ARTHROSCOPIC SURGERY IN CHILDREN AND ADOLESCENT – A DOMAIN TO BE DEVELOPED

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Abstract

The application of arthroscopic surgery in children is becoming wider and a more complete understanding of its use is needed.

In this article we present our experience with arthroscopic surgery over the course of 17 months, from April 2019 until October 2020.

We diagnosed and treated minimally invasive 49 patients, with ages between 6 and 18 years old, 22 boys (44.9%) and 27 girls (55.1%). The pathologies varied, the most common being anterior cruciate ligament tears with 49 cases representing 49%, some of which also needed meniscal repair with sutures or by partial meniscectomies. Second most common condition was isolated meniscal tears in 8 patients representing 16.33% of all cases.

But the application of arthroscopic approach is not limited to the treatment of knee instability or related sports injuries. We also want to emphasize the importance of a minimal invasive treatment when it comes to lose bodies in the elbow by presenting a case of an incarcerated medial humeral epicondyle after an elbow dislocation, a case of a symptomatic os trigonum in a 14 years old swimmer or a fractured anterior calcaneal process unresponsive to the conservative treatment, tibial spine fracture in a six years old child.

The benefits of minimally invasive surgery are widely accepted among the orthopaedic surgeons, but it is yet under a lot of reluctance in the paediatric professionals because of the sometimes slow and difficult learning curve.

Keywords: arthroscopy, children, anterior cruciate ligament, epicondyle fracture, os trigonum

Introduction

Since the late 50's when arthroscopy was invented by Watanabe et all [1] the advantages of minimally invasive surgery increasingly has led to the expansion of arthroscopic procedure in adults and later in children. As many other devices, the arthroscopy tools and procedures needed to be adapted to childhood conditions and to the slower learning curves in paediatric field of orthopaedic surgery.

Virtually, all joints may be approached arthroscopically [2-4], ankle, knee, hip, elbow, shoulder, many excisional, reparative or reconstructive gestures being possible via small portals.

Unfortunately, the expansion of arthroscopic techniques in children encounters the same economic and cultural obstacles as any other new technique.

The purpose of this paper is to report our experience with the arthroscopic techniques in children.

Materials and Methods

Between April 2019 and October 2020, we used arthroscopic techniques in different paediatric conditions. Most of our arthroscopic procedures addressed the adolescent knee to reconstruct anterior cruciate ligament (ACL) or repair the menisci. Besides, some uncommon conditions were approached arthroscopically: anterior calcaneal process pseudarthrosis, removal of os trigonum, tibial eminence fracture in small child, removal of incarcerated medial epicondyle of humerus.

All cases of arthroscopic procedures in our department were identified and the data were collected afterward. The patients' charts were reviewed, the main characteristic of patients is centralised in Table 1: sex, age, type of surgery, achievement of full recovery, complications and follow-up.

Results

We performed arthroscopic surgery in 49 patients, with ages between 6 and 18 years old, with various pathologies. Of the 49 patients 22 were boys (44.9%) and 27 were girls (55.1%). There were 25 patients (49%) who required ACL repair, of which 3 (12%) also had meniscal sutures and 5 (20%) had partial meniscectomies. Of the 25 patients, 13 (52%) were boys and 12 girls (48%).

Another 8 (16.33%) patients had meniscal tears that required meniscal sutures, and 9 (18.37%) patients were treated by partial meniscectomy. Of these 17 patients, two girls, ages 8 and 13 were diagnosed with discoid meniscus.

The median age of patients who needed knee arthroscopy for ACL tear or meniscal repair was 15 years.

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Table 1: Main characteristics of study group.

Patient	Sex	Age (years)	Surgery	Joint	Complete recovery achieved	Remarks	Follow up (months)
1	F	12	Meniscectomy	Right Knee	yes		20
2	F	16	Meniscectomy	Right Knee	yes		20
3	M	16	ACL reconstruction + meniscectomy	Left Knee	yes		19
4	F	14	ACL reconstruction	Left Knee	yes		18
5	M	17	ACL reconstruction	Left Knee	yes		17
6	M	13	ACL reconstruction + meniscectomy	Right Knee	yes		17
7	M	15	ACL reconstruction	Right Knee	yes		17
8	M	11	Tibial eminence fixation	Right Knee	yes		4
9	F	13	Meniscectomy	Left Knee	yes		16
10	M	17	ACL reconstruction	Right Knee	no	Graft rupture	13
11	F	12	Meniscectomy	Right Knee	yes		13
12	F	14	ACL reconstruction + meniscectomy	Left Knee	yes		13
13	M	18	PCL reconstruction	Right Knee	yes		12
14	M	17	ACL reconstruction + meniscal suture	Left Knee	yes		12
15	M	16	Meniscal suture	Right Knee	yes		12
16	F	15	ACL reconstruction	Left Knee	yes		11
17	F	15	ACL reconstruction	Right Knee	yes		11
18	M	11	Meniscectomy	Right Knee	yes		11
19	M	16	Meniscectomy	Right Knee	yes		11
20	M	15	Meniscectomy	Left Knee	yes		11
21	M	16	ACL reconstruction	Left Knee	yes		10
22	F	6	Tibial eminence fixation	Left Knee	no	Incomplete range of motion	11
23	F	12	Meniscal suture	Left Knee	yes		10
24	F	12	Meniscal suture	Left Knee	yes		10
25	M	16	Loose body extraction	Right Knee	yes		10
26	F	17	ACL reconstruction	Right Knee	no	Incomplete range of motion	10
27	F	16	ACL reconstruction	Left Knee	yes		10
28	F	14	Meniscal suture	Left Knee	yes		10
29	M	17	ACL reconstruction	Right Knee	yes		10
30	F	14	ACL reconstruction	Left Knee	yes		9
31	F	15	ACL reconstruction + meniscal suture	Left Knee	yes		9

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32	F	8	Meniscal suture	Right Knee	yes		9
33	F	14	Os trigonum resection	Left Ankle	yes		10
34	M	17	Meniscal suture	Left Knee	yes		5
35	F	17	ACL reconstruction	Right Knee	yes		5
36	M	18	ACL reconstruction + meniscal suture	Left Knee	yes		5
37	M	17	ACL reconstruction + meniscectomy	Left Knee	yes		5
38	M	17	ACL reconstruction	Right Knee	yes		5
39	F	14	Anterior calcaneal process resection	Left Ankle	yes		4
40	M	15	ACL reconstruction	Right Knee	yes		3
41	F	14	Meniscal suture	Left Knee	yes		3
42	F	16	ACL reconstruction	Left Knee	yes		3
43	F	16	ACL reconstruction	Left Knee	yes		3
44	F	17	Meniscal suture	Left Knee	yes		2
45	M	17	ACL reconstruction + meniscectomy	Left Knee	no		1
46	F	17	Meniscectomy	Right Knee	no		1
47	M	11	Loose body extraction	Left Elbow	no	Incomplete range of motion	1
48	F	14	Meniscectomy	Right Knee	no		1
49	F	13	ACL reconstruction	Left Knee	no		1

Other pathologies which needed arthroscopic intervention were: knee arthroscopy for tibial spine fractures (2 patients) and for a posterior cruciate ligament rupture (1 patient), ankle arthroscopy for anterior calcaneal process fracture (1 patient) and for a symptomatic os trigonum (1 patient), elbow arthroscopy for an incarcerated medial humerus epicondyle (1 patient). We also had a case of a 16-year-old boy with multiple intraarticular loose bodies after lateral femoral condyle osteochondritis dissecans.

Time of full recovery varies on the pain threshold of each patient, but it is expected that in 6 to 8 weeks, full range of motion is acquired. In the ACL reconstruction group, we had two patients (8%) who didn't achieve full recovery, a girl because of a failure to maintain the recovery program, and a boy who suffered a graft rupture at 3 months after surgery.

The recovery of full range of motion can be more problematic when it comes to intraarticular fracture, even the ones treated minimally invasive. To this idea we have the example of a tibial spine fracture on a 6 years old girl, currently at 11 months after surgery, and an incarcerated medial epicondyle humerus fracture on a 11 years old boy, at 2 months after surgery, who have yet to achieve full range of motion.

Anterior cruciate ligament reconstruction

All surgeries were performed under pneumatic tourniquet assistance, the patient being positioned in decubitus with knee flexed at 90 degrees and hip flexed so the foot and buttock are on the same level (Figure 1.A). The technique we use in our department is based on principle of anatomical single bundle reconstruction of ACL. The autograft source was semitendinosus and gracillis tendons (Figure 1.B). The tunnels were transphyseal in all cases (Figure 1.C,D). The fixation in the femoral tunnel is made with adjustable loop and the fixation in the tibial tunnel is achieved with interference screw. The placement of tunnels is based on principle of respect of native ligaments footprints. On occasions we preferred to verify the tunnel placement with fluoroscopy according to lateral X-ray criteria of tunnel placement [5].

Suction drainage was placed in all cases and removed at 24-48 hours after surgery. The knee was immobilised in 15 degrees of flexion with an adjustable hinged knee brace. The patient was mobilised early after surgery with contact of the foot with the ground but no load for 3 weeks. The load is started after the 3rd week and progressively completed to the 6th week post-surgery. In all this time the passive and active recovery of the knee flexion is worked. The recovery protocol is started during the hospital stay and continued after discharging.

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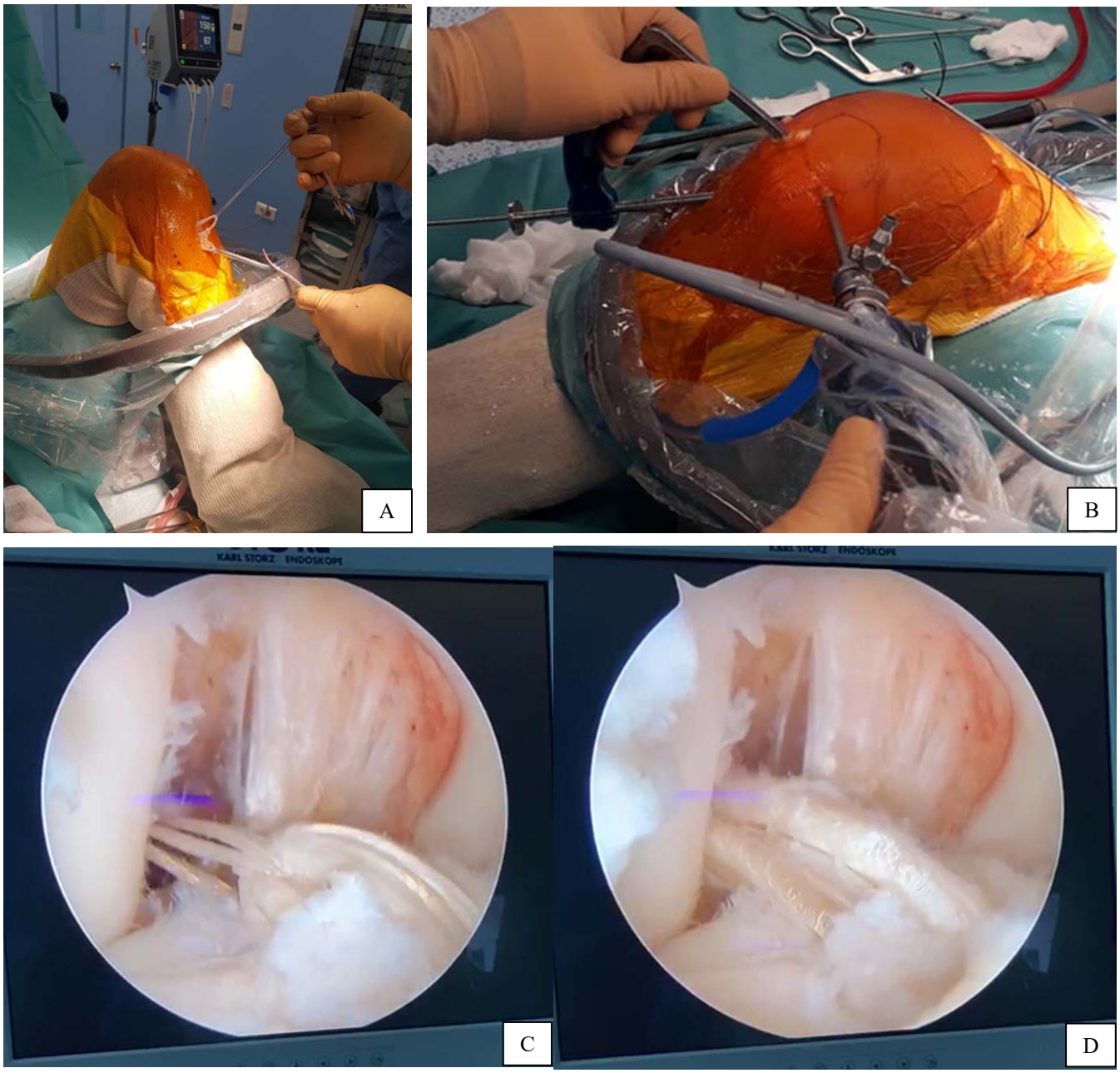

Figure 1. A - Semitendinous and gracillis tendon dissection. B - The tibial tunnel is made transphyseal. C - Intraoperative image of the right femoral notch, the graft is about to enter the joint and travel (upward and laterally) to the lateral femoral condyle, pulled by the adjustable loop. D - Intraoperative image of the right femoral notch, the graft is in place.

In some cases, the recovery treatment was assisted remotely via smart devices providing learning tools for the patient to execute passive flexion-extension of the knee with settings of time and speed that allow calibration according to the individual needs and pain threshold.

In 3 patients the ACL reconstruction was accompanied by the meniscus repair and in 5 patients the ACL reconstruction was accompanied by meniscus partial resection.

Even though complete range of motion was accomplished in one case, unadvised sport activity resulted in a graft complete tear at 3 months after arthroscopic repair. In one case the recovery protocol was not properly followed so at 10 months post-surgery the lack of 5 degrees of full extension is to be recovered.

In one case a discrete snap during knee flexion persisted for 8 months after surgery. The subjective “giving way” or “giving out” sensation of the knee disappeared in all cases.

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Os trigonum resection

A 14 year old girl, swimmer, presenting with posterior ankle impingement was operated because of important function impairment during walk and run. X-ray exam (Figure 2.A) and CT (Figure 2.B) exam were performed prior to surgery. The patient was placed in prone position. Two portals adjacent to the Achilles tendon were used. The work chamber was created prior to portals creation by injecting saline solution in the ankle. The os trigonum was identified and harvested with a motorized burr. The flexor hallucis longus was exposed during surgery. The resection was complete and the recovery was fast (Figure 2.C,D). At 48 hours after surgery the patient was able to walk on heals and on tiptoes without any pain. Very discrete hemarthrosis was present.

Figure 2. A - Lateral view of the ankle on the X-ray demonstrating the presence of os trigonum. B - Figure 2.b: CT scan examination of os trigonum. C - Postoperative X-ray of the ankle, showing good resection of os trigonum. D - The osteocartilaginous fragment removed from the ankle joint.

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Anterior calcaneal process pseudarthrosis

A 14 years old girl presented in our department with chronic pain of the midfoot, without known history of trauma. The pain was provoked by medium walking, 500-1000 meters, since few months. Clinical examination revealed fixed pain corresponding to a point 2 centimetres in front of the sinus tarsi. The subtalar joint mobilisation and the attempt to mobilise the Chopart joint triggered the pain corresponding to anterior calcaneal process. The X-ray (Figure 3. A) and CT (Figure 3. B,C) scan revealed a small bony fragment seeming to be avulsed from the anterior calcaneal process. We described this as an old fracture with no signs of healing. An immobilisation with short leg cast was recommended. After 6 weeks of immobilisation no signs of healing process or symptoms improvement were identified and we recommended the arthroscopic removal of the avulsed fragment. The operation was performed arthroscopically under fluoroscopy (Figure 3. D,E). The avulsed fragment was removed with a burr. The recovery process was started immediately after surgery. Full weight bearing of operated foot was authorized 3 weeks after surgery with no pain. The tolerance to long distance walks returned to normal.

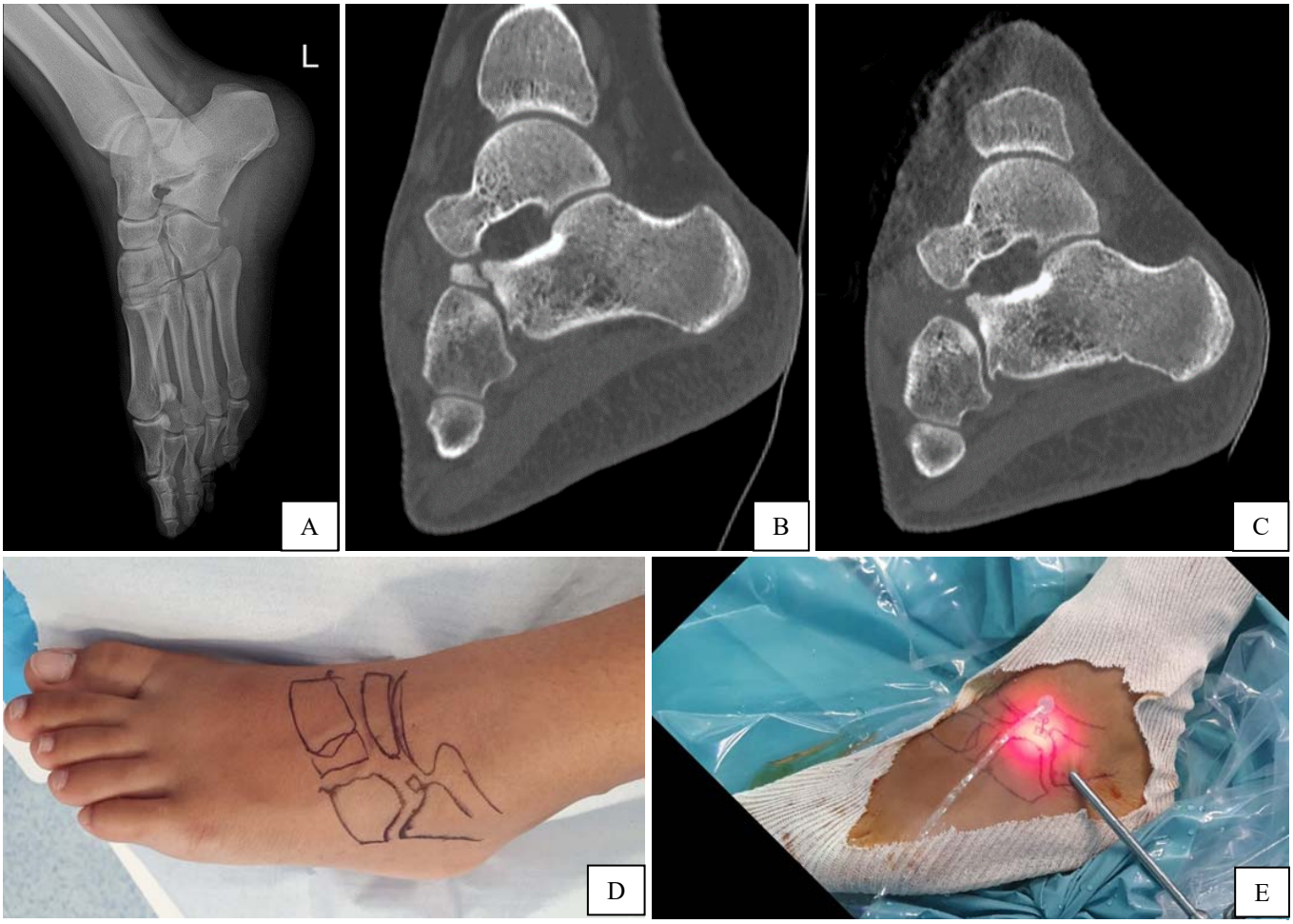

Figure 3. A - Anterior calcanean process is fractured, visible at X-ray exam. B - Preoperative CT scan demonstrating the fracture of anterior calcaneal process. C - Postoperative CT scan examination, the intraarticular fragment was completely removed. D - Intraoperative landmarks identified under fluoroscopy. E - Intraoperative aspect of portal placement to remove the anterior calcaneal process.

Tibial spine fracture

A 6 years old girl was referred to our service one week after a fall from toboggan, presenting a type IV Meyers and McKeever tibial spine fracture (Figure 4. A). An arthroscopic assisted transphyseal fixation with nonabsorbable suture and anterior button was performed. Intraoperative exploration revealed the anterior horn of medial meniscus incarcerated. The fixation material was removed 3 months after the surgery. The recovery has begun 3 weeks after surgery and was disrupted due to pandemics rush. The flexion recovered slowly, at 10 months after surgery 20 degrees of flexion is to be recovered. Postoperative CT showed good integration of avulsed bony fragment (Figure 4. B).

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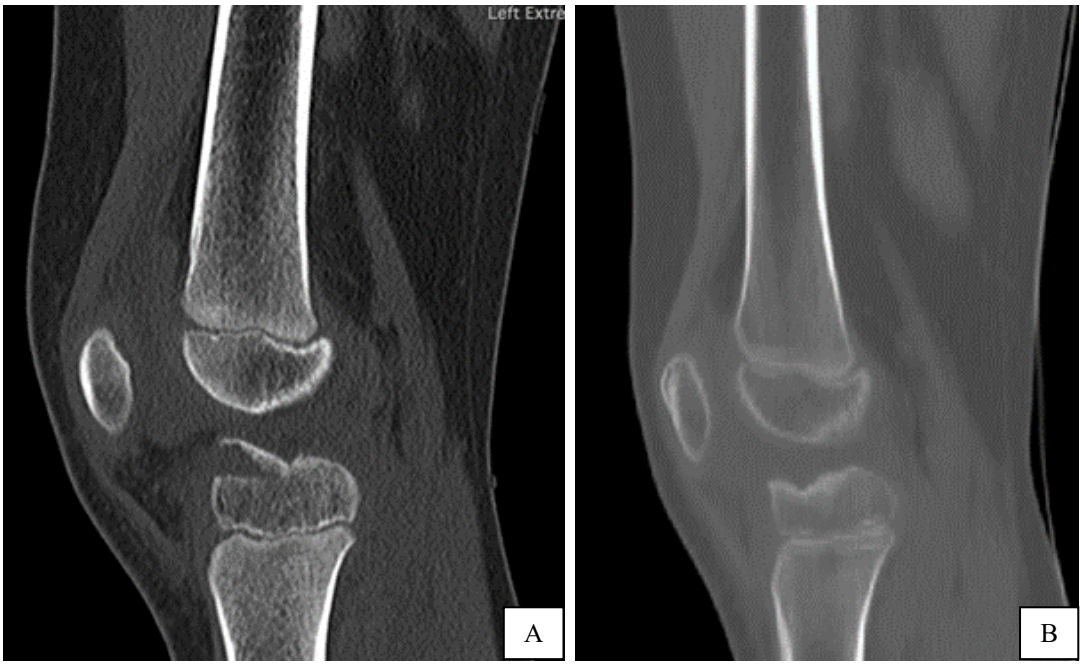

Figure 4. A Preoperative CT scan demonstrating displaced tibial spine fracture in 6 years old girl. B - Postoperative CT scan at 6 months follow-up demonstrating good integration of avulsed fragment.

Humerus medial epicondyle removal

An 11 years old boy presented in our department with fixed stiff elbow and a misdiagnosed fracture of medial epicondyle of left humerus, after 4 weeks of immobilisation because an elbow dislocation (Figure 5. A). The CT scan and MRI exam revealed the incarceration of an osteochondral fragment of the medial epicondyle into the humeroulnar joint. The removal of the fragment was performed arthroscopically via posteromedial and posterolateral portals (Figure 5. B). Intraoperatively we discovered a small defect in the olecranon articular surface; a reparation procedure was considered unnecessary (Figure 6. A,B). The stiffness changed rapidly postoperatively from fixed to elastic. The recovery is ongoing, the patient gained 90 degrees of mobility during the first month postoperatively. The elbow is stable and nonpainful.

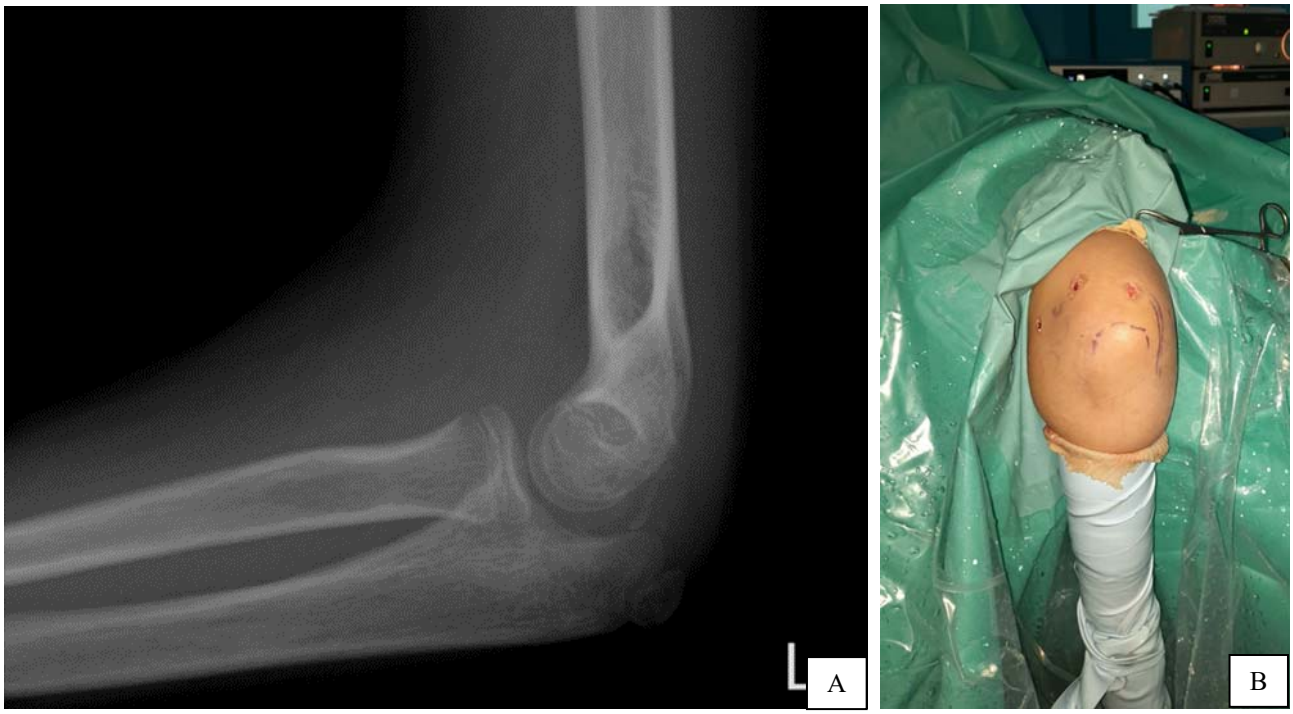

Figure 5. A - Humeroulnar subluxation secondary to incarceration of osteochondral medial epicondyle fragment. B - Portals placement for elbow arthroscopy.

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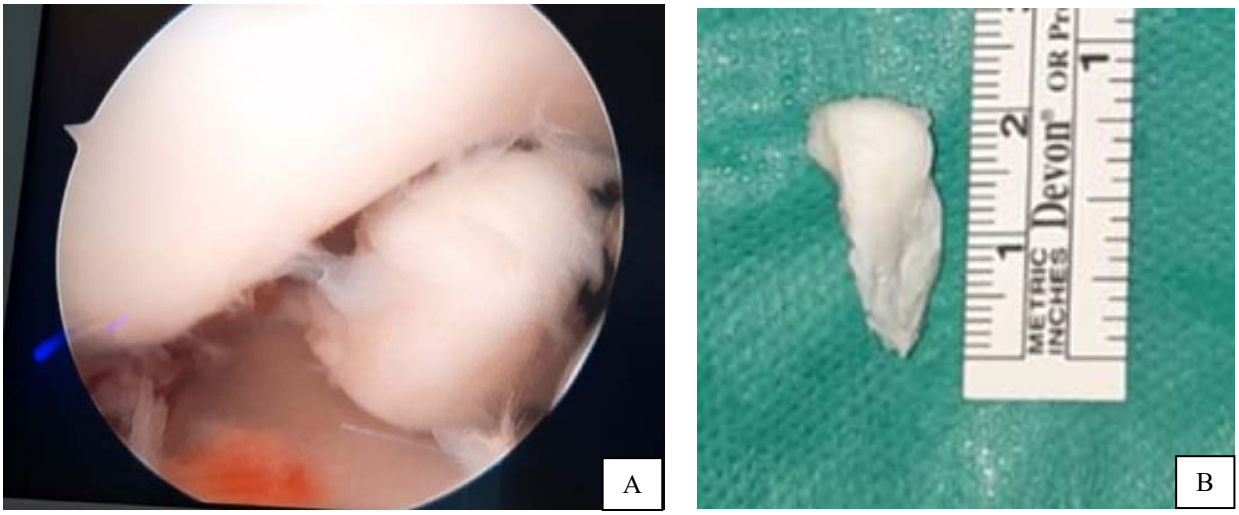

Figure 6. A - Intraoperative aspect demonstrating the large osteochondral fragment trapped between the humeral trochlea and olecranon. B - Osteochondral fragment removed from the elbow joint.

Discussion

ACL reconstruction in paediatric population was subject of debate. Few aspects of ACL tears diagnosis and treatment were the subject of international consensus [6].

Concerning the diagnosis there are two remarks to keep in mind. When the clinical exam does not reveal instability of the knee or the MRI exam is negative the probability of having an ACL injury is low; on the other hand, the positive clinical examination or MRI exam cannot rule in an ACL tear in all cases. However, the decision making should not rely on one single test or examination technique.

One of the concerns raised by the ACL reconstruction is the physeal injury during tunnel creation. The international consensus [6] agreed the transphyseal techniques may be used in paediatric patients with the condition of not to place rigid plugs (bone or screws) in the growth plate. The soft tissue occupying the tunnel is protective against the development of bony bridges and growth disturbances.

The moment to return to sport activities is another topic of debate. Two numbers should be emphasized. The duration of rehabilitation procedure should continue at least 9 months after the surgery. Returning to pivot activities should be delayed after 12th months post-surgery [6] given high risk of re-rupture during the first 12 months after surgery.

Posterior ankle impingement syndrome is a recently entity approached with arthroscopic tools[7]. The condition is generated by the mechanical conflict in the rear ankle. Removal of os trigonum is reserved for people engaged in athletic activities or if the conservative treatment has failed. Despite the small space to work and the neighbourhood of the posterior tibial bundle the technique is reliable giving good access and even better visualisation than open technique. Yasui [7] described a four staged systematic arthroscopic approach to the posterior ankle. After a systematic inspection of the ankle the fragment is removed with a burr.

The technique we used in the treatment of anterior calcaneal process pain syndrome was inspired by the treatment of calcaneonavicular coalition [8]. However, the mechanism we illustrated in this case may be part of TLAP syndrome[9]. Given the fibrous attachment on the fragment we found during surgery a fracture secondary to fibrous calcaneonavicular coalition is highly probable. Few open or miniopen techniques are described to remove the calcaneonavicular coalition [10]. Arthroscopy is an attractive method given the minimisation of the articular instability of the midfoot joint secondary to surgical approach.

Displaced tibial eminence fracture in children is a rare condition requiring surgical treatment. The choosing of hardware fixation is limited by the presence of growth plate and the poor bone quality immediately below the avulsed fragment. Transphyseal techniques are attractive due to the strength generated by the new nonabsorbable sutures [11]. We used a simplified technique and passed a suture behind the ACL, the loop was closed outside the bone, over a titanium button. The MRI showed an excellent reduction of the fracture. The slow progression of the rehabilitation pushed us to remove the implant three months after the surgery due to some skin discomfort in front of the titanium button. Arthrofibrosis is a known complication of the tibial spine fracture [12]. Early start of rehabilitation program may enhance the development of such complication. The quality of recovery is in direct relation to the quality of fixation, given the limitation of hardware volumes we can use in children, the suture fixation is a better option.

Medial epicondyle fracture in children may be easily misdiagnosed [13]. The incomplete ossification of the distal humerus at different stages of development make the diagnosis even more difficult. Advanced diagnosis tools as CT or MRI may be necessary to have a correct description of the fracture. Incarcerated medial epicondyle fracture needs early surgical treatment in order to avoid articular stiffness [14]. Elbow stiffness secondary to the elbow

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dislocation is an invalidating condition needing surgery [15] to restore the range of motion. Foreign body removal using arthroscopic tools is an attractive alternative allowing early start of rehabilitation. The case we presented in this paper is particular because of small amount of bone tissue in the avulsed fragment and difficulty of visualisation on X-ray exam and even at CT scan.

Patient comfort and duration of full recovery are indicators of quality of life after surgery. The pain is influencing considerably the recovery process, the level of pain is in direct relationship with the soft tissue damage during the surgery. Minimally invasive techniques are expected to generate less pain comparing with open surgery and consequently better quality of life after surgery. This domino effect may explain the amount of work to develop minimally invasive techniques. Given the techniques developed for small patient are based on lessons learned after the development in adult surgery a gap is appearing between the development of such techniques for paediatric patient when comparing with adults.

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