Sleeve Fracture of the Patella in Children
—A Report of Two Cases—

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Abstract
Two cases of sleeve fracture of the patella are reported. One occurred in the upper part of the patella, although this type of fracture usually affects the lower patella. The clinical features and mechanism of this fracture are reviewed in our patient and seventeen other cases reported in the literature. Treatment should be initiated immediately, with open reduction being performed to reduce the fragments accurately, because a large fragment of articular cartilage is also separated with the bone. Additionally, tight immobilization of such fractures, in adolescence, may induce aseptic necrosis of the patella.

We therefore recommend the accurate reduction of the articular cartilage fragment and tension band wiring to immobilize this type of fracture.

Introduction

The patella in children and young adolescents is usually covered by cartilage, with the undersurface being covered by articular cartilage. It is also surrounded by the patellar ligament, which consists mainly of elastic fibers. Therefore, an excessively forceful quadriceps muscle contraction can cause the avulsion of a large cartilage fragment together with bone from the body of the patella. The avulsed fragment is cup-shaped and named a "sleeve fracture" by Houghton.4

This fracture has received little attention in the English literature,24 although seven reports are found in the Japanese literature7813 and one is available in French.5

Case reports

Case 1: The patient was a 14-year-old girl who fell down while walking in February 1982. She developed right knee pain and so immediately consulted the Accident Service, where the knee was immobilized in a plaster-of-Paris cylinder cast. The diagnosis was a second degree sprain of the right medial collateral ligament. After two weeks, the cast was removed, but the knee remained stiff. Physiotherapy was undertaken to increase knee flexion. During that time, she fell again and was unable to walk due to knee pain. There was no direct blow to the knee. Patellar fracture was then diagnosed by the Accident Service and she was referred to our clinic.

The girl was of average build and did not have any other known disorders. Her right knee showed moderate swelling, local heat, effusion, and severe tenderness. In addition, a hard bone-like was palpable at the upper end of the patella. Slight extension of knee was possible, but flexion was restricted by knee pain.

Serum levels of calcium, phosphorus, and alkaline phosphatase were within normal limits. The lateral roentgenogram and tomogram showed that
the upper fragment of the patella was widely separated from the body and consisted of a crescent-shaped piece of bone (Fig. 1—A & B).

On the basis of the clinical history and roentgenographic features, the diagnosis of avulsion fracture of the patella was made and open reduction of the fracture was performed.

At operation, it was discovered that half of the patellar cartilage had been avulsed from the body of the patella, and that this cup-shaped cartilage fragment had been displaced proximally. Also, the corresponding part of the aponeurosis was torn at the same level (Fig. 1—C). The avulsed fragment was approximated to the body of the patella and immobilized with a tension band wire (Fig. 1—D). In addition, the articular cartilage and quadriceps expansion were reconstructed anatomically with polyglycolic acid (Dexon) sutures.

On histological examination, the avulsed fragment showed normal cartilage and bone accompanied by mild chronic inflammation (Fig. 1—F).

After the operation, a plaster-of-Paris cylinder cast was applied from the groin to the ankle. Seven weeks later, passive motion was initiated and after four months the knee had a full range of pain-free movement. The wire was removed at this time.

At the latest follow-up review, six years after the operation, the knee had a full range of pain-free movement and the patient was fully active with no residual symptoms. Her X-rays showed that the fracture had healed completely in an excellent position with good reconstruction of the subchondral bone, although there was slight deformity of the upper part of the patella. (Fig. 1—E).

(CASE 2): A physically fit 11-year-old boy performed his first high-jump training session. After sufficient preparatory exercise, he jumped over an 80 cm high bar ten times. On his eleventh jump, as he took off from the ground, he suddenly felt a pain in his right knee. Subsequently, he had severe pain around the knee cap and couldn't walk. He was seen by the Accident Service immediately, and referred to our clinic with the diagnosis of patellar tendon rupture in June 1986.

The right knee was markedly hot and swollen, severe tenderness was noted around the patella and patellar ligament, and the range of motion was limited due to pain.
Fig. 1—C
Photograph demonstrating the cup-shaped socket from which the patellar fragment has been avulsed. A) cartilage  B) bone

Fig. 1—D
Tension band wiring of the avulsed patellar fragment.

Fig. 1—E
Lateral radiogram showing complete healing with slight deformity of the upper part of the patella 6 years after surgery. Note the low density of the lower part of the patella.
Fig. 2—A
Pneumoarthrogram of the right knee shows a high-riding patella with avulsion of its lower portion.

Fig. 1—F
Photomicrograph of a section of the cartilaginous part of the patella (A in Fig. 1—C). Normal cartilage and bone are seen together with slight chronic inflammation.

Fig. 2—B
At operation. Note that one third of the cartilage surrounding the patella has been avulsed from the body.
A: The bony part of the patella is exposed.
B: The articular cartilage of the proximal patella.
C: A large sleeve of articular cartilage and the bony fragment avulsed from of the lower part of the patella.

Fig. 2—C
Tension band wiring in a figure-of-eight shape.
Although radiographs showed a high-riding patella, the avulsed fragment was not clearly demonstrated. Pneumoarthrography indicated the gap clearly, so a sleeve fracture was able to be diagnosed (Fig. 2–A).

During the operation, it was found that the avulsed distal part of the patella consisted of a large sleeve of articular cartilage surrounding a fragment of bone (Fig. 2–B). The patellar ligament was torn at about the lower one-third of the patella. Reduction of the fragment was easily accomplished by pulling the proximal fragment distally and securing it with a figure-of-eight tension band wire fixed to the tibia. The retinacular ligament was repaired with Dexon sutures (Fig. 2–C).

On histological examination, the avulsed fragment was normal ligament and cartilage, which showed some ischemic changes induced by the fracture (Fig. 2–E).

After this operation, the knee was immobilized in slight flexion for three weeks in a plaster-of Paris cast. Five months after the operation, he had a full range of motion of the knee without pain and the wire was removed. At the present time, three years later, the patient has no further complaints. However, X-rays show that the distal part of the patella is slightly deformed by new bone formation (Fig. 2–D).

**Discussion**

Rupture of the knee extensor apparatus in adolescence usually occurs as an avulsion fracture of the tibial tuberosity, but between 10 and 15 years of age avulsion of the distal patella occasionally occurs.

Regarding patellar growth, there is extremely little literature available. There is usually multicentric ossification of the patella during infancy, and towards adolescence other centers of ossification may appear.

Maroteaux has started that the growth of the patella...
patella is similar to the growth of an epiphysis logically; i.e., its growth occurs at the periphery of the ossification centers, where one finds a zone of cartilaginous cells acting like growth cartilage. On its inner surface, there is also a similar arrangement of columnar cartilaginous cells and they show evolution towards ossification. The external layer of this cartilaginous zone provides a source for the replacement of cells on the articular surface. During adolescence, the posterior surface of the patella is covered with articular cartilage, while the anterior surface is covered by cartilage and the patellar ligament. If an excessively forceful quadriceps muscle contraction acts on the patella, an extensive cup-shaped sleeve of cartilage including the articular cartilage can be avulsed from the bony part of the patella. This has been termed a "sleeve fracture" and current textbooks have also used this name. Until now, seventeen cases have been reported in addition to our two, most involving the lower part of the patella and all occurring in children under fourteen years of age.

The mechanism of the injury was witnessed in most of the cases reported, and in twelve of the nineteen cases (63%) it occurred during jumping, especially at take-off. Two cases were due to falls, and there were only two cases in which a direct blow to the knee was involved. Thus, this fracture is similar in mechanism to avulsion fractures of the tibial tuberosity in adolescence, which usually occur while jumping playing basketball or during high jumping.

Sleeve fractures mainly occur between 8 and 14 years of age while the incidence of tibial tuberosity fractures peaks at 14 to 16 years of age, and there is a significant difference of the age distribution among these two patient groups (p < 0.05).

In the early teens period, the patella is covered by cartilage, but during the midteens, the weakest point of the extensor system seems to shift to the tibial tuberosity. This may occur because the development of the patella is then complete but the epiphyseal plate of the tibial tuberosity is still in the developmental stage.

It would be easier to diagnose this fracture if its characteristics were better understood. Plain X-rays may be very helpful when avulsed osseous fragment is small, but tomography and pneumoarthrography can then aid in the diagnosis, as shown in our second case. The chief complaints are severe pain, sudden giving way, and the inability to extend the knee. The patella is frequently high riding and a gap can be palpated on examination. Immediately after the injury, however, the gap is sometimes hard to detect because of a tense knee effusion and hemarthrosis. If the correct treatment is not performed because of misdiagnosis, the patella could undergo developmental disturbances, resulting in a double patella or possible disorders of the extension mechanism.

Jacquemier reported that this lesion is an epiphyseal fracture. Our histological examination showed that cartilage existed between the bony fragment and the patellar tendon, but it was not obvious that this cartilage was responsible for the growth of the patella.

To re-establish the articular surface of the patella, accurate reduction of the avulsed fragment and stable immobilization are very important in this fracture.

Plaster casting and simple suture may lead to inadequate fixation, resulting in a high-riding patella. Firm fixation of the avulsed fragment is necessary and this fixation must be rigid enough to withstand the strong forces exerted by the quadriceps muscles. Two of the cases reported were treated with wire loops, which led to marked deformity of the patella. Jacquemier reported a case in which the patella developed aseptic necrosis after surgery, and suggested that open reduction increases the risk of this occurring. Our first case also showed slight evidence of aseptic necrosis of the distal part of the patella.

The nutrient vessels of the patella follow two main routes: enters via the middle third of the anterior surface and the other enters the lower pole of the patella behind the patellar ligament. Tight immobilization of the patella, such as tight loop wiring, seems to disturb the blood supply route. Therefore, in our second case we chose
figure-of-eight tension band wiring to prevent aseptic necrosis of the distal patella, and removed the wire as soon as possible to prevent premature closure of the tibial tuberosity.

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Reference
