An 11-year-old Boy with a Patella Fracture

Jason A. Nydick DO, Martin J. Herman MD,
Jean-Pierre de Chadarevian MD

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History and Physical Examination

An 11-year old boy presented to the pediatric emergency department with left knee pain after tripping in the school yard and striking his knee on concrete. He denied having left knee pain before his fall. There was no history of recent skin or other infections, fever, or constitutional symptoms or signs. His medical history and family history were noncontributory.

On physical examination, his skin was intact except for a small superficial abrasion over his left patella. A small knee effusion was present and the patella was tender to palpation. He was able to actively extend the knee, but

flexion was painful and limited to 30°. The remainder of the physical examination was unremarkable. Radiographs were interpreted as showing a minimally displaced transverse patella fracture (Fig. 1). He wore a cylinder cast for 6 weeks and radiographs were obtained after cast removal (Fig. 2). Three months after cast removal, he was prescribed physical therapy for persistent quadriceps weakness. This consisted of quadriceps strengthening, active assisted knee range of motion, and activity as tolerated. When seen 8 months after injury for routine followup, he had normal knee motion but complained of pain with maximal knee flexion and prolonged walking.

Radiographs were repeated 8 months after injury (Fig. 3) and the prior radiographs were rereviewed. MRI of the knee was performed 10 months after injury (Fig. 4). Complete blood count, erythrocyte sedimentation rate, and C-reactive protein were normal.

Based on the history, physical examination, and imaging studies, what is the differential diagnosis?

Imaging Interpretation

Injury radiographs of the left knee revealed a minimally displaced transverse midpatella fracture (Fig. 1). Thinning of the anterior cortex of the patella and a well-circumscribed area of lucency in the patella were evident (Fig. 1). Radiographs taken 6 weeks and 8 months after injury revealed fracture healing, with the patella lesion appearing slightly larger and multiloculated (Figs. 2, 3). Small areas of calcification were seen in the quadriceps on 6-week postinjury radiographs. Followup imaging did not reveal changes of the quadriceps calcifications.

MRI performed 10 months after injury revealed a well-defined, multiloculated cystic lesion (4.3 cm × 1.6 cm)

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Each author certifies that his or her institution has approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at St. Christopher's Hospital for Children.

J. A. Nydick (✉)

Department of Orthopaedic Surgery, Philadelphia College
of Osteopathic Medicine, 4170 City Avenue, Philadelphia,
PA 19131, USA
e-mail: jason31878@yahoo.com

M. J. Herman

Department of Orthopaedic Surgery, Drexel University College
of Medicine and St. Christopher's Hospital for Children,
Philadelphia, PA, USA

J.-P. de Chadarevian

Department of Pathology and Laboratory Medicine, Drexel
University College of Medicine and St. Christopher's Hospital
for Children, Philadelphia, PA, USA

Fig. 1 A lateral radiograph of the left knee taken at the time of initial injury shows a transverse patella fracture with associated anterior lytic lesion.

Fig. 2 A lateral radiograph of the left knee taken 6 weeks after injury reveals fracture healing, with the patella lesion appearing slightly larger and multiloculated. Small areas of calcification are seen in the quadriceps, evidence of heterotopic ossification.

with scalloping of the endosteal bone surface in areas and multiple fluid-fluid levels (Fig. 4). It encompassed nearly the entire patella. The lesion was heterogeneous but predominantly hyperintense on T1- and T2-weighted images, with lower signal intensity layering in the dependent

Fig. 3 A lateral radiograph of the left knee taken 8 months after injury shows the fracture is well healed but reveals the presence of an enlarged loculated lytic lesion of the patella.

portions of the loculations, representing a hematocrit effect. No disruption of the articular surface or associated soft tissue mass was noted.

Differential Diagnosis

- Simple bone cyst
- Aneurysmal bone cyst
- Giant cell tumor
- Chondroblastoma
- Osteosarcoma
- Osteoblastoma
- Langerhans cell histiocytosis

An open bone biopsy of the patella with intraoperative frozen section was performed. The soft tissues appeared normal, but a thin anterior cortex of the patella was seen and punctured with an elevator. After removal of a large window of thin cortical bone, a large well-defined cavity filled with serosanguinous fluid was found. A rim of tissue that lined the cavity and curettings from within the cavity were sent for histologic analysis. The bony rim was sclerotic and intact. The posterior wall of the cavity was cartilaginous, but the patellar cartilage revealed no obvious violation of the joint surface. There was no evidence of malignancy. Intraoperative Gram stain and cultures were negative. The lesion was diagnosed as a bone cyst pending histologic analysis. Based on these intraoperative findings, the lesion was completely curetted. The periphery of the cavity was cauterized and then burred. The defect was

Fig. 4A–B (A) A sagittal T1-weighted MR image taken 10 months after injury reveals a well-defined, multiloculated cystic lesion (4.3 cm × 1.6 cm) with scalloping of the endosteal bone surface in areas. No disruption of the articular surface or associated soft tissue mass is seen. (B) An axial T2-weighted MR image taken 10 months after injury reveals multiple fluid-fluid levels. The lesion is heterogeneous, with lower signal intensity layering in the dependent portions of the loculations, representing a hematocrit effect.

Fig. 5A–B (A) A low-magnification (×10) photomicrograph shows the empty spaces outlined by thin septa made of spindle cells, randomly scattered benign giant cells, and capillaries in a collagenous matrix spaces making up the aneurysmal bone cyst (Stain, hematoxylin and eosin). (B) A higher-magnification (×20) photomicrograph shows details of the fine strands of woven bone septa (thin arrows) and randomly scattered multinucleated giant cells (thick arrow) (Stain, hematoxylin and eosin).

packed with a combination of demineralized bone matrix and allograft cancellous chips. The final histologic evaluation is shown (Fig. 5).

Based on the history, physical examination, imaging studies, and histology, what is the diagnosis and how should this lesion be treated?

Histology Interpretation

Histologic examination (Fig. 5) of the biopsy material showed empty spaces outlined by thin septa made of spindle cells, randomly scattered benign giant cells, and capillaries in a collagenous matrix. The septa were made of

fibrous connective tissue containing fine strands of immature woven bone. Fiber osteoid was observed in some septa. There were no mitoses or atypical cells.

Diagnosis

Aneurysmal bone cyst.

Discussion and Treatment

Patellar tumors are uncommon, but almost 75% of these diagnosed in children and adults are benign [13]. Giant cell

tumor and chondroblastoma are the most common benign patellar neoplasms whereas osteosarcoma is the most frequent primary malignancy [13]. Based on radiographic and histologic findings, an aneurysmal bone cyst was identified in this patient. The patient had associated heterotopic ossification of the quadriceps secondary to the initial trauma.

A simple bone cyst or unicameral bone cyst is characterized by a thin cyst lining consisting of fibroblasts and eosinophilic fibrinous material known as cementum [21]. Unicameral bone cysts often are asymptomatic and discovered from pain from an associated fracture [21]. Plain radiographs show a purely lytic lesion with well-marginated outline. Giant cell tumor of bone is a benign but locally aggressive neoplasm distinguished by a uniform pattern of multinucleated giant cells in a background of mononuclear stromal cells [12]. Giant cell tumors are rare in skeletally immature patients and most commonly occur between 20 and 40 years of age [12]. Chondroblastoma is a rare benign neoplasm similar radiographically and histologically to giant cell tumor except that it produces a chondroid matrix [21]. Osteosarcoma contains neoplastic woven bone with malignant-appearing stroma. Radiographic characteristics include destructions of normal trabecular pattern with periosteal elevation. Osteoblastoma histologic appearance is composed of interlacing trabeculae surrounded by loose fibrovascular connective tissue [21]. Langerhans cell histiocytosis or eosinophilic granuloma is characterized by histiocytes and eosinophils on histology [19]. Given the above differential, we excluded simple bone cyst, giant cell tumor, chondrosarcoma, osteosarcoma, osteoblastoma, and Langerhans cell histiocytosis based on histologic evaluation. There was no evidence of uniformly arranged giant cells, chondroid matrix, cellular atypia, interlacing trabeculae, or histiocytes. The MRI with

presence of fluid-fluid levels excluded simple bone cyst. Aneurysmal bone cyst was diagnosed by excluding the differential based on radiographic, MRI, and histologic evaluation.

An aneurysmal bone cyst is a benign aggressive bone lesion first described by Jaffe and Lichtenstein in 1942 [8]. It is typically an expansile osteolytic lesion consisting of blood-filled spaces and channels that are divided by connective tissue septa, which may contain osteoid tissue and osteoclastlike giant cells [5]. The presence of a fluid-filled cavity on MRI without an associated soft tissue component is highly suggestive of an aneurysmal bone cyst. Aneurysmal bone cysts comprise less than 1% of all primary bone tumors. There are few reported cases of aneurysmal bone cyst of the patella (Table 1) [2, 3, 6, 9–11, 14, 16, 18]. The most common extrapatellar site is the distal femur and proximal tibia, followed by the spine and pelvis [15]. It has been suggested aneurysmal bone cysts are associated with other tumors, including giant cell tumor and chondroblastoma that have been obliterated by hemorrhage [21].

Intralesional curettage and bone grafting are the preferred treatment for benign patella tumors without articular involvement. Dormans and Pill [5] described a four-step process for treatment of aneurysmal bone cysts: (1) intraoperative frozen section with histologic confirmation of diagnosis; (2) intralesional curettage through a wide cortical window; (3) cauterization of the cyst wall and careful exploration of the cyst wall for subtle crevices or pockets of residual soft tissue; and (4) final cleaning of the cyst cavity using a high-speed burr. Total patellectomy or a patellar prosthesis is recommended for aggressive lesions that disrupt the patellar articular surface [10, 13]. Recurrence rates after curettage vary widely from 9% to 71%, with lesions of the humerus and femur most common [1, 4]. Some authors have reported higher recurrence rates

Table 1. Reported cases of primary aneurysmal bone cysts of the patella

Study	Number of patients	Age (years)	Race	Gender	Fracture	Treatment	Recurrence
Castro and Irwin [2]	1	14	White	Male	No	Curettage + allograft	No
Copeland et al. [3]	2	22, 29	African American, African American	Male, male	No	Patellectomy, patellectomy	No
Faris et al. [6]	1	22	African American	Male	Yes	Curettage + autograft	No
Kumar et al. [9]	1	16	NR	Female	No	NR	No
Linscheid and Dahlin [10]	1	15	NR	Male	No	Patellectomy	No
Mapelli and Giraldi [11]	1	33	White	Male	No	Curettage + bone graft	No
Mercuri et al. [14]	2	25, 56	NR	Male, male	No	Curettage + allograft, patellectomy	No
Oh et al. [16]	1	30	Asian	Male	No	Curettage + allograft	No
Pevny and Rooney [18]	1	15	White	Female	No	Curettage + allograft	No
Current study	1	11	White	Male	Yes	Curettage + allograft	No

NR = not reported.

Fig. 6A–B (A) Lateral and (B) sunrise radiographs taken 10 months after curettage and bone grafting show an intact patella articular surface with remodeling of the patella. Heterotopic ossification is still present in the quadriceps.

with aneurysmal bone cysts in children younger than 15 years [20]. The average time between surgery and initial recurrence was 7.6 months [4]. Repeated extended curettage and bone graft are recommended in the event of recurrence. However, a literature review did not reveal any recurrences for aneurysmal bone cyst of the patella.

The treatment of children with pathologic fractures is based on the suspected diagnosis [17]. Clinical history, physical examination, and imaging allow the surgeon to narrow the list of differential diagnoses. The absence of a prior history of pain or associated systemic signs or symptoms, such as fever, malaise, or weight loss, suggests the condition is benign. Radiographic analysis of the lesion often is most helpful. However, a pathologic fracture can obscure the radiographic characteristics used to distinguish benign from malignant. Findings consistent with benign lesions include a well-circumscribed or geographic lytic zone with increased density at its periphery and no periosteal lamination or reaction. MRI is useful to further define the lesion and narrow the differential diagnosis.

The first priority for the surgeon is to establish a diagnosis by open bone biopsy. Because many lesions can be identified definitively as benign on frozen section, lesion management usually can be performed under the same anesthetic [7]. If the diagnosis cannot be established, especially if malignancy is suspected, definitive surgery is best deferred until final pathology results are available. Aneurysmal bone cysts most commonly are treated by curettage, cavity cauterization, and high-speed burring, followed by bone grafting.

Ten months after intralesional curettage and bone grafting, our patient returned to full activities without pain. He has regained full range of motion of his knee.

Radiographs at 10 months showed progressive healing of the cyst without evidence of recurrence (Fig. 6). We report a particularly young patient with an aneurysmal bone cyst of the patella that presented with a pathologic fracture.

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