Subacute Superior Patellar Pole Sleeve Fracture

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Abstract

Patellar fractures are uncommon, representing 1% of pediatric fractures. Most of these injuries are sleeve avulsions of the inferior pole. Sleeve avulsion of the superior pole is rare, with only 14 cases reported in the English-language literature. These injuries occur in adolescents after forced knee flexion or direct anterior blow. Radiographs may reveal patella baja, anterior tilt, and suprapatellar calcifications. Ultrasound and magnetic resonance imaging (MRI) can confirm the diagnosis.

We present a subacute superior pole sleeve fracture in a 15-year-old boy who sustained a left knee injury. Initial radiographs were negative. Ten days later, the patient returned with hemarthrosis and suprapatellar calcification. MRIs were read as "distal quadriceps tendon tear." Twenty-three days after the injury, the patient presented with a limp, palpable quadriceps tendon gap, and inability to maintain a straight leg raise. A superior pole sleeve fracture was repaired surgically the following day.

An understanding of the injury demographics and radiological findings associated with superior pole sleeve fractures can prevent missed diagnosis of a rare injury. We review the literature for injury demographics, operative and nonoperative treatment methods, and outcomes.

Patellar fractures are uncommon, consisting of only 1% of all fractures in children.[1-3] Sleeve fractures of the patella, first described in 1979,[4] are even rarer. Fewer than 2% of all patellar fractures occur in skeletally immature individuals, although a majority of these patients will suffer a sleeve type injury.[5-7] Most of the reported sleeve fractures describe injuries to the inferior pole of the patella. To our knowledge, only 14 cases reporting sleeve avulsions of the superior pole have been published in the English language literature to date.[1,6,8]

The cartilaginous origin of the bony patella develops by the 9th embryonic week and begins ossification between the ages of 3 to 6 years. Typically, the ossification process occurs via multiple centrally located ossicles, which gradually coalesce. The process continues peripherally until ossification is complete by the second decade of life.[9] The central-to-peripheral course invariably leaves an osseochondrous ring surrounding the patella in the immature skeleton of an adolescent.[5] Here, the superior and inferior poles are subjected to the tensile forces of the quadriceps and patellar tendons, respectively. In a moment of extreme tensile loading, rather than causing a tendinous injury, the osseochondral cuff, consisting of articular cartilage, osseopotent cells, and periosteum, avulses circumferentially from the incomplete bony patella.[5]

Sleeve fractures of the superior pole of the patella are of clinical interest for several reasons. First, although the general incidence of patellar fractures is low, 57% of these injuries are of the sleeve type.[2] Second, because the fracture consists mostly of radiolucent cartilage and soft tissue, radiographic findings may be minimal and lead to misdiagnoses. Finally, the superior pole sleeve fracture has been noted to be the least common of all patellar fractures.[10]

We describe a 15-year-old boy who presented with a subacute sleeve fracture of the superior pole of the patella. We also review the current English language literature on similar injuries. The purpose of this report is to provide the orthopedic surgeon with a better understanding of the management, treatment, outcomes, and points of concern of this injury.

The patient's guardian provided written informed consent for print and electronic publication of this case report.

Case Report

A 15-year-old adolescent boy sustained a forced flexion injury to the left knee while playing basketball. Radiographs taken in the emergency department were negative (**Figure A**). The patient was discharged with pain medication, no immobilization, and orthopedic follow-up information. Ten days later at the orthopedic clinic, the patient reported continued pain. Repeated radiographs indicated suprapatellar calcification from cortical avulsion or calcified quadriceps tendon (**Figure B**) and joint aspiration revealed hemarthrosis. Magnetic resonance imaging (MRI) was ordered and findings showed an intrasubstance tear of the distal quadriceps tendon (**Figure C, D**). The patient was referred to an operative orthopedic sports specialist 23 days after the injury.

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Examination revealed an adolescent boy with an antalgic gait. The patient reported tenderness over the distal quadriceps tendon without a palpable defect. A 3+ joint effusion was present. The patient was unable to actively extend the knee from 90° of flexion or maintain a straight leg raise. Lachman, anterior/posterior drawer, posterior sag, and varus/valgus laxity tests were negative. Neurovascular examination findings were normal. A sleeve fracture of the superior pole of the patella was diagnosed and the patient underwent primary surgical repair.

After exposure of the quadriceps defect, fibrous, cartilaginous, and osseous material was defined at the distal edge of the tendon. This represented early calcification of the avulsed cartilaginous superior pole. The repair was anchored primarily with 2 Krackow stitches passed through the patellar midsubstance and tied transosseously over the distal patella. Postoperatively, the patient's leg was placed in a Bledsoe knee brace (Bledsoe Brace Systems, Grand Prairie, Texas) locked-in extension. The patient has been lost to follow-up to date.

Discussion

Sleeve fractures of the superior patellar pole are traumatic avulsions of osseopotent tissue consisting of a cartilaginous superficial layer and a deep layer of articular cartilage and periosteum.[4,5] Patients with this injury are often adolescents (age range, 7-16 years) (**Table**).[1,3] Many of the patients reported in the literature presented for initial evaluation within 48 hours,[3,6,8,11] although Grogan and colleagues[10] described 5 patients who presented at least 4 weeks after the injury reporting persistent knee pain. Our patient presented less than 12 hours after injury with acute knee pain; later, he too was re-evaluated for persistent pain.

Of the 7 studies reporting a mechanism of injury, 3 noted a forced eccentric contracture of the knee extensors,[1,3,11] which also occurred in our case, while 4 reported a direct blow to the anterior knee.[6,8,12] Patients typically present with acute knee pain, swelling, decreased range of motion, and inability to bear weight without assistance. Physical examination may reveal knee effusion, tenderness to palpation, lack of terminal extension, inability to maintain straight leg raise, or palpable gap at the superior patellar pole. In our case, several of these findings were present even 23 days after injury. At 10 days, our patient presented with significant hemarthrosis as determined by joint aspiration; this finding was present in 2 other cases.[6,12]

Radiographs were obtained in all studies and included findings of knee effusion, suprapatellar calcifications,[1,3,6,11,12] anterior patellar tilt,[1,6,8] and patella baja (patella infera).[3,8,9] Interestingly, initial radiographs of our patient (**Figure A**) showed knee effusion but otherwise were read as negative. Kumar and Knight[6] reported a similar situation, in which initial radiographs were read as negative and the patient was discharged with supportive treatment and orthopedic follow-up. However, review of the same radiographs by an orthopedic surgeon 3 days later revealed several pathological findings, including anterior patellar tilt, patella baja, and a superior patellar pole bony fragment. In our case, a new set of radiographs taken 10 days later (**Figure B**) revealed ossification at the superior pole not appreciable on initial imaging.

Secondary imaging was used in 4 cases but none used more than 2 modalities. Van Isacker and De Boeck[3] used ultrasound to definitively diagnose a sleeve fracture originally declared a bony avulsion of the superior pole based

Figure. Lateral radiograph taken in the emergency department on the date of injury in a 15-year-old boy sustaining a forced flexion injury to the left knee (A). Lateral radiograph of the left knee taken 10 days after date of injury, revealing hemarthrosis in a 15-year-old boy sustaining a forced flexion injury to the left knee (B). Coronal T1 (C) and sagittal T2 (D) MRIs of the left knee in a 15-year-old boy, depicting patellar articular cartilage disruption and an avulsed tendinocartilaginous sleeve proximal to the superior pole of the patella.

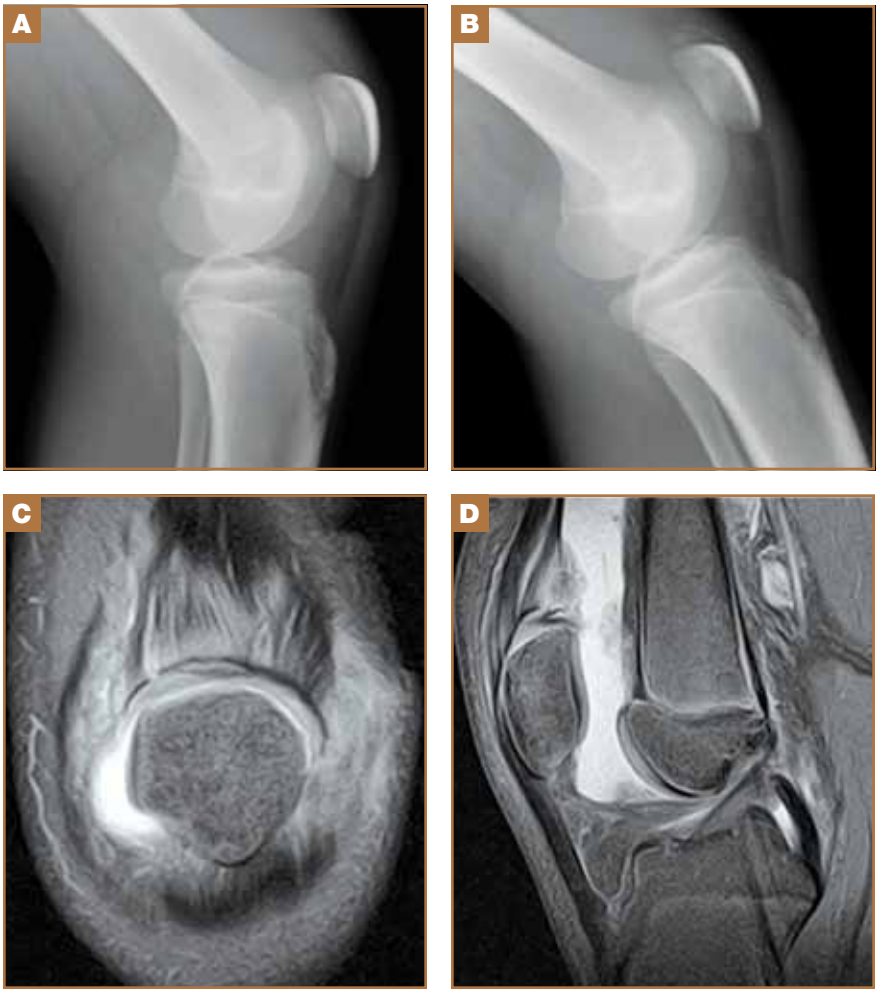

Table. **Patient Demographics, Mechanism of Injury, Treatment, and Outcomes**

Nonoperative Reports				
Author	**Age/Sex**	**Mechanism of Injury**	**Treatment**	**Outcome**
Khanna and El-Khoury[8]	12-year-old boy	Direct anterior blow	6 weeks of immobilization	Unknown
Grogan et al[10]	5 patients	Unknown	3-8 weeks of immobilization	Adequate quadriceps function at 3 months; no radiographic patellar abnormality
Maripuri et al[7]	14-year-old boy	Direct anterior blow	4 weeks of immobilization	Full ROM and quadriceps strength at 10 weeks
Operative Reports				
Author	**Age/Sex**	**Mechanism of Injury**	**Treatment**	**Outcome**
Brennan et al[1]	16-year-old boy	Eccentric forced flexion	Four suture anchors	Full ROM, quadriceps strength, intact straight leg raise at 6 months
Van Isacker and De Boeck[3]	7-year-old girl	Eccentric forced flexion	Three nylon surgical sutures; 4 weeks of immobilization	Full ROM and quadriceps strength at 8 weeks
Kumar and Knight[6]	14-year-old girl	Direct anterior blow	Nylon surgical sutures with bone anchors; 6 weeks of immobilization	Full ROM and quadriceps strength at 4 months
Bishay[12]	9-year-old girl	Direct anterior blow	Figure-of-eight sutures; 5 weeks of immobilization	Full ROM and good quadriceps power at 4 weeks
Gettys et al[11]	10-year-old boy	Eccentric forced flexion	Two polyester sutures, two 2.7-mm screws; 4 weeks of immobilization	Full ROM and quadriceps strength at 4 months
Grogan et al[10]	12-year-old boy	Direct anterior blow	Tension band	Unknown
	12-year-old boy	Eccentric forced flexion	Open reduction; 4 weeks of immobilization	Full ROM at 3 months

Abbreviation: ROM, range of motion.

on initial radiographs. Sonography allowed visualization of the chondral piece attached to the distal quadriceps tendon. Maripuri and colleagues[7] used sonography for diagnostic confirmation and measured a 2-mm fracture gap, dictating a nonoperative course. Ultrasound, with proper technique, can be a quick, cost-effective means to image bone, cartilage, and soft tissue, and to accurately measure fragment separation.[13]

Brennan and colleagues[1] used computed tomography (CT) scanning to diagnose a forced flexion knee injury. Initial radiographs showed joint effusion, anterior patellar tilt, and a suprapatellar calcification. CT scanning showed an avulsed fragment of cortical bone from the superior patellar pole. While CT imaging is an effective tool to visualize bony anatomy, it does not define the fractured chondral fragment. Furthermore, it subjects the pediatric patient to a significant amount of radiation.

MRI provided greater detail of our patient's injury. Gettys and colleagues[11] also used MRI for diagnostic confirmation and preoperative planning. They noted that T2-weighted sagittal MRI could reveal the size of the chondral fragment, distance of fragment displacement, extent of the periosteal sleeve, and integrity of the patellar articular surface.[14] Khanna and El-Khoury[8] used MRI to confirm a suspected superior patellar pole sleeve fracture. Again, T2-weighted fat-suppressed sagittal images demonstrated a chondro-osseous avulsion from the superior pole and disruption of the patellar articular cartilage superiorly. These radiological conclusions mirrored our patient's MRI findings; he also had extensive disruption of the superior patellar articular cartilage and significant joint effusion.

To our knowledge, only 7 patients underwent nonoperative treatment for sleeve fracture of the superior patellar pole. Grogan and colleagues[10] described 5 patients with delayed presentation of sleeve fracture; no patient was treated earlier than 4 weeks after injury. Bony healing had already begun, evidenced by fragment stability under fluoroscopy with flexion-extension stress, and all patients were treated with cast immobilization in extension for 3 to 8 weeks. Every patient had adequate return of quadriceps function and no radiographic deformity of the patella by 3 months. Maripuri and colleagues[7] used splint immobilization of the knee in extension for 4 weeks in a patient with a 2-mm fracture gap. Range of motion therapy was started after 4 weeks, and by 10 weeks, the patient had full quadriceps strength, full range of motion, and no radiographic patellar abnormality. Khanna and El-Khoury[8] reported a patient presenting 10 days after injury treated with casting in extension for 6 weeks; unfortunately, the outcome was not documented.

Our patient underwent operative fixation of the sleeve fracture, as did 7 other reported patients. We used 2 parallel Krackow whipstitches to reduce the fracture gap. Use of a figure-of-eight technique,[12] bone anchors,[6] Mason-Allen technique,[1] tension band wiring,[10] and Bunnell whipstitch with screw fixation[11] have also been reported. Postoperative protocol involved immobilization with the knee in extension, whether by locked bracing or cylinder casting, for approximately 4 to

6 weeks. Every patient began a physical therapy program after the immobilization period focused on knee range of motion and quadriceps strengthening. All patients regained full painless knee range of motion and quadriceps strength, some as early as 2 months postoperatively.[3,12] All reported cases underwent surgery within 1 week of injury. However, in our case, owing to delayed presentation the patient did not undergo operative fixation until 24 days after the injury.

We present the first case of a chronic sleeve fracture of the superior pole of the patella managed operatively. Review of the literature documenting this injury clearly defines the patient demographics, mechanisms of injury, presenting reports, and radiological findings. However, beyond this information, evidence that could be used for making treatment decisions, planning operative technique, or designing a postoperative protocol is lacking.

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This paper will be judged for the Resident Writer's Award.