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CASE REPORT

Femoral avulsion fracture of the anterior cruciate ligament in an 11-year-old girl

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Case history

An 11-year-old girl injured her right knee falling from a horse with her foot briefly caught in the stirrup. Her knee was immediately swollen and very painful and she was unable to walk on it.

Physical examination revealed a haemarthrosis and her knee was held in 90° of flexion. The knee was too painful and swollen to examine the cruciate and collateral ligaments. On AP- and lateral radiographs, the fracture could not be identified (Fig. 1A and B), but an intercondylar notch view showed an avulsion fracture of the femoral condyle at the site of origin of the anterior cruciate ligament (ACL) (Fig. 1C).

She was initially immobilised in an extension-brace for 4 weeks in which she was allowed to walk. For the next 4 weeks she wore a brace with range of motion limited to 10—80° to protect the ACL. After 6 weeks however we decided to perform an arthroscopy because of pain, laxity and swelling of the knee. Radiographs (AP, lateral and intercondylar notch view), taken at that stage, still showed the fracture line. During examination under anaesthesia, there was increased laxity of the right knee compared to the contralateral knee, but a firm stop was found at the end of the anteroposterior drawer and Lachman tests. The knee was stable to valgus and varus. At arthroscopy, no concomitant damage to the cartilage or menisci was identified and the avulsed fragment had healed with minimal displacement (Fig. 2), so we felt there was no need for fixation of the fragment. Further treatment was with intense physiotherapy consisting of passive and active mobilisation and strengthening exercises of the quadriceps and hamstrings muscles to improve the stability of the knee.

After 6 months there was a painless knee with a full range of motion, and slight laxity of the ACL but with a firm stop. Two years after the injury, there were no limitations in daily living, no complaints of instability and she has returned to her sporting activities (horse riding and gymnastics at school). Re-examination of the knee at 2 years of follow up did not show a difference in laxity in the AP and collateral directions. Unfortunately, K1000 measurements were not available in our hospital.

Discussion

ACL injury is uncommon in children, especially under 12 years of age. Andrish et al. found a 0.5% incidence of ACL-lesions.[2] In contrast, diagnostic arthroscopy in children under 12 years with acute traumatic knee haemarthrosis showed a 47% incidence of ACL tears.[10] Lo et al. found avulsion fractures of the ACL under the age of 12 years in 80% of

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Figure 1

cases and interstitial injury in 90% above this age.[7] These figures are reported by tertiary referral institutions and may be an overestimation of the incidence of ACL injury.

Although much literature is present about ACL-lesions in children, there are only very few case reports which describe the proximal avulsion fracture of the ACL.[3–5]

These case reports describe two patients of 3 years old and one of 7 years old. These young children are known to have strong ligaments in comparison to the insertions. Our patient is rela-

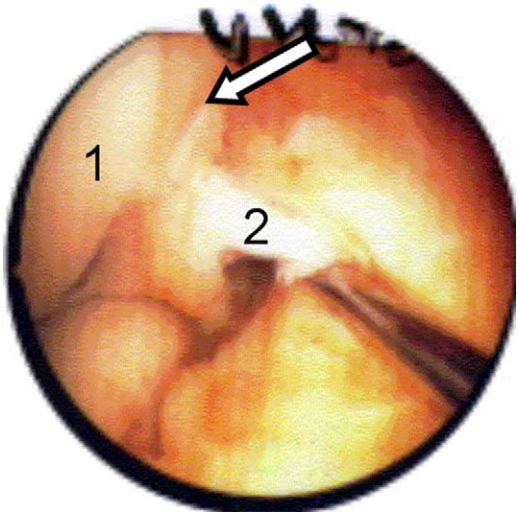

Figure 2

tively old in comparison to the other cases presented. In all patients the injury was missed at first presentation, because the standard radiographs were normal. This shows the importance of an additional notch view. In one patient the fragment was reinserted because of dislocation, no exact measurement of dislocation was mentioned. From these few case-reports there is no standard therapy strategy to suggest conservative treatment or surgical fixation of the fragment.

The ACL is the primary stabiliser of ventral translation of the tibia, and it is a secondary medial stabiliser. It consists of two bundles, the anteromedial and the posterolateral. The posterolateral bundle is more stretched in extension and the anteromedial bundle in flexion.[1] The femoral origin is attached to the lateral condylar epiphysis, the tibial insertion is posterior to the aspect of the physis at the intercondylar notch.[2] The mechanism of injury is often difficult to detect in children as they cannot remember exactly what happened. Hyperextension trauma with a rotation component is a typical cause of ACL-injuries in children.[2] Kawate described a case of a femoral avulsion of the ACL in a 3-year-old boy who sustained a hyperflexion injury, combined with internal rotation.[5]

When falling off a horse with one foot stuck in a stirrup, hyperflexion may be more likely to occur than hyperextension so we think that our patient may have had a similar injury to the one described by Kawate. It still remains unclear why tibial avulsions occur more frequently than femoral avulsion fractures. One possible explanation may be that the physis of the tibial eminence in the intercondylar notch, which is an apophysis, is weaker than the physis of the distal femur.

The physical examination in children does not differ from that in adults, consisting of the anterior drawer, pivot shift and Lachmann's tests. It can be difficult to examine a child if they cannot relax. On the other hand, the physiological laxity in children can give the impression of pathologic laxity,[2] so comparison with the contralateral knee is important.

Radiographs need to be taken to demonstrate avulsion fractures. Standard radiographs usually include AP and lateral views, but the femoral avulsion fracture in our patient was only seen on the notch view. If there is a suspicion of an ACL-lesion, we, like Wasilewski,[11] recommend taking a notch view.

MRI has been proposed as a non-invasive diagnostic tool, with a high sensitivity for intra-articular lesions,[9] but it depends on the interpreter and the cooperation of the child. Physical examination of the knee in children, in comparison with MRI, was just as sensitive when compared to arthroscopy afterwards.[6] Arthroscopy is invasive, but it can accurately determine the diagnosis and combine surgical treatment.

Meyers and McKeever described a classification for tibial avulsion fractures, based on a lateral radiograph (Fig. 3). Type I and II can be treated conservatively. No classification has been described for femoral avulsion fractures, so there is no clear treatment strategy.

Although the injury in our patient was in a different location, we adapted the Meyers and McKeever classification. Our patient showed only a little step off and good apposition of the fragment to the femoral condyle. We classified this fracture as type II, analogous to the tibial avulsion fractures. We therefore decided to treat our patient conservatively, which meant immobilisation for 4 weeks in an extension plaster cast and 4 weeks in a brace. This is according to the recommended treatment for type I–II fractures.[8]

Type I -	Minimal displacement of avulsed fragment with excellent bony apposition
Type II -	Displacement of the anterior third or half (with intact posterior hinge) with production of a beak-like deformity on the lateral radiograph
Type III -	Fragment of bone completely separated from its bone bed in the intercondylar eminence with no bony apposition

Figure 3 Meyers and McKeever classification of fractures of the intercondylar eminence of the tibia.

Femoral avulsion fractures are rare. The true incidence is probably lower than Stanistki mentioned due to a selection bias, assuming that not all children with acute knee trauma should undergo surgery, but will increase when notch views will be taken if there is a joint effusion or haemarthrosis of the knee, because these injuries are missed on the standard views.

References

1. Amis AA, Dawkins GP. Functional anatomy of the anterior cruciate ligament. fibre bundle action to ligament replacements and injuries. J Bone Joint Surg Br 1991;73:260—7.
2. Andrish JT. Anterior cruciate ligament injuries in the skeletally immature patient. Am J Orthop 2001;30:103—10.
3. Corso SJ, Whipple TL. Avulsion of the femoral attachment of the anterior cruciate ligament in a 3-year-old boy. Arthroscopy 1996;12(1):95—8.
4. Eady JL, Cardenas CD, Sopa D. Avulsion of the femoral attachment of the anterior cruciate ligament in a 7-year-old chilf. A case-report. J Bone Joint Surg Am 1982;64:1376—8.
5. Kawate K, Fujisawa Y, Yajima H, Sugimoto K, Tomita Y, Takakura Y. Avulsion of the cartilaginous femoral origin of the anterior cruciate ligament in a 3-year-old child. J Bone Joint Surg Am 2004;86:1787—92.
6. Kocher MS, DiCanzio J, Zurakowski D, Mitcheli LJ. Diagnostic performance of clinical examination and selective magnetic resonance imaging in the evaluation of intraarticular knee disorders in children and adolescents. Am J Sports Med 2001; 29:292—6.
7. Lo IKY, Kirkley A, Fowler PJ, Miniaci A. The outcome of operatively treated anterior cruciate ligament disruptions in the skeletally immature child. Arthroscopy 1997;13 (5):627—34.
8. Meyers MH, McKeever FM. Fracture of the intercondylar eminence of the tibia. J Bone Joint Surg Am 1959;41:209—22.
9. Reddy P, Posteraro R, Schenck R. The role of MRI in evaluation of the cruciate ligaments in knee dislocations. Orthopedics 1996;19:166—70.
10. Stanitski CL, Harvell JC, Fu F. Observations on acute knee hemarthrosis in children and adolescents. J Pediatr Orthop 1993;13(4):506—10.
11. Wasilewski SA, Frankl U. Osteochondral avulsion fracture of femoral insertion of the anterior cruciate ligament. Am J Sports Med 1992;20(2):224—6.