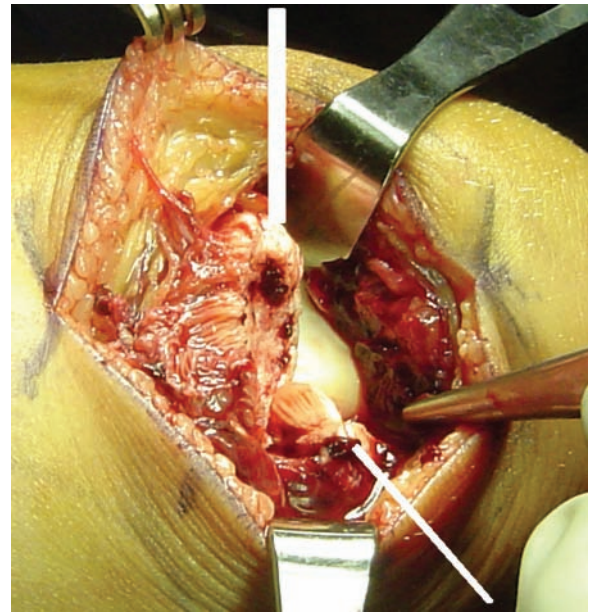


Figure 3. Intraoperative photograph. Wide line is pointing to superior fragment. Narrow line points to lateral fragment. Forceps are on inferior fragment.

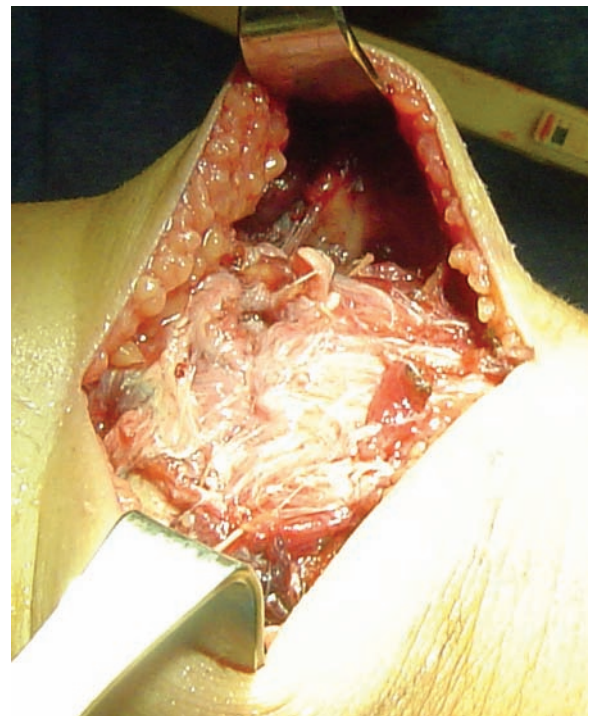


Figure 4. Intraoperative photograph after fixation of superior and lateral fragments to inferior pole of patella.

resuming all his previous activities without any complaints or symptoms.

At 3 years postoperatively, the patient was seen back for evaluation before starting basketball camp. He reported



Figure 5. Anteroposterior (A) and lateral (B) radiographs at 8 weeks after surgery.

occasional anterior knee pain after certain activities that required prolonged running and jumping. At the time of examination, he denied any symptoms or activity limitations. On physical examination, the patient had full knee range of motion (0° - 135°), normal patellar tracking, negative patellar grind, normal medial and lateral patellar mobility, symmetrical circumference of his thighs, and symmetrical quadriceps strength. Radiographs revealed intact hardware, and the fracture was healed (Figure 6). The patient was again encouraged to perform all activities without any restrictions.

DISCUSSION

Patellar fractures are uncommon in the pediatric population, and when they do occur, a sleeve avulsion is typically observed in skeletally immature patients.⁶ A sleeve fracture of the patella is a traumatic avulsion of the lower or



Figure 6. Lateral radiograph at 3-year follow-up.

upper pole, in which a small osseous fragment gets pulled off along with a sleeve of periosteum and cartilage of the patella.^{13,22} The majority of these sleeve avulsions involve the inferior pole of the patella. It is believed that an indirect injury to a flexed knee is the most common mechanism in sleeve fractures of the inferior pole.^{13,14} To our knowledge, only 7 articles in the literature have reported specific cases of superior pole sleeve fractures. The clinical data from the previous reported cases are summarized in Table 1. In the majority of the cases, the forceful quadriceps contraction on a flexed knee, as in our case, was the mechanism of injury; the others involved direct trauma.^{5,11,12,19}

Bishay⁵ reports a case of a 9-year-old girl sustaining a superior pole sleeve fracture of the patella during a squash match. As in our case, a large chondral fragment was discovered and reduced during surgery with fixation consisting of a figure-of-8 suture technique. The knee was immobilized for 5 weeks, and then physical therapy was initiated. The patient regained full range of motion by 8 weeks after surgery.

Kumar and Knight¹⁷ describe a superior pole fracture in a 14-year-old girl. The patient had been immobilized in a cylinder cast for 1 month because of a self-reducing patellar dislocation. Two days after the cast was removed, she tripped while going downstairs and sustained a superior pole avulsion patellar fracture. They described a thin rim of bone from the superior pole of the patella avulsed by the quadriceps tendon. Unlike this case and Bishay's,⁵ no chondral fragment or damage to the articular cartilage was identified on visual inspection. The patient's age suggests that the patellar ossification was complete and explains why a cartilaginous fragment was not present. At surgery, the bony fragment and the quadriceps tendon were reduced onto the patella. They were fixed using Ethibond (Ethicon, Somerville, New Jersey) sutures through the quadriceps tendon and attached to bone anchors in

TABLE 1
Summary of Previous Cases From Review of Literature^a

Author(s)	Age, y; Gender	Mechanism	Treatment	Outcome	Concomitant Lesion	Immobilization
Bishay ⁵	9; F	Direct trauma	Figure-of-8 sutures	Full ROM at 9 wk, good quadriceps power	None	5 wk
Kaivers et al ¹⁵	8; M	Indirect	Transosseous sutures	Full ROM at 8 wk	None	6 wk
Khanna and El-Khoury ¹⁶	12; M	N/A	Nonoperative, in long-leg cast	N/A	None	6 wk
Kumar and Knight ¹⁷	14; F	Indirect	Ethibond suture in quadriceps tendon attached to bone anchors in patella	Full ROM at 16 wk, normal quadriceps power	Dislocation of patella	6 wk
Grogan et al ¹²	12; M	Indirect	Tension band wiring	N/A	None	N/A
Grogan et al ¹² and Donelson and Tomaioli ¹¹	12; M	Direct	Open reduction of patella, immobilized in long-leg cast	Full ROM at 3 mo	Intra-articular dislocation of patella	4 wk
Grogan et al ¹²	5 others (9-15)	N/A	Nonoperative, in cast	Adequate function and quadriceps strength within 3 mo of cessation of immobilization	N/A	3-8 wk
Maripuri et al ¹⁹	14; M	Direct trauma	Nonoperative, knee splint in extension	Full ROM and quadriceps strength at 10 wk	Intra-articular dislocation	4 wk
Van Isacker and De Boeck ²²	7; F	Indirect	Transosseous sutures	Full ROM at 8 wk, excellent quadriceps function	Lateral retinaculum tear	4 wk

^aF, female; M, male; N/A, not applicable; ROM, range of motion.

the patella.¹⁷ The knee was immobilized in a cylinder cast for 6 weeks, and the patient regained full range of motion with normal quadriceps strength at 4 months postoperatively.

Khanna and El-Khoury¹⁶ presented a superior pole avulsion fracture in a 12-year-old boy after a sledding accident that was diagnosed 10 days after the original presentation. The patient returned for suture removal and was found to have loss of strength in the quadriceps and inability to extend his leg. Radiographic imaging was performed, including MRI that revealed an osteochondral fragment avulsed from the superior patella, with the avulsion extending posterior to involve the superior aspect of the patellar articular cartilage. The patient was treated in a long-leg cast for 6 weeks. This case emphasizes the difficulty in diagnosing these injuries acutely.

Van Isacker and De Boeck²² reported a case of a healthy 7-year-old girl who presented after a fall with a step. They reported that the patient had an intra-articular accumulation of fluid, diminished active extension, and full active flexion of the knee on physical examination. Radiographs and ultrasound imaging revealed a low position of the patella and an upper pole sleeve fracture. The patient was treated operatively, with anatomical reduction of the fragment and repair of an associated lateral retinaculum tear. The fragment was fixed with 3 Ethibond (Ethicon) transosseous sutures. Postoperatively, the patient was kept in an extension cast for 4 weeks, and then physical therapy was started with cast removal.²² The authors stated that at 8 weeks, the patient had full range of motion of the knee, excellent quadriceps function, and was without pain.²²

In 2008, Maripuri et al¹⁹ reported a case of a 14-year-old boy who sustained a sleeve fracture of the superior pole of

the patella with an intra-articular dislocation after a direct blow to the suprapatellar area of the knee. Initial radiographs revealed the intra-articular dislocation, but it was not until the postreduction films that the superior pole sleeve fracture of the patella was appreciated. An ultrasound scan of the knee confirmed the presence of the sleeve fracture and that the quadriceps tendon was intact.¹⁹ The fracture line was aligned with the superior pole of the patella, with a fracture gap of 2 mm. The knee was treated nonoperatively with immobilization in extension for 4 weeks. The patient ultimately regained full range of motion and normal strength.

In the largest reported series, Grogan et al¹² evaluated 47 avulsion fractures of the patella in skeletally immature patients. Seven patients were identified as having superior pole avulsion fractures. Five of the 7 patients presented greater than 4 weeks after injury and had active extension of the knee against gravity on the initial physical examination. Fluoroscopy showed no change in fragment position with flexion and extension of the knee. These patients were treated with cast immobilization, and the fractures healed without sequela. The other 2 patients underwent open reduction and internal fixation. One patient described in further detail¹¹ sustained an intra-articular dislocation of the patella in which the quadriceps tendon was avulsed from the superior pole of the patella. The patella lodged under the femoral condyle with the articular surface directed toward the tibia. After failed closed reduction, open reduction was performed with the quadriceps tendon reapproximated and sutured to the superior pole of the patella with the soft tissue repair. The other surgical patient was a 12-year-old child with diplegic cerebral palsy who sustained a superior sleeve fracture after a fall. Fixation was obtained with a tension band

wire. In both patients, a large cartilaginous fragment was present.

The peak incidence of sleeve fractures in children is 12.7 years, with a range of 8 to 16 years.²⁰ Ossification of the patella begins between 3 and 5 years of age and is complete by the beginning of the second decade.^{2,16} Adolescents are most susceptible, which may be related to their rapid growth with osteochondral transformation at the periphery of the patella and increasing participation in high-intensity sports.¹⁶ Patients typically present with a sudden onset of severe pain after explosive acceleration during a sporting activity or a fall. On examination, the knee may have a joint effusion, focal tenderness to palpation, a palpable gap superior to the patella, or an extension lag with straight-leg raise. It should be noted that if the disruption is minimal or is a delayed presentation, the child may have learned to lift the leg by internally rotating the limb, using the tensor fascia lata.¹⁴ However, the child could present with minimal signs on examination.

Plain radiograph findings of this injury can be minimal and obscure. A small fragment of bone adjacent to the proximal pole of the patella might be the only radiographic finding in a superior sleeve fracture of the patella.¹⁶ The fracture can be largely cartilaginous; therefore, the diagnosis can be missed on initial radiographs and the extent of the injury underestimated.¹⁶ The only findings on initial imaging may be limited to a joint effusion, soft tissue swelling, and/or patella baja. Kumar and Knight suggested that the anterior tilt of the patella is a characteristic feature of sleeve fractures of the superior pole.^{17,19} This sign was noted in our patient as well as in some of the previous cases in the literature.^{5,17} However, this sign was not present in another reported case,¹⁹ showing that its absence cannot rule out a fracture. Delayed imaging might reveal an enlargement of the bony fragment caused by new bone formation by the avulsed periosteum.¹³

Ultrasound and MRI are additional modalities that can help diagnose an injury that is usually more extensive than what is interpreted on radiographs.¹ The use of ultrasound or MRI is recommended if the diagnosis is still unclear after examination and plain radiographs. Ultrasound is an accessible, rapid, safe, and cost-effective method for imaging soft tissues, cartilage, and bony interfaces.¹⁰ Trikha et al²¹ documented that ultrasound findings were well correlated with operative findings. Magnetic resonance imaging helps to assess the true extent of injury by evaluating the size of the chondral fragment, integrity of the articular surface of the patella, the extent of periosteal avulsion, and the relationship of the fracture fragments.¹ The periosteum and avulsed cartilage are best seen on T2-weighted images in the sagittal plane through the quadriceps tendon.¹⁶ The cartilage of the patella is hypointense to bone on T2-weighted images even with fat suppression, making T2-weighted images best for differentiating the cartilaginous sleeve from the hyperintense fracture line.¹⁶ Understanding the extent of the injury to the articular cartilage is important for determining the need for surgical fixation.

The 2 treatment options include nonoperative management or surgical repair. When considering either treatment option, it is important to consider that the fracture extends

through tissue that has osteogenic potential. If healing with callus formation occurs, in cases with displacement, this may result in enlargement or even duplication of the patella and subsequent dysfunction of the extensor apparatus of the knee.¹³ Sleeve fractures that are less than 2 mm displaced may be amenable to closed treatment with cast immobilization, although the results may be unsatisfactory.^{7,13,14} A nondisplaced or minimally displaced fracture may displace secondary to the pull of the quadriceps muscle, necessitating surgical treatment with anatomical reduction and stable fixation.²²

As in our case, surgical treatment with anatomical reposition and stable fixation is the other treatment option. Through a longitudinal midline incision, the superior pole of the fracture is exposed, paying close attention to inspect for avulsed articular cartilage not appreciated on plain radiographs.² The operative repair requires careful approximation of the patella to prevent persistent deformity and extensor lag.² Stability may be achieved by means of suture fixation or tension band wiring with either nonabsorbable suture or wire. Transosseous sutures are simple and efficient.^{15,22} Additionally, the use of intraosseous anchors has been described.^{13,17} Fixation should be performed carefully to minimize damage to the delicate nutrient vessels of the patella, which come from the anterior surface and the distal pole.^{2,14} The extensor retinaculum should be repaired.² These different techniques have had varying levels of success, but the most important aspect of each is to achieve a solid anatomical fixation.

The operative complications from the surgical repair of superior pole sleeve fractures of the patella were not reported in the previous cases. However, if the fracture is left unreduced or displaced, it could lead to patella magna, extensor lag, or atrophy of the quadriceps muscles.^{2,3,14} Houghton and Ackroyd¹³ reported complications of avascular necrosis of the patella and infection after the repair of inferior sleeve avulsion fractures. Although not currently reported in the literature for the operative repair of superior sleeve avulsion fractures, commonly reported complications involving surgical repair of patellar fractures in general include loss of fixation, stiffness, nonunion, malunion, hardware irritation, and pain.^{2,3,8,23}

Postoperatively, our patient was immobilized in extension for 4 weeks. After 4 weeks, the patient underwent physical therapy. The period of immobilization in the literature ranges between 4 to 6 weeks, after which range of motion exercises were initiated in all cases but in Kaivers et al.¹⁵ In all cases including ours, full knee motion with adequate strength was achieved by 8 to 16 weeks. Prompt diagnosis and straightforward treatment can be expected to produce an excellent result with full return to all activities as in our patient's case. Failure to make the diagnosis can result in permanent disability and instability, extensor lag, quadriceps wasting and weakness, patella pain associated with osteochondral damage, and ossification of the stretched patellar tendon, giving rise to patella magna or even duplication of the patella.²⁴

In conclusion, sleeve fractures of the patella can occur at the superior pole but are typically located at the inferior

pole of the patella. Because the superior pole consists mainly of cartilage, initial radiographs may fail to manifest this injury. One must consider this injury for patients under 16 years old who have sustained an acute knee injury, typically noncontact, with resulting extensor mechanism deficits. Awareness of sleeve avulsion fractures in the skeletally immature patient is important because missed or delayed diagnosis of this injury is not uncommon.⁴

REFERENCES

- Bates DG, Hresko MT, Jaramillo D. Patellar sleeve fracture: demonstration with MR imaging. *Radiology*. 1994;193:825-827.
- Beatty JH, Kasser JR. *Rockwood and Wilkins' Fractures in Children*. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
- Beatty JH, Kumar A. Fractures about the knee in children. *J Bone Joint Surg Am*. 1994;76:1870-1880.
- Belman DAJ, Neviasser RJ. Transverse fracture of the patella in a child. *J Trauma*. 1973;13:917-918.
- Bishay M. Sleeve fracture of upper pole of patella. *J Bone Joint Surg Br*. 1991;73:339.
- Bostrom A. Fracture of the patella: a study of 422 patellar fractures. *Acta Orthop Scand Suppl*. 1972;143:1-80.
- Bruijn JD, Sanders RJ, Jansen BR. Ossification in the patellar tendon and patella alta following sports injuries in children: complications of sleeve fractures after conservative treatment. *Arch Orthop Trauma Surg*. 1993;112(3):157-158.
- Carpenter JE, Kasman R, Matthews LS. Fractures of the patella. *J Bone Joint Surg Am*. 1993;75:1550-1561.
- Davidson D, Letts M. Partial sleeve fractures of the tibia in children: an unusual fracture pattern. *J Pediatr Orthop*. 2002;22:36-40.
- Ditchfield A, Sampson MA, Taylor GR. Case reports: ultrasound diagnosis of sleeve fracture of the patella. *Clin Radiol*. 2000;55(9):721-722.
- Donelson RG, Tomaiuolo M. Intra-articular dislocation of the patella: a case report. *J Bone Joint Surg Am*. 1979;61:615-616.
- Grogan DP, Carey TP, Leffers D, Ogden JA. Avulsion fractures of the patella. *J Pediatr Orthop*. 1990;10:721-730.
- Houghton GR, Ackroyd CE. Sleeve fractures of the patella in children: a report of three cases. *J Bone Joint Surg Br*. 1979;61:165-168.
- Hunt DM, Somashekar N. A review of sleeve fractures of the patella in children. *Knee*. 2005;12:3-7.
- Kaivers P, Busch T, Lies A. [An avulsion (sleeve) fracture of the proximal patella pole in a child: diagnosis, treatment and results in a patient after a fall onto the knee]. *Unfallchirurg*. 2003;106(8):676-679.
- Khanna G, El-Khoury GY. Sleeve fracture at the superior pole of the patella. *Pediatr Radiol*. 2007;37(7):720-723.
- Kumar K, Knight DJ. Sleeve fracture of the superior pole of patella: a case report. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:299-301.
- Maguire JK, Canale ST. Fractures of the patella in children and adolescents. *J Pediatr Orthop*. 1993;13:567-571.
- Maripuri SN, Mehta H, Mohanty K. Sleeve fracture of the superior pole of the patella with an intra-articular dislocation: a case report. *J Bone Joint Surg Am*. 2008;90(2):385-389.
- Ray JM, Hendrix J. Incidence, mechanism of injury, and treatment of fractures of the patella in children. *J Trauma*. 1992;32:464-467.
- Trikha SP, Acton D, O'Reilly M, Curtis MJ, Bell J. Acute lateral dislocation of the patella: correlation of ultrasound scanning with operative findings. *Injury*. 2003;34:568-571.
- Van Isacker T, De Boeck H. Sleeve fracture of the upper pole of the patella: a case report. *Acta Orthop Belg*. 2007;73(1):114-117.
- Wu CD, Huang SC, Liu TK. Sleeve fracture of the patella in children: a report of five cases. *Am J Sports Med*. 1991;19:525-528.
- Yeung E, Ireland J. An unusual double patella: a case report. *Knee*. 2004;11(2):129-131.