Surgical treatment of anterior cruciate ligament avulsion injuries in skeletally immature patients by cerclage wire loop technique

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Introduction
Tibial eminence avulsion fracture is the pediatric equivalent to a midsubstance anterior cruciate ligament (ACL) injury. It is most common between the ages of 8 and 19 years.
Patients and methods
From June 2009 to December 2012, 26 patients with ACL avulsion fractures were submitted to surgical treatment by means of a cerclage stainless steel wire loop. Seventeen patients were male and nine were female. Their ages ranged from 8 to 15 (mean: 12) years, and they were followed up for 6–22 (mean: 16) months.
Results
The Meyers & McKeever and Zaricznyj classifications were used for evaluating fractures for surgery. Radiographs in two views are often sufficient to establish a diagnosis. Cases were evaluated clinically by means of the anterior drawer test, which was negative in 21 patients, whereas four patients had residual laxity of about 2–3 mm increased manual anteroposterior tibial translation compared with the contralateral knee, without subjective feeling of instability. According to the Lyslholm scoring system excellent and good results were achieved in 24 (92%) cases, two patients showed fair results, and there were no poor results.
Conclusion
The use of a stainless steel wire loop cerclage by open technique gives excellent results, with benefits such as capture and control tension on ACL on each side of the avulsed fragment proper and adequate mechanical strength.

Keywords:
anterior cruciate ligament avulsion, cerclage loop wire, immature patients

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Introduction

Injuries of the anterior cruciate ligament (ACL) in children and adolescents were considered rare years ago. Some believed that complete ACL disruption occurs only after growth plate closure [1]. Avulsion fractures of the tibial spine occur more frequently in children than in adults. Skak and colleagues reported an annual incidence of three per 100 000 children. However, this number is increasing because of an increase in the number of young children participating in sports activities [2]. In skeletally immature individuals, because ligamentous structures are stronger than their osseous attachments, intrasubstance injuries are rare [3]. Therefore injuries that stress the ACL result in chondral or osteochonral avulsion fractures from the tibial attachment of the ligament [4]. Poncetin in 1985 was probably the first person to document these types of injuries [5] and it was only in 1959 that Myeres and Mckeever [6] described a case of surgical management of type II injuries. These injuries are commonly seen in children aged 8–13 years, with growing evidence that ACL avulsion injuries in skeletally immature children are more common than previously thought and a poor outcome is associated with conservative management [7]. The goals of treatment are anatomical reduction of displaced fragment to achieve continuity of the ACL fibers, while removing any block to reduction, like bony fragments, intermeniscal ligament, or meniscus adequate rigid fixation, which allows early range of motion exercises, and elimination of the extension block and impingement due to displaced fragment [8].

Patients and methods

From June 2009 to December 2012, twenty six patients with ACL avulsion fractures were submitted to surgical treatment with a cerclage stainless steel wire loop in Misr University For Science And Technology Teaching Hospital and were followed up for 6–22 (mean: 16) months. The follow-up intervals were 3 weeks (early complications), 3 months (union and complications), and 6 months (union, complications, and return to work) postoperatively. Seventeen were male and nine

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[9] were female; patients ages ranged from 8 to 15 (mean: 12) years. The most common injuries were secondary to sports participation, such as playing football, bicycling, and running. Road traffic and motor car accidents were the mode of trauma in the rest of the cases.

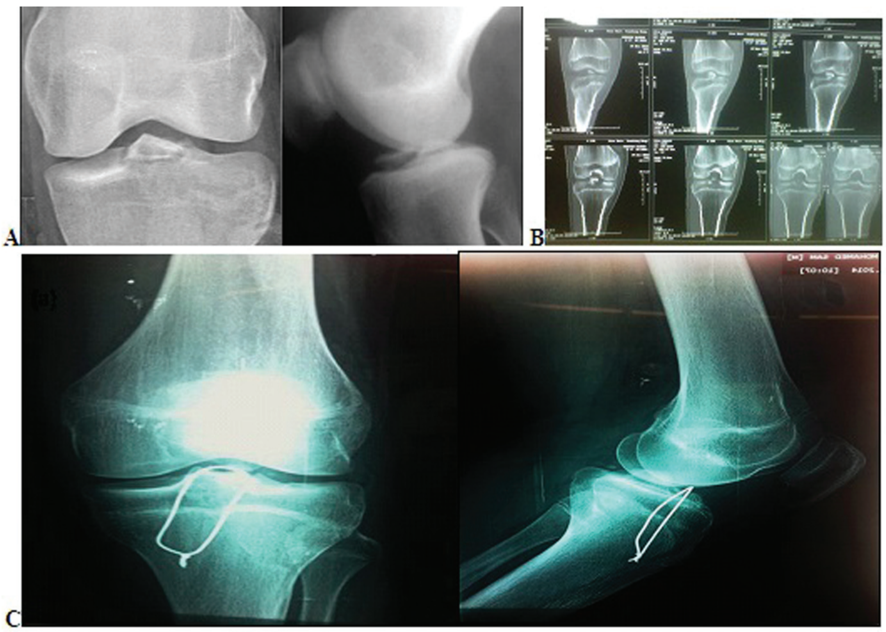
The injuries were diagnosed by means of plain radiographs of the knee joint in anteroposterior and lateral views, and by clinical examination. All patients presented with hemoarthrosis and limitation of range of motion, and had positive Lachman's test results. In this study, no associated ligaments or meniscal injuries requiring surgical intervention were detected. Fractures were classified according to Myeres and Mckeever's classification [6]: four cases were type II, 19 were type III, and three were type IV by Zaricznyj [9]. The mean interval from injury to surgery was 5 (range: 2–21) days.

Patients were assessed by Lysholm functional knee score as excellent (100–95 points), good (84–94 points), fair (65–83 points), or poor (<64 points) [10]. Range of motion, limb malalignment, and shortening were assessed, and stability of the knee was clinically evaluated by the anterior drawer test. Quadriceps wasting was also measured. Follow-up anteroposterior and lateral radiographs were assessed for fracture reduction, union, and loop wire position.

Operative technique

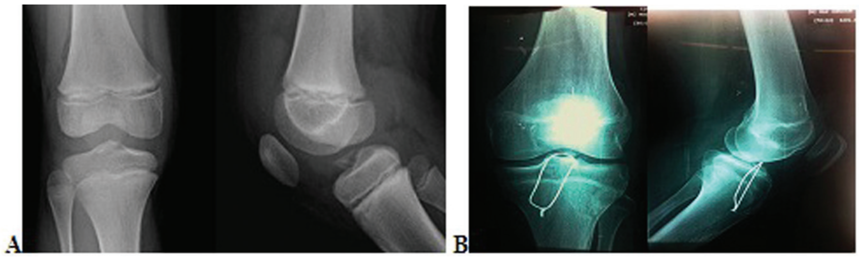
The patient was positioned supine. A single dose of iv cephalosporin was administered before inflation of a high thigh tourniquet. The knee was examined under anesthesia to confirm the diagnosis. The knee joint was exposed through a medial parapatellar approach. The joint was cleared of blood and debris. The avulsed fragment bed was cleaned of clots and bony fragments. If a part of the meniscus or the intermeniscal ligament had flipped, the fragment was lifted by a hook and positioned in its anatomical place. The fragment was then reduced and held in position either by a temporary K-wire or by an ACL tibial guidewire. In comminuted cases of type IV it was merely pressed with a finger. Two drill holes, 5 cm apart, were made with a 2.7 mm drill pit, starting medial to the tibial tubercle and passing obliquely and superiorly to emerge in the avulsed fragment if sizable, or on either side around if it was small or comminuted. A stainless steel wire was then passed through the holes. The two ends were pulled distally, reducing and fixing the bony fragment, and tensioned over the bony base on the medial side of the tibia. Complete homeostasis was achieved, and the wound was closed over a suction drain. A plaster of paris cast was applied above the knee, and the drain was removed after 48 h. The mean length of hospital stay was 2 (range: 0–4) days. Stitches were removed at 14 days postoperatively. At 4 weeks the cast was removed and gradual knee flexion up to 90° was allowed. Quadriceps and hamstring exercises were started, and at 8 weeks the patient returned to activities (Figs 1 and 2).

Figure 1



Case presentation: (a) Plain radiography in anterioposterior (AP) and lateral (preoperative) views of a 14-year-old boy with anterior cruciate ligament avulsion fracture injury; (b) preoperative computed tomography; (c) postoperative AP and lateral radiographs

Figure 2



Case presentation: A 15-year-old boy with anterior cruciate ligament avulsion fracture injury. (a) preoperative anterioposterior (AP) and lateral radiographs; (b) postoperative AP and lateral views

Results

All patients regained full extension, and flexion ranged from 120° to 140° at the final follow-up. None of them had a hypersensitive scar causing discomfort on kneeling. Two patients had quadriceps wasting 30–40 mm, respectively, which improved with physiotherapy. Anterior drawar test was negative in 21 patients, whereas four patients had residual laxity of about 2–3 mm increased manual anteroposterior tibial translation compared with the contralateral knee without subjective feeling of instability. None of them had symptoms of giving way on daily activities and all of them returned to their preinjury activity level. According to the Lyslholm scoring system excellent and good results were achieved in 24 (92%) cases, two patients showed fair results, and there were no poor results. Radiographic assessment shows that the position achieved after surgery was maintained with sound union. No angular deformity or growth disturbance was reported. Three cases needed cerclage wire removal at an average 2–3 years postoperatively, which was done by a small incision over the medial knot and the stainless steel wire was pulled out.

Discussion

Biomechanical studies have demonstrated that ligament failure characteristics are influenced by overall age and skeletal immaturity. In young age, the epiphyseal bone offers less resistance to traction forces than does the ACL substance. This lower resistance can generate these fractures [11]. Similar loads cause rupture of the ligament in adults, making these injuries less common in adults [12]. ACL avulsion fractures cause knee instability, and the interarticular fragment may cause mechanical block to knee flexion and extension. Most authors agree that anatomical reduction and stable internal fixation are required to restore normal knee biomechanics [13–16]. Treatment of avulsion fractures of tibial eminence has evolved over time, starting with conservative management and progressing to open or arthroscopic reduction. However, the debate regarding the better approach is still under debate. The first applications of arthroscopy to intra-articular fractures were reported as limited services or techniqual notes in the early 1990s, with the advantages of being less invasive, causing less soft tissue damage, and resulting in shorter hospital stay [17–20]. However, follow-up studies have demonstrated a disturbing amount of residual laxity after arthroscopic treatment [21–25]. Several factors are likely responsible for residual laxity: plastic deformation of the ACL before ultimate fracture may lead to an elongated ligament [26]; the arthroscopic technique is complicated and techniqually demanding and hence improper reduction may result in nonunion, which could lengthen the ACL complex; and secondary dislocation of the bone fragment attributable to insufficient fixation techniques or aggressive rehabilitation [15,17–19,21,22]. Nevertheless, among all the available methods for surgical treatment of ACL avulsion fractures the arthroscopic pull-out method is the most widely applicable, because it can be performed in different sizes or comminution degrees, and does not require removal of internal fixation [22,27].

Several methods of fixation have been reported for the treatment of ACL avulsion injuries in immature bones, varying from antegrade, retrograde AO screws, Herbert screws, absorbable sutures, steel loop, K-wires, and tension band wiring [28]. Disadvantages with screw fixation include possible further comminution during insertion, possible impingement of the screw head during knee extension, and the requirement of a secondary procedure for screw removal [29]. Cerclage suture is also used as an alternative method [30,31]. Eggers *et al.* [32] support this technique, because in their experience suture fixation provides more biomechanical strength than does screw fixation. In another study performed by Hunter and Wills [33] assessing the stability of different methods of fixation in the form of one or two screws, ethibond, or fiberwire under cyclic loading tests, they concluded that the fiberwire was superior than other methods. In recent years, various attempts have been made to overcome the above demerits, including the usage of intra-articular suture devices and UHMWPE sutures [34,35]. In this study the use of a stainless steel wire loop cerclage by open technique achieved excellent and good results in 92% of cases, with the following benefits: capture and control tension on ACL on each side of the avulsed fragment proper; adequate mechanical strength; no need for wire removal, and if needed the ease of achieving it by means of a small incision; anatomical reduction of the avulsed fragment to its bed with removal of all soft tissue interposition like blood clots, meniscus, and intermeniscal ligament; and lower laxity [30,36]. No patients complained of subjective instability, although four patients had positive results on the Lachman test. Despite that, all of them returned to the same level of activity and none of them underwent further surgery for instability. Loss of complete extension may be due to overgrowth of the tibial spine, or due to arthrofibrosis or hardware block of range of motion, which did not occur in this study. All patients started early range of motion, at 4 weeks postoperatively, and full range was achieved in all of them.

Conclusion

The use of a stainless steel wire loop cerclage by open technique achieves excellent results in the form of capture and control tension on the ACL on each side of the avulsed fragment proper and adequate mechanical strength.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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