



Hallux Valgus in Adolescents: A Retrospective and Descriptive Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Hallux valgus is the deviation of the first metatarsal in varus and the big toe in valgus. Through a retrospective study we analyzed 10 feet managed for hallux valgus between January 2014 and March 2020. The average age was 14 years with female predominance. Patients reported pain and the deformation. 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 six feet (60%), four others had sesamoid class 2 (40%). Seven 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°. All patients underwent uneventful surgery. McBride surgery was performed on two feet. A stabilized re-axation osteotomy with K-wires associated with a release of the abductor hallucis was performed in six feet out of the other eight. In these eight, 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 6 weeks 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%.

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Given the immaturity of the child's skeleton, the surgical treatment of hallux valgus must be as innocuous as possible.

Keywords: Hallux; valgus; teenagers.

1. INTRODUCTION

Hallux valgus is the most common deformity affecting the big toe. It can occur at any age even in children or adolescent with a frequency of 2 to 4% [1]. It is defined as a deformity centered on the first web space 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].

Surgery is indicated usually for the pathology related to the exostosis (friction, hygroma, fistulization, corns...), anesthetic discomfort, and pain. We respect these indications. We aimed to expose epidemiologic, clinical and radiologic aspects of hallux valgus in adolescents with a particular highlight of the results of our experience in its management.

2. MATERIALS AND METHODS

It was a retrospective and descriptive study performed in the department of Pediatric Orthopedics and Traumatology at the Hassan 2 University Hospital in Fez. We included 10 feet, between January 2014 and March 2020.

After clinical examination, we performed plane radiograph of the affected foot in all patients. Surgery was performed in all patients according by the same team. The foot was maintained into a cast for 6 weeks. Results was analyzed on the clinical aspect and on the plane radiograph.

3. RESULTS

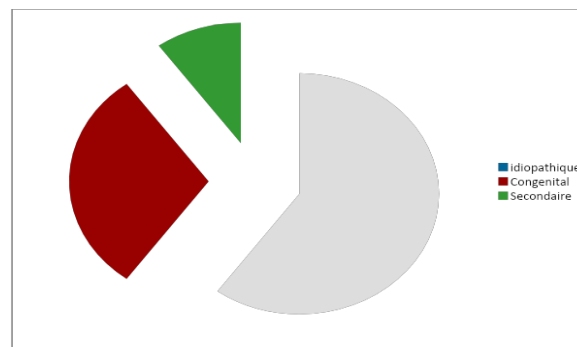
The average age was 14 years (10 and 15 years), and 75% were girls (sex ratio 0.33). Only one patient had a family history of hallux valgus (12.5%). In 60% of cases, the hallux valgus was idiopathic (6/10). Congenital origin was found in 30% (3/10); one case was after trauma (Graph 1).

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).

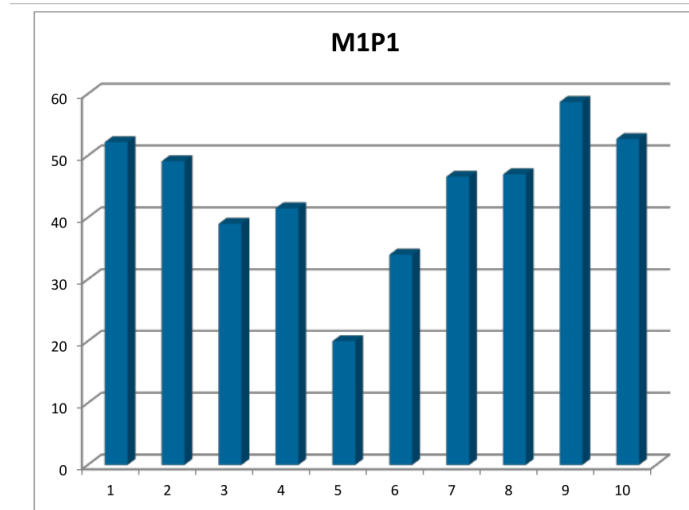
Six of 10 feet were Greek (60%), 4 Egyptian (40%), no square foot was noted, as well as static disorders of the forefoot. Hallux valgus is the cause of several lesions of the soft parts of the forefoot which are generally absent in children. In our series, only one patient had bursitis, and no patient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

Table 1. Frequency of the different clinical signs

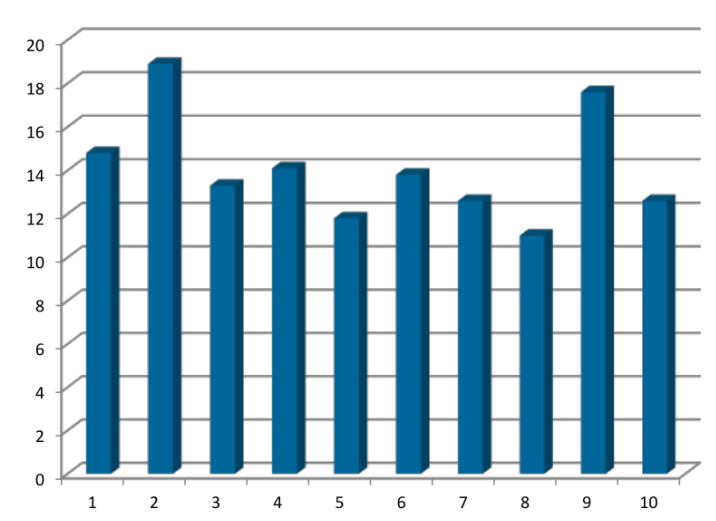
Functional symptoms	Percentage
Pain	100%
Deformity	100%
Walking disorder	12.5%
Discomfort in footwear	75%
Metatarsalgia	12.5%



Graph 1. Etiologies of hallux valgus



Graph 2. Histogram representing the values of the M1P1 angle



Graph 3. Histogram representing the values of the M1M2 angle

Radiologically, the mean M1P1 angle was 44.08° with a standard deviation of 11.09° and extremes ranging from 20° to 58.7° (Graph 2).

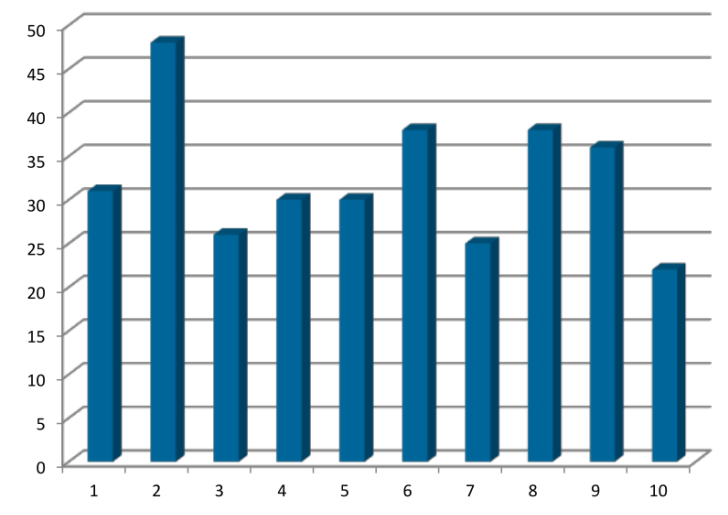
The mean value of the M1M2 angle was 14.05° with a standard deviation of 2.49° and extremes ranging from 11° to 18.9° (Graph 3).

The mean DMAA value was 18.8° with a standard deviation of 7.61° and extremes ranging from 8° to 30. The mean M1M5 angle was 32.4° with standard deviation of 7.72° with extremes ranging from 22° to 48° with a median of 30.5° (Graph 4).

A sesamoid class 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°, the average angle of attack of M1 was 20.87°, with extremes ranging from 12° to 34°.

Various surgical procedures were performed (Graph 5); conservative McBride surgical treatment was performed in 2 feet (20%), they had moderate hallux valgus, the average M1P1 angle was 27°. Other procedures were associated with this operation, such as exostosectomy of the metatarsal head, capsulotomy, and capsulorrhaphy.



Graph 4. Histogram representing the values of the M1M5 angle



Graph 5. Percentage of different surgical procedures

A stabilized reaxation osteotomy with Kirshner wires, 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. (Fig. 1)
- 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 osteotomy about 30° is made (Fig. 2)
- 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 (Fig. 3).
- In our series, the resumption of walking was immediate on the heel with a 6 weeks boot

cast. None of our patients wore total forefoot relief shoes. A radiological check-up was performed in the immediate postoperative 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.

4. 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].



Fig. 1. Frontal incidence showing a hallux valgus before, and immediate postoperative and 2 months after the chevron procedure stabilized by two crosswise Kirshner wires



Fig. 2. X-ray of the left forefoot showing hallux valgus corrected by Mitchell osteotomy

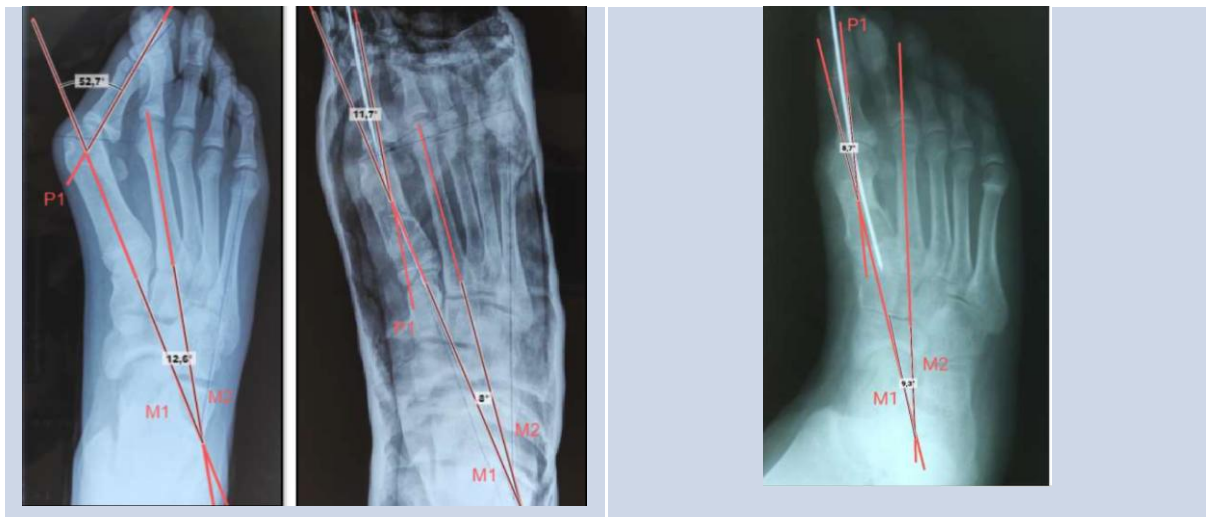


Fig. 3. Frontal X-ray of the weight-bearing right forefoot showing ahallux valgus preoperatively and after surgical correction by modified Scarf immediately and 3 months later

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 treatment allows a first management, very helpful while waiting for 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].

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 that can 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 results still significantly better than the results of the study by Schwitalle and al [10] (Table 2).

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

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

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

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

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

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°
Study	50.76°	18.56°	13.73°	12.1°

It should also be noted that the AOFAS score was excellent, with an average of 97.5/100, so the functional results can be considered gooder than the those of Schwitalle et 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.

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, 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].

We use the classic Mitchell osteotomy fixed by two K-wires, this technique was used in 3 out of patients, although the preoperative M1P1 angle in our study was among the highest our postoperative results are considered good.

Nowadays, this classic technique has become less used 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 first and 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 in the 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.

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

The subjective evaluation of Mitchell's osteotomy was 100% of satisfaction. This results remains significantly better than the study by Schwitalle et al. [10], who found a satisfaction level at 81%, and the study of John et 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 was a V metaphyseal-epiphyseal V-shaped osteotomy, but nowadays the osteotomy lines are no more V-shaped, but describe an acute angle L. This cut offer additional 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].

We performed four distal chevron osteotomy. The preoperative phalangeal valgus was 45.45°, which became 16.62°. This result is close to the study of Kraus et 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 et al. [17], which was 92%.

The objective evaluation by the AOFAS score of these four feet, was less than 60/100 before surgery and becomes 92.5/100 postoperatively. This score is close to that of Kraus et 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 allows precision in the correction, and immediate solidity for early functional recovery. Also permits multiple possibilities of displacement 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).

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

The objective functional results postoperatively were 90pts/100, which was significantly better than the study by George et al. [18], which was 85.8pts/100, but still lower than the study by Farrar and al [21] (93pts) and that by John et 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 serious earlier they occur; they are aggravated by the remaining growth potential. The parents must be informed of the complications of the surgical intervention as well as the benefits. The indication should therefore not be given too easily and for the wrong reasons [6].

10% of the cases had complications, a little high compared to the study of Eric et 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 [22].

Septic complications are very fearsome in children. Fortunately, it is rare; and none of the patients had it. In contrast, in the study by Harb et 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 from 2.7% to 16%, depending on the authors, for all causes [24-25]. One (10%) patient had the recurrence, and 8 % reported by Harb et al. [23]. It's often due to an inappropriate choice of correction techniques. This rate can be reduced to a minimum with some considerations:

- do not neglect the misdirection of the MTC,
- do not overlook hypermobility of the 1st web space,
- do not ignore the association with retraction of the Achilles,
- 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. No cases of necrosis of the head of M1 were noted, like in the study by Harb et 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.

Only one patient presented residual pain and this was related to the recurrence of hallux valgus. In contrast, in the study by Harb et 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. 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.

No case of stiffness or pseudarthrosis was found, but Harb et al. [23] found 0.5% of pseudarthrosis.

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 reported.

5. 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. Surgical technics are well described with good results. We highlight the importance to carefully analyze the deformity and the associated pathologies in order to determine an appropriate surgical strategy.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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