Original Research Article

Adolescent hallux valgus

Abstract

Hallux valgus is a foot deformity corresponding to the deviation of the first metatarsal in varus and the big toe in valgus

We conducted a retrospective study in the department of Pediatric Orthopedics and Traumatology at Hassan 2 University Hospital in Fez (Morocco), covering 10 feet, between January 2014 and March 2020. The average age of our patients was 14 years with female predominance. The majority of our patients complained of pain and deformities. Idiopathic origin was the most frequent.

The average of M1P1 angle was 44.08°, the M1M2 angle was 14. 05°.The mean DMAA value was 18.8°, and the mean M1M5 angle was 32.4°.

Sesamoid class 1 was found in 6 feet (60%),4 others had sesamoid class 2 (40%). 7 feet had dislocated or subluxated non-congruent metatarsophalangeal joints with a percentage of 70%. The average medial arch measurement was 110°, the average angle of attack of M1 was 20.87°.

McBride surgery was performed on 2 feet (20%). A stabilized re-axation osteotomy with Kirschner wires associated with a release of the abductor hallux was performed in 6 feet out of 8 with a percentage of 80%, in which:

- 40% had a chevron osteotomy. 30% had a Mitchell Osteotomy and 10% had a modified Scarf Osteotomy.

They resumed walking on the heel immediately with a 6weeks boot cast.

- The mean value of the M1P1 angle decreased from 44.08° pre-operatively to 15.46° post-operatively with a reduction rate of 64.92%.

The principal reasons for surgical treatment of this disease, are the pathology related to the exostosis (friction, hygroma, fistulization, corns...), anesthetic discomfort, pain related to the consequences of this deformity.

Introduction:

Hallux valgus is the most common deformity affecting the big toe, it can occur at any age even in children. It's a common deformity affecting children and adolescents with a percentage of 2 to 4% [1]. It's defined as a deformity centered on the first ray of the forefoot and characterized by an outwardly deviated big toe with a valgus more than 12° and by an inwardly displaced first metatarsal [2].

Materials and methods:

We have conductedretrospective study in the department of PediatricOrthopedics and Traumatology at Hassan 2 University Hospital in Fez, covering 10 feet, between January 2014 and March 2020.

The objective of this study is to specify the epidemiological, clinical and radiological characteristics of children with hallux valgus, to evaluate the functional, clinical and radiological results of different surgical methodsand then to identify the postoperative complications of hallux valgus in children.

Results:

The average age of our patients is 14 years (10 and 15 years). 75% of our patients were females with a sex ratio 0.33. Only one patient had a family history of hallux valgus (12.5%). In 60% of cases, the hallux valgus was idiopathic (6/10). Congenital origin was found in 30% (3/10); one case was post-traumatic. (figure 1)

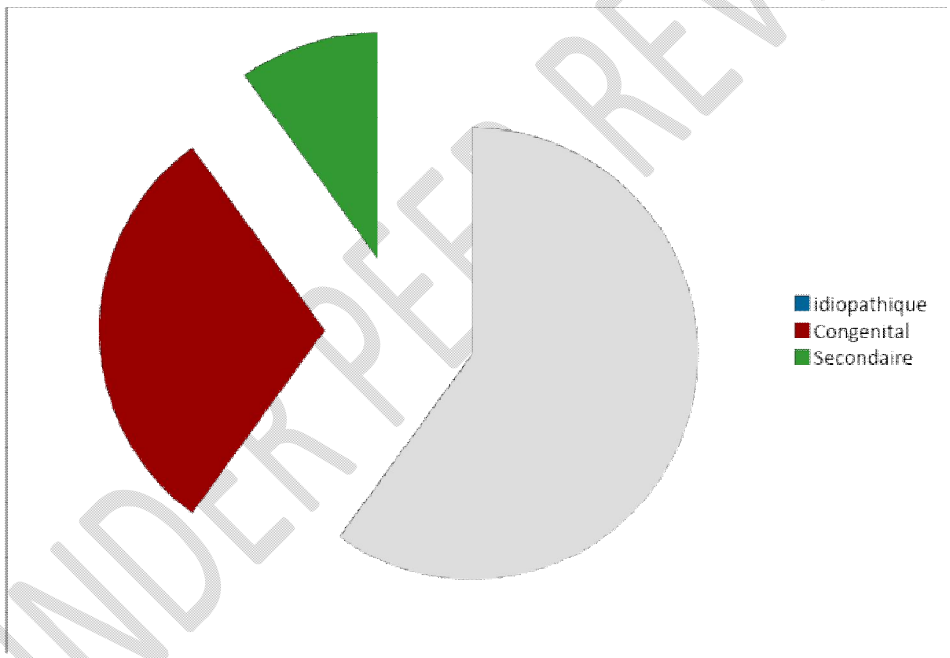


figure 1: Etiology of hallux valgus

Pain and deformity were the principal reasons for consultation, they were present in all cases, 7 of them complained of mechanical pain with a percentage of 87.5%, only one patient complained of inflammatory pain (table 1).

Functional symptoms	Percentage
Pain	100%
Deformity	100%
Walking disorder	12.5%
Discomfort in footwear	75%
Metatarsalgia	12.5%

table 1: percentage of different clinical signs

Six of 10 feet were Greek (60%), 4 Egyptian (40%), no square foot was noted, as well as static disorders of the forefoot. Hallux valgus is the cause of several lesions of the soft parts of the forefoot which are generally absent in children. In our series, only one patient had bursitis, and no patient had hyperkeratosis or callus.

Radiologically, the mean M1P1 angle was 44.08° with a standard deviation of 11.09° and extremes ranging from 20° to 58.7° (Graph 1). The mean value of the M1M2 angle was 14.05° with a standard deviation of 2.49° and extremes ranging from 11° to 18.9° (Graph 2). The mean DMAA value was 18.8° with a standard deviation of 7.61° andextremes ranging from 8° to 30. The mean M1M5 angle was 32.4° withstandard deviation of 7.72° with extremes ranging from 22° to 48° with a median of 30.5°. (Graph 3)

A sesamoidclass I was found in 6 feet with a percentage of 60%, while 4 others had a sesamoid class II with a percentage of 40%. 7 feet had dislocated or subluxated noncongruent MTP joints with a percentage of 70%. The average medial arch measurement was 110° with extremes ranging from 98° to 125°, theaverageangle of attack of M1 was 20.87°, with extremes ranging from 12° to 34°.

Various surgical procedures were performed (Figure 1); conservative McBride surgical treatment was performed in 2 feet (20%), they had moderate hallux valgus, the average M1P1 angle was27°. Other procedures were associated with this operation, such as exostosectomy of the metatarsal head, capsulotomy, and capsulorraphy.

A stabilized reaxation osteotomy with Kirshner wires (figure 2), associated with a release of the abductor hallux, was performed in 6 of 8 feet with a percentage of 80%, in which:

- 40% had a chevron osteotomy, the line describes a metaphyseal-epiphyseal L describing an acute angle. (figure 3)

- 30% of a Mitchell Osteotomy, it was used in young patients with painful hallux and moderate valgus. This classic technique is replaced by the modified Mitchell which instead of making a 90° bone cut with the axis of the metatarsal, an angulation of the osteotomyabout 30° is made (figure4),

- and 10% of a modified Scarf osteotomy, the line is oblique to the medial side of the 1st metatarsal, the fixation was ensured by 2 Kirchner wires (figure 5).

In our series, the resumption of walking was immediate on the heel with a 6weeks boot cast. None of our patients wore total forefoot relief shoes. A radiological check-up was performed in the immediatepostop to evaluate the angular corrections of our patients, which were as follows:

-The mean value of the M1P1 angle went from 44.08° preoperatively to 15.46° postoperatively with a reduction rate of 64.92%.

-The mean value of the DMAA angle decreased from 18.8° preoperatively to 6.3° postoperatively with a reduction rate of 66.48%.

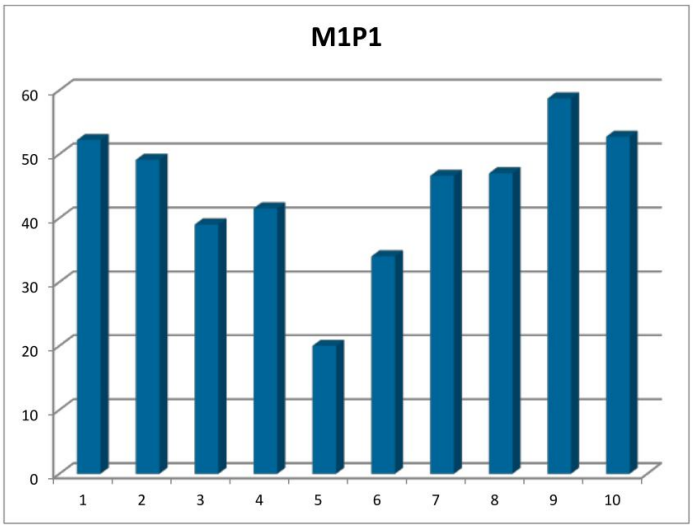
-The mean value of the M1M5 angle decreased from 32.4° preoperatively to 23.3° postoperatively with a reduction rate of 28%.

Sutures and dressings were removed between the 10th and 15th day depending on the tissue healing.

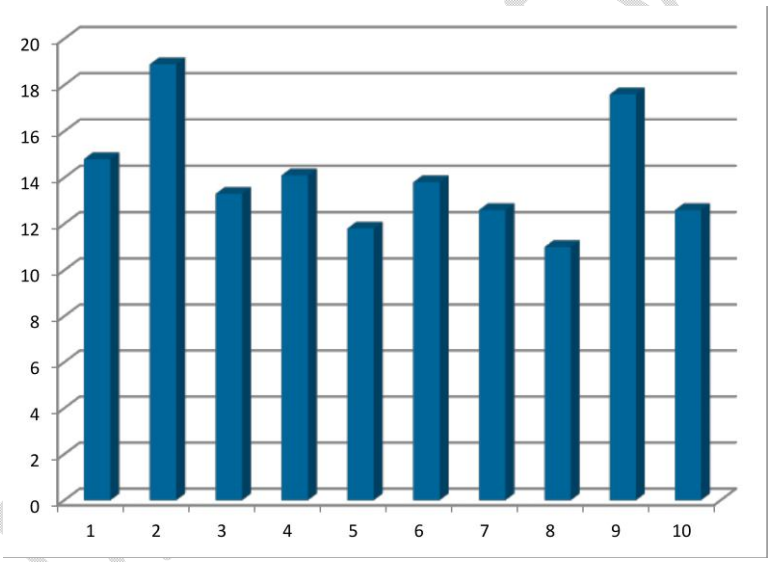
concerning the Kitakoka score: preoperatively it was lower than 60/100, with an average of 52.3/100 and a standard deviation of 8.1% and values ranging from 45/100 to 56/100

postoperatively the mean value of the score increased to 92/100 with a standard deviation of 5.37% and extreme values ranging from 80/100 to 100/100

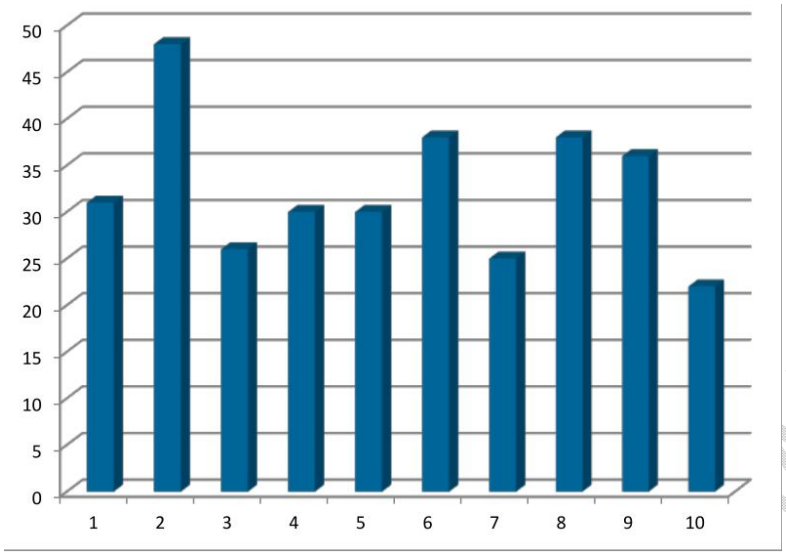
Residual pain and recurrence were observed in one case.



Graph 1: Histogram representing the values of the M1P1 angle.



Graph 2: Histogram representing the values of the M1M2 angle.



Graph 3: Histogram representing the values of the M1M5 angle.

figure 2: percentage of different surgical procedures

Figure 3: Frontal incidence showing a hallux valgus before, and immediate postoperative and 2 months after the chevron procedure stabilized by two crosswise Kirshner wires.

Figure 4: X-ray of the left forefoot showing hallux valgus corrected by Mitchell osteotomy.

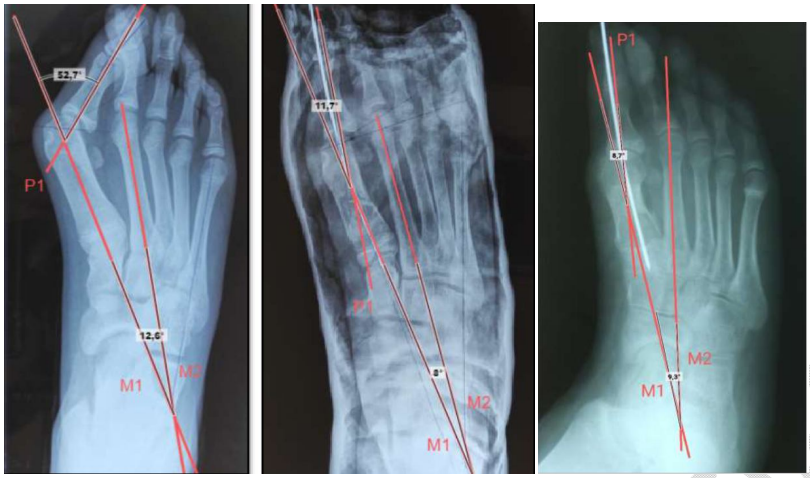


Figure 5: Frontal X-ray of the weight-bearing right forefoot showing ahallux valgus preoperatively and after surgical correction by modified Scarf immediately and 3 months later

Discussion:

More than 150 operative procedures have been described in the management of hallux valgus since the first hallux valgus operation was performed in 1871 [3], this diversity is also reflected on the pediatric population [4].

Thus, it's necessary to distinguish between those that can be used in children, considering the principles of pediatric orthopedics, which must respect the growth zones, the objectives are to:

- Establish a congruent MTP joint.

- Reduce metatarsus varus and phalangeal valgus.

- Realign the sesamoids under the metatarsal head.

- Eliminate or reduce pain.

- Maintain or increase the range of motion of the MTP joint.

In children, conservative treatmentallows a first management, very helpful while waitingfor the surgical treatment. This attitude also allows time for ligament laxity to decrease over time [5]. The surgical indication should be discussed given the risk of recurrence, and the risk of early surgical revision, especially as the child is skeletally immature [5].

In our serie, all our patients were admitted late at the stage of significant deformity; at this moment; conservative treatment has no effect on deformities already present; the same thing was put forward by Bouffioux [6] who found that conservative treatment has no corrective effect on deformities that have already occurred; it mainly allows reducing or even eliminate the symptoms. Kilmartin [7] agree with, in his study MTP joint angle had increased in the group that used plantar orthoses more than in the untreated group. In contrast Groiso [8] found that the M1P1 angle or the M1M2 angle, or both, were improved in about half of the

feet that received a conservative method (using a thermoplastic splint at night as well as passive and active exercises).

Surgical treatment of hallux valgus is discussed in children only after failure of conservative treatment with persistent symptoms and worsening of the deformity [6]. The timing of surgery should; whenever it possible; being after maturity, to allow time for growth achievement and to prevent recurrence or over-correction.

First described by McBride in 1928 [9]. This procedure, still regularly performed by many surgeons, corrects deformities by acting on the soft tissues. The advantage is thatcan be combined with osseous intervention if there are more severe deformities.

McBride recommended lateral sesamoidectomy in his original technique, but this intervention is almost abandoned by the new foot surgeons, because the removal of the lateral sesamoid bone frequently caused hallux varus. This is more serious than the initial problem because it's difficult to put on shoes when the toe is deviated outward.

In our series, the McBride technique was performed on two feet with moderate hallux valgus, the M1P1 angle was an average of 27° preoperatively, which was reduced to 10.35° with an improvement of 61.6%. These resultsstill significantly better than the results of the study by Schwitalle and al [10] (Table 2).

Author	Techniques	M1P1 Pre-op	M1P1 post-op	M1M2 pre-op	M1M2 post-op
Schwitalle et al. [10]	McBride	29.5°	24.5°	13.5°	12.5°
Our study	McBride	27°	10.35°	12.8°	10.1°

Table 2: Comparison of the radiological results of the McBride procedure

It should also be noted that the AOFAS score was excellent, with an average of 97.5/100, so our functional results can be considered good and better than the study by Schwitalle and al [10], in which the postoperative results were good in only 58.8%, satisfactory in 11.76%, and not satisfactory in 29.41%. Koop se [11] reports that McBride soft tissue procedures have often been associated with a high rate of recurrence and poor results.

Author	Number of feet	Good result	Satisfactory result	Unsatisfactory Result
Schwitalle et al. [10]	17	58.8%	11.76%	29.41%
Our study	2	100%	0	0

Table 3: Comparison of functional results according to the McBride technique.

There are different metatarsal osteotomies available to correct the hallux valgus, but preference should be given to those that can be used in children and obey to the principles of pediatric orthopedics. Distal osteotomies should be preferred because they seem to have good results, with a low risk of complications compared to other surgical techniques. However, double osteotomy may give better correction of the 3 radiological angles but there's a high risk of overcorrection of DMAA. [12]

Mitchell's distal first metatarsal osteotomies are the commonly performed procedure. It is used in young patients with painful hallux and moderate valgus, but the indications have been expanded to include a broader patient population. [13]

In our practice, we use the classic Mitchell osteotomy fixed by two Kirschner wires, this technique was used in 3 of our patients, although the preoperative M1P1 angle in our study was among the highestour postoperative results are considered good.

Nowadays, this classic technique has become less popular because by shortening the 1st metatarsal without considering the length of the 2nd metatarsal, the risk of metatarsalgia is increased by exaggerated pressure on the head of the 2nd metatarsal, which becomes longer than the firstand often the osteotomy moves in dorsiflexion if the osteosynthesis is not stable. This classic technique has been replaced by the modified Mitchell technique, which instead of making a 90° bone cut inthe axis of the metatarsal, the osteotomy is angled at about 30°, which gives more stability to the osteotomy than a straight cut. It's also more suitable for screw fixation.

Our results concerning this osteotomy were close to those of Peter and al and Churg and all. [13-14]

Authors	M1P1 Pre-op	M1P1 Post-op	M1M2 Pre-op	M1M2 Post-op
Chung and al. [14]	41°	15°	15°	9°
Peter and al. [13]	21.9°	13.8°	11°	6.7°
Our study	50.76°	18.56°	13.73°	12.1°

Table 4: Comparison with the radiological results of the modified Mitchell osteotomy series.

The subjective evaluation ofMitchell's osteotomy in our patients indicates 100% of satisfaction. Our results remain significantly better than the study by Schwitalle and al [10], who found a satisfaction level at 81%, and the study of John and al [15], who found only 61% of satisfaction.

The Chevron osteotomy remains the most frequently performed osteotomy in the rest of the world [16]. It has been practiced since 1962 by Austin and popularized by Johnson. Originally, it wasa V metaphyseal-epiphyseal V-shaped osteotomy, but nowadays the osteotomy lines are

no more V-shaped, but describe an acute angle L. This cut offeradditional stability and increase the bone contact surfaces of the two fragments. After the L-shaped cut, the translation can reach 6 to 7 mm, but the upper fragment should not be pushed, as it may tip over due to the lack of a bearing surface with the lower fragment, and then the whole is fixed with a compression screw. There're two types of chevron osteotomy, distal and proximal, the distal one is the one used for children, since there is a growth zone proximally. This technique is indicated in deformities with a phalangeal valgus less than 30° or an M1M2 angle less than 13° and/or DMAA less than 15°-20°, It's an extra-articular correction with a high satisfaction rate (84-85%). [6]

In our study, 4 feet underwent distal chevron osteotomy. The preoperative phalangeal valgus was 45.45°, which became 16.62°. This result is close to the study of Kraus and al [17], although our preoperative angles are significantly higher.

Our subjective postoperative results were satisfactory in 100%, which is close to the satisfaction rate found in the study of Kraus and al [17], which was 92%.

The objective evaluation by the AOFAS score of our 4 feet operated on by Chevron metatarsal osteotomy, was less than 60/100 before surgery and becomes 92.5/100 postoperatively, this score is close to that of Kraus and al [17] which was 94.5, so we can say that distal chevron osteotomy gives very good results in children in terms of correction.

SCARF was the name given in 1984 by Lowell Scott Weil to this osteotomy of the 1st metatarsal [18]. In fact, the SCARF belongs to the diaphyseal osteotomies, it's a double chevron, proximal and distal, which provides a good stability.

It's a technique that allowsprecision in the correction, and immediate solidity allowing for early functional recovery and also multiple possibilities of displacement allowing for the treatment of any hallux valgus (amplitude and origin). [19]

Since Barouk's initial description, the longitudinal line has progressively become more oblique to the medial side of the 1st metatarsal in order to increase the stability and rigidity of this diaphyseal osteotomy and also to decrease the risk of fracture. Lateral translation is the main displacement, but the SCARF technique allows the association of a wide variety of displacement like: medial rotation of the head, supination...

Normally, stable fixation is obtained with two reversed-pitch compression screws, one proximal and one distal. Due to the lack of compression screws, we used wires in our series (modified Scarf).

Our results are good compared to the study of George and al [20], and Farrar and al [21] and close to that of John and al [15]. Even if only one foot is not sufficient to judge this osteotomy in our series.

Our objective functional results postoperatively were 90pts/100, which was significantly better than the study by George and al [18], which was 85.8pts/100, but stilllower than the study by Farrar and al [21] (93pts) and that by John and al [15] (96.43pts/100).

Among the numerous surgical techniques designed to correct hallux valgus, percutaneous surgery, also called mini-invasive surgery, remains the least aggressive and can be performed in ambulatory care. This surgical technique seems to us to be a fundamental advance in forefoot surgery, performed under radiological control, and it's a new concept based on less aggression of the soft tissues with mini-approaches [20]. Unfortunately, none of our patients benefited from it, as well as the osteotomy of the 1st cuneiform and basi metatarsal osteotomy.

Postoperative complications are more seriousearlier they occur; they are aggravated by the remaining growth potential. The parents must be informed of the complicationsof the surgical intervention as well as the benefits. The indication should therefore not be given too easily and for the wrong reasons. [6]

In our study 10% of the cases had complications, a little high compared to the study of Eric and al [12] who objectified 8% of complications using distal osteotomy, and low compared to the same study which objective 21% using proximal osteotomy, and 15% using multiple osteotomy. Therefore, distal osteotomy should be preferred, while respecting the proximal part, given the presence of growth plate.

Septic complications are very fearsome in children, Fortunately, this type of complication is rare; in our series, none of our patients had an infection of the surgical site or systemic infection. In contrast, in the study by Harb and al [23], which included 9 studies on the treatment of hallux valgus in children and adolescents, 4% of cases had septic complications.

The risk of recurrence of hallux valgus in children is estimated to be between 2.7% and 16%, depending on the authors, for all causes [24-25]. This is in line with our study, in which the recurrence rate was 10%, and the study by Harb and al [23], which was 8%. It's often due to an inappropriate choice of correction techniques. This rate can be reduced to a minimum if we do not neglect the misdirection of the MTC, ifwe do not overlook hypermobility of the 1st ray, if we do not ignore the association with retraction of the Achilles, and if we do not fail to consider an elevation of the head of M1[6].

Avascular necrosis of the head of M1 is very rare but very dangerous in children. The increase in length of M1 puts tension on the vascular pedicles and compromises the viability of the head, for this, it's necessary to pay attention to the effect of corrective osteotomies on the length of the 1st ray. To avoid this complication, the vascularization of the first ray must be respected and known. In our series, no cases of necrosis of the head of M1 were noted, like in the study by Harb and al [23].

Iatrogenic varus is due to overcorrection when the head of M1 exceeds the level of the sesamoids. This expression of iatrogenic hallux varus is usually used to designate what is in fact an iatrogenic hallux, occurring after the first few months postoperatively. The frequency varies according to the series, from 1.5 to 13%, and the appearance is very badly experienced by the patient and the surgeon [26]. It generally associates three components: supination (the nail is oriented outwards), dorsal flexion of the first phalanx, and sometimes a claw of the interphalangeal joint of the big toe, which is usually reducible. In our series, no case of iatrogenic varus was noted.

Surgery in children is supposed to be performed to relieve the patient of stabbing pain, for this reason residual pain is an infrequent reason in the postoperative follow-up.

In our study, only one patient presentedresidual pain and this was related to the recurrence of hallux valgus. In contrast, in the study by Harb and al [23], 11.9% of patients had postoperative pain, in which 4.5% was due to hypersensitive scars.

In the Harb and al series [23], metatarsalgia was present in only 0.5% of cases, it's shows that this complication is very rare in children; in our study, no patient noted metatarsalgia during follow-up.

This complication can be avoided by considering the foot as a whole, by taking an interest in the harmony of the metatarsal area and the plantar position of the 1st ray, because an elevation of M1 by the osteotomy leads to a relative insufficiency of the 1st ray and to transfer metatarsalgia on the lateral rays.

Stiffness of the MTP joint is a classic complication after hallux valgus surgery, where there's a decrease in the mobility of the joint in dorsal and plantar flexion. To avoid this, passive mobilization must be started early, using the shoe prescribed before the operation.

We did not find any cases of stiffness or pseudoarthrosis in our patients, but Harb and al [23] found 0.5% of pseudoarthrosis.

There are other rare complications of hallux valgus surgery such as secondary displacement, non-union of the bone, and fracture of the metatarsal head, none of this complication have been noted in our series or in the literature.

Conclusion:

Hallux valgus is a particular pathology in children, the laxity of the child's foot is very different from that of the adult, ossification is weak and the cartilage plate are fragile as well as their remodeling possibilities. The choice of correction technique depends much more on the teams and the individual experience.

During growth, the foot is subject to rotational variations of the lower limb skeleton. Although this influence is complex and varies from child to child, it must be considered in the surgical indications. More than anything else, it's important to carefully analyze the deformity and the associated pathologies in order to determine an appropriate surgical strategy.

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