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Case report

Staged treatment of a chronic patellar sleeve fracture using the Taylor spatial frame

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ABSTRACT

Patellar sleeve fractures are easily missed injuries since plain radiographs may not show a bony fragment at the time of injury. Failure to diagnose these injuries can result in patellar instability, extensor lag, and anterior knee pain. We report a novel treatment using a Taylor spatial frame as part of a staged reconstruction to regain length of the extensor mechanism and maintain knee motion prior to performing primary repair of the avulsed patellar sleeve fragment. In our case, an 11-year-old male presented to our institution six months after sustaining a patellar sleeve fracture. Radiographic examination with the knee in extension revealed a 23-mm gap between the inferior patellar pole fragment and the remaining patella. The patient was ultimately taken to the operating room twelve months after the initial injury for placement of a Taylor spatial frame to regain length of the extensor mechanism. The patient began immediate knee range-of-motion exercises, and performed daily soft tissue lengthening of two millimeters. After four weeks of treatment the patient underwent removal of the fixator and primary repair of the patella. At final follow up six years after patellar reconstruction, the patient had an active knee range-of-motion from five degrees of hyperextension to 140° of flexion. Where current literature reports suboptimal results even when treatment is delayed for two months, in our case the patient was able to obtain a high level of function after treatment with a two-stage reconstruction using a Taylor spatial frame.

1. Introduction

Patellar fractures are rare in children because the patella is largely cartilaginous and has greater mobility compared to the patella of an adult [1]. Of all patellar fractures, less than two percent occur in the skeletally immature. However, in patients younger than 16 the most common fracture pattern is that of a patellar sleeve fracture [2]. The fracture is named due to the sleeve, or cuff, of cartilage that is pulled from the patella in addition to an avulsion of a small osseous fragment from the pole of the patella [3]. The patella begins to ossify at age three, and patellar sleeve fractures generally occur in patients between eight and 12 years of age, before ossification is complete.

These injuries are often the result of an indirect force on the patella, such as rapid contraction of the quadriceps on a flexed knee [3,4]. Appropriate diagnosis and treatment of these injuries are important to maintain length of the patellar tendon, the function of the extensor mechanism, and to restore the articular surface of the patella [3,5]. The diagnosis may be difficult at initial presentation, because plain radiographs may not show a visible bony fragment at the time of injury. In these instances where clinical suspicion remains high, advanced imaging studies such as ultrasound or magnetic resonance imaging (MRI) are needed to prevent a missed or delayed diagnosis [6].

Failure to diagnose these injuries can result in a myriad of complications including patella alta or instability, extensor lag, quadriceps wasting, anterior knee pain from patellar osteochondral damage, as well as ossification of the patellar tendon or duplication of the patella [3,7]. There are very few cases in the literature documenting treatment of chronic, displaced patellar sleeve fractures [8–10]. The treatments described for these patients ranged from continuing non-operative treatment to resection of the ossified fragment and reconstruction of the patellar tendon [8]. In our case, an 11-year-old male underwent surgical fixation one year after sustaining a patellar sleeve fracture. We describe a novel technique for the treatment of a chronic patellar sleeve fracture using the Taylor spatial frame (TSF) as part of a staged reconstruction to regain length of the extensor mechanism prior to performing a primary repair of the avulsed and ossified patellar sleeve fragment.

2. Case report

An 11-year-old boy presented to our facility six months after landing on his left leg with knee in the flexed position. The patient's family reported that at the time of injury, the initial treatment prescribed by the outside institution was to place him into a knee immobilizer with instructions that he had no fracture and did not require any treatment. At time of presentation to our hospital, the patient was unable to actively

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extend his knee and had a passive range of motion of zero to 40°. Radiographic examination with the knee in extension revealed evidence of a chronic patellar sleeve fracture with a 23-mm gap between the inferior patellar pole fragment and the remaining patella (Fig. 1).

The patient was referred to physical therapy to work on regaining range of motion prior to any surgical intervention. The patient missed a number of office visits and at follow-up five months after the initial evaluation at our institution, the patient had a 30° extensor lag with a passive range of motion from zero to 120°. We discussed preoperatively with the patient and family surgical options of fragment excision, primary fracture fixation with surgical lengthening of the extensor mechanism, as well as a staged reconstruction with the Taylor spatial frame. Due to the displacement of the fracture fragments and the chronicity of the injury, plans were made to use a Taylor spatial frame as part of a staged reconstruction if primary fracture fixation was not stable. With a 23-mm fracture gap on radiographs with the knee in extension, we expected to encounter a greater discrepancy with flexion of the knee. We felt that the best way to gain length and perform primary repair of the fracture was to lengthen the quadriceps tendon. The TSF would allow the patient to continue moving his knee during treatment. Additionally it gave us the ability to adjust the rate of quadriceps tendon lengthening if the patient lost knee motion during the course of treatment. Pre-operative planning on a sawbone model is shown in Fig. 2.

2.1. Operative procedure and post-operative care

The patient was taken to the operating room twelve months after the initial injury. Examination under anesthesia revealed a passive range of motion from zero to 140° in both knees. A six-centimeters midline incision was made to expose the patella and distal fragment. Extensive fibrous scar tissue between the two fragments and along the intact extensor mechanism was released. After direct reduction of the two fragments, continuity could not be maintained beyond 10° of flexion. Bringing the knee to 90° of flexion created a four-centimeters gap at the fracture site between the patella and its now-ossified inferior pole fragment. It appeared that a standard V–Y lengthening of the contracted quadriceps tendon would not give us sufficient length to primarily fix the fracture fragments [11]. The decision was made to proceed with a staged reconstruction, and to first apply a Taylor spatial frame to lengthen the extensor mechanism while maintaining knee motion.

A two-ring fixator was fixed into the distal tibia itself via three orthogonal hydroxyapatite-coated Schanz-pins. A third ring was then placed more proximal and attached to the distal ring construct via six adjustable struts. Two olive wires (2.0 mm) were placed through the patella in anterograde fashion and fixed to the proximal ring of the spatial frame as pulling wires (Fig. 3). The ability to maintain descent of the patella with knee flexion and extension was confirmed prior to closure of the surgical incision.

The patient's family was instructed to lengthen the soft tissues two millimeters per day. Range-of-motion exercises for the knee were initiated on post-operative day one. The post-operative course was uneventful with no signs of pin tract infection. The family complied with the daily adjustments for three weeks, but during the final week the adjustments were performed every other day due to patient's decreased ability to tolerate the adjustments. After four total weeks of treatment with the TSF, the patient returned to the operating room for removal of the fixator as well as definitive fixation of the patella sleeve fracture.

At the second procedure, the olive wires and TSF were removed. The prior surgical incision was used to gain access to the fracture site, and both fracture fragments were debrided to healthy, bleeding bone. Fracture fixation was performed via tension band wiring (Fig. 4). Inspection of the extensor mechanism revealed the lateral third of the patellar tendon to be damaged by the olive wire. We decided to augment the repair with a semitendinosus autograft to reduce the risk of future tendon rupture. Under direct fluoroscopy, the fixed patella fracture was stable through knee range-of-motion from full extension to 100° of flexion with no evidence of gapping at the fracture site.

Post-operatively the patient was started in a formal physical therapy program consisting of isometric strengthening, passive extension only, and passive and active-assisted prone flexions from zero to 30° for the first week increasing by 10° per week. He initially was limited to 50% weight bearing in a knee immobilizer, and advanced to full weight bearing after one month. By nine months follow-up the patient had an extensor lag of less than five degrees and an active range of motion from zero to 120°. At this time he started to participate in sports and physical activities that he was unable to prior to surgery. At 18 months post-op the patient had symmetric active and passive knee ranges of motion from zero to 130°. At final follow-up 72-months after the definitive fixation, the patient reported no knee pain and a full return to all pre-injury activities and recreational sports without problems or deficiencies. His physical exam was notable for mild quadriceps atrophy and patella alta without patellar instability. Active knee range-of-motion was from five degrees of hyperextension to 140° of flexion. Radiographs showed a well-healed patella and maintained hardware (Fig. 5). On subjective outcome measures at 72-months, the patient had a Lysholm score of 95, Tegner activity level of seven, and knee injury and osteoarthritis outcome score (KOOS) of 94.0. For comparison, the patient reported a pre-injury Tegner activity level of seven and Lysholm score of 100.

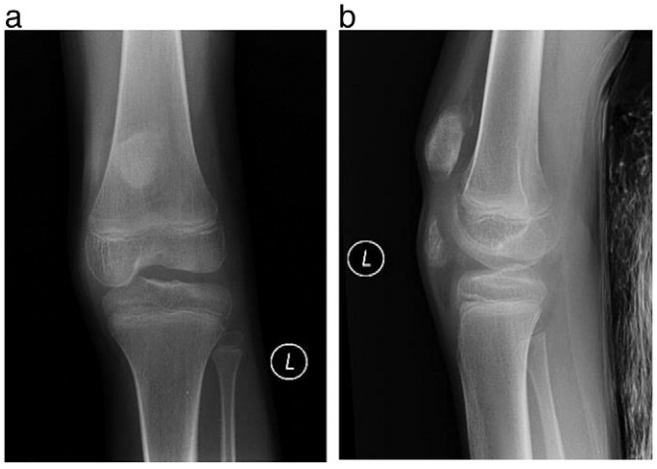

Fig. 1. Anteroposterior (a) and lateral (b) view radiographs taken at time of presentation to our institution, six months after the initial injury. Demonstrated is a 23-mm gap between the patella and the ossified patellar sleeve fracture fragment.

3. Discussion

The patella begins to ossify at age three, and the pattern of ossification leaves a rim of soft, osseo-potent cartilage around the patella. Injury to the extensor mechanism in adolescents is more likely to avulse the cartilage or neo-bone rather than rupture the tendon [3]. In patellar sleeve fractures, the avulsed fragment contains articular cartilage on the deep surface and periosteum and cartilage on the superficial surface. Occasionally a small fragment of avulsed bone is the only visible finding on plain radiographs. The absence or obscurity of this fragment can lead to a missed injury or underestimating the severity of the injury [12]. Despite seemingly normal radiographs, patients may have difficulty bearing weight, decreased active extension, and an effusion [8]. Keen clinical judgment warrants an ultrasound or MRI of the knee to obtain a diagnosis [3,6].

The goal of treatment in the acute setting is to restore length of the patellar tendon and therefore reduce the patella alta [3]. While closed treatment in a cylinder cast is justified for non-displaced fractures, the results are often unsatisfactory and are associated with weakness of the extensor mechanism and ossification of the patellar tendon [5,9].