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Juvenile Hallux Valgus

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Background

Multiple terms have been used to describe this deformity in the young population. Adolescent hallux abductovalgus is a commonly used term; however juvenile hallux abductovalgus may be the more appropriate term, as the age of onset may be earlier than typically recognized [9]. In a long-term retrospective study, 40% of juvenile bunions were shown to have occurred by the age of 10 or earlier [7]. Multiple studies [7, 23, 40, 41] support this early onset, reporting 46–92% of patients had the deformity in their juvenile years before skeletal maturation [9]. These reports show the deformity begins prior to the age of 20 with an average clinical onset at 12 years.

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Hallux valgus is the most common pathology that affects the great toe. The prevalence of this deformity is similar regardless of the age, affecting 3.5% of the juvenile population and 2–4% of adults [8, 37, 42]. The bilaterality of the deformity, however, is unknown mostly due to unreported contralateral evaluation. Hand dominance may be influential but is also lacking consensus [8]. Yet, one study reported 84% incidence of bilateral deformity with more right foot than left foot surgical corrections. Even though 91% were right handed, the correlation of hand dominance was not significant statistically [8].

The incidence of juvenile hallux valgus tends to increase if associated with metatarsus adductus [2]. In a randomized, controlled study, 35% with metatarsus adductus had hallux valgus compared to 13% of the control group having no bunion deformity [2]. Another report showed similar values with an 18% prevalence of metatarsus adductus without hallux valgus versus 55% with concomitant deformity [14, 33]. Also identified was the significant relationship between the degree of metatarsus adductus and the degree of hallux abductovalgus in male and female subjects [14].

Several studies have shown marked female preponderance of hallux abductovalgus with rates ranging from 3:1 to as high as 15:1 in the adult population [14]. Coughlin supported these statistics in juvenile patients with 88% female association in his series, which does not differ significantly from the adult population [7]. Pique-Vidal et al. in a study of 350 patients observed an

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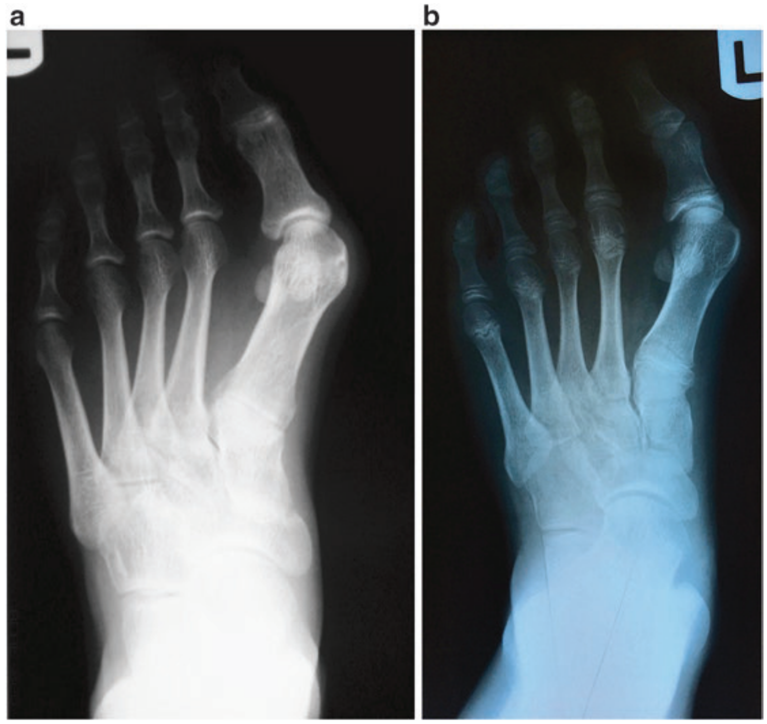

Fig. 15.1 (**a**) A 15-year-old female who reached skeletal maturity. Note the large intermetatarsal angle, diastasis between the base of the first and second metatarsal and the medial and intermediate cuneiform. Additionally, the hallux valgus angle is large, and this typically incorporates pathological sesamoid position with a frontal plane rotation of the hallux. This patient underwent a Lapidus (arthrodesis of the TMT-1 (first tarsal-metatarsal) bunionectomy. (**b**) A juvenile HAV deformity in a patient who has not reached skeletal maturity with a triplane abnormality. Note the increase in the intermetatarsal angle, the increase in the hallux valgus angle, and the rotation into valgus of the hallux as well as the sesamoid position indicating first ray valgus rotation

even higher male-to-female ratio of 1:14.9 [42] (Figs. 15.1 and 15.2).

Although the etiology of juvenile hallux valgus is unclear, there is evidence of familial involvement. Pique-Vidal et al. showed that in 90% of patients, bunion deformities were present in at least two members of the family with a vertical transmission through three generations [42]. Incomplete penetrance of the bunion deformity was noted in 56% of patients. Coughlin similarly reported that 72% of subjects displayed maternal transmission with variable penetrance and concluded the disorder was more severe in these patients [8]. This trait was associated with an X-linked dominant transmission, autosomal dominant transmission, or polygenic transmission [7]. These findings indicate a high likelihood that hallux valgus is hereditary, with probable autosomal dominant transmission. Hardy et al. described 77% of his subjects reported bunion deformities in their mothers and only 16% implicated their fathers [23]. Subsequently, Johnston et al. led a trial based on family history where 94% of the females had a pattern of inheritance consistent with maternal transmission with only two noting paternal involvement [25]. All three males in the study exhibited positive family history through maternal transmission. This in-depth study concluded that juvenile hallux abductovalgus was autosomal dominant with incomplete penetrance.

Extrinsic factors may not affect juvenile hallux valgus as much as adult onset deformities. In the adult population, ill-fitting shoes affected 24% of patients [42]. However, tight shoe gear and high heels play a small role in the etiology of juvenile hallux valgus [7, 42]. This also supports the conclusion that bunions in children younger than 10 years of age are likely inherited [42]. In contrast, Sim-Fook and Hodgson reported 33% of shod individuals displayed hallux valgus compared with a 2% incidence in unshod subjects [49]. Others

Fig. 15.2 An AP radiograph of a young patient who has reached skeletal maturity demonstrating a met adducts deformity who demonstrates a mild HAV deformity clinically

Fig. 15.3 A clinical photo of a juvenile HAV abnormality with a flatfoot deformity

(Pique-Vidal, McGlamry) shared similar observations that hallux valgus is more common among shoe wearers [37, 42]. Yet, Kilmartin et al. noted hallux valgus increases in children regardless of whether they wear biomechanical orthoses or well-fitting shoes [29]. Footwear may be responsible for the correlation between metatarsus adductus and juvenile hallux abductovalgus in that lateral forces of shoe gear may displace the great toe [14, 44].

There have been many causative factors suggested in previous literature. Hohmann notably penned the phrase, "Hallux valgus is always combined with pes planus, and pes planus is always the predisposing factor in hallux valgus" [32]. Kalen and Brecher noted there was an 8–24 times greater incidence of pes planus in juveniles with hallux valgus [28]. Scranton et al. reported 51% of subjects had concomitant pes planus [7, 47]. These studies support Hohmann in that a flatfoot deformity was a predisposing factor for juvenile hallux valgus, yet current literature supports otherwise for the juvenile onset deformity.

Kilmartin and Wallace noted that the incidence of pes planus is as common in the normal population as in those with hallux valgus [32]. Coughlin showed that only 17% of juveniles with hallux valgus had moderate or severe pes planus [7]. In one cohort, they found the calcaneal inclination angle was not significant statistically and suggested pronation may not be related in the development of juvenile bunions [37]. In fact, there is a very low incidence of advanced pes planus in patients with hallux valgus, which does not increase occurrence of juvenile hallux valgus or recurrence following surgical correction [6, 7, 32, 39]. Kilmartin concluded that pes planus was not a significant etiologic factor [32] (Fig. 15.3).

Metatarsus adductus has been associated with juvenile hallux valgus. Early literature noted linear correlation between increasing juvenile hallux valgus and increasing metadductus [2, 43] as well as increased recurrence rates of bunion deformity following a hallux valgus repair when metadductus was present [35]. Using Engel's criteria, Coughlin measured metatarsus adductus angle in juvenile with hallux valgus and reported 100% of subjects with angles greater than 15° and 22% measuring above 21° [9]. This strong association between juvenile hallux valgus and metatarsus adductus, however, had no increased recurrence rates postoperatively. Coexistent hallux valgus with significant metatarsus adductus may exaggerate the deformity and make surgical treatment difficult [52].

McCluney and Kilmartin have reported the metatarsus adductus angle was not statistically significant and only a causal association of metatarsus adductus in the development of juvenile hallux valgus [30, 37]. Yet neither could exclude metatarsus adductus as a possible predictor of juvenile hallux valgus. Ferrari et al. noted distribution of hallux valgus is significantly different between males and females with and without metatarsus adductus [13]. With normal metatarsus adductus angle, males also had a normal hallux abductus angle, whereas half the females displayed a bunion deformity. In both groups, the rate of hallux valgus increased with abnormal metatarsus adductus angles. Actually, 100% of females with abnormal metatarsus adductus angles had abnormal hallux valgus angles. This study found that when metatarsus adductus was present in females, hallux valgus always accompanies it. Therefore, this coexistence should be assessed during surgical consideration [14] (Figs. 15.4).

Fig. 15.4 An AP radiograph demonstrating a mild metatarsus adductus with congruent first metatarsal phalangeal joint and a pes planus deformity. Note the dorsal talar-first metatarsal angle

Radiographic Evaluation

A distinct characteristic of juvenile hallux valgus is congruent joints [8]. Piggott in his adult series noted <10% had a congruent metatarsophalangeal joint [41]. However, later studies revealed 47–68% of juveniles with hallux valgus had congruent joints [7, 52]. Hardy and Clapham coined the term "critical angle of hallux valgus" or the point at which the hallux abuts the second toe, pushing the first metatarsal into varus [23]. The intermetatarsal angle was found to be stable until this point, at which the intermetatarsal and hallux abductus angles increased more rapidly [31].

Plain radiography of the deformity will aid in deciding corrective procedures as well as detecting coexisting abnormalities. Dorsoplantar, lateral, and sesamoid axial X-rays will project all three cardinal planes for evaluation. Commonly evaluated are the intermetatarsal, hallux abductus, and distal metatarsal articular angles, sesamoid position, and metatarsal length. An increased distal metatarsal articular angle (DMAA) may be the defining characteristic of juvenile hallux abductovalgus [8, 9]. Early recognition of an increased distal metatarsal articular angle will aid in avoiding excessive lateral tilt after bunion repair [52]. A relatively high distal metatarsal articular angle occurs with concomitant metadductus [20, 52]. Normal values for distal metatarsal articular angle are 8° or less [4, 20, 37, 46]. Interestingly, the literature shows much variability when measuring the distal metatarsal articular angle. Vittetoe et al. observed that 1 out of 20 times measurements of the angle would be off more than 5° [51]. Amarnek et al. found preoperative measurements averaged 7° below the intraoperative value and recommended distal metatarsal articular angle be determined intraoperatively [1]. The distal first metatarsal articular angle is considered to be one of the main intrinsic factors responsible for the early onset, heritable nature, and severity of the hallux valgus deformities in juveniles [39].

Metatarsus primus adductus is a significant radiographic deformity in hallux valgus and may exaggerate the bunion deformity [2]. The metatarsus adductus angle is the line bisecting the second metatarsal and the longitudinal line bisection of the lesser tarsus on standard weight-bearing dorsoplantar radiographs [14]. Engel determined a metatarsus adductus angle greater than 21° is abnormal [12]. Though some authors believe the increase in intermetatarsal angle is a result and not a cause of hallux valgus, obtaining the true intermetatarsal angle is important in the presence of metatarsus adductus. This is defined as the sum of the intermetatarsal and metatarsus adductus angles and subtracting 15° [11] (Fig. 15.5).

The presence of a long first metatarsal has been indicated in the development of juvenile hallux valgus [37]. Hardy and Clapham observed differences in protrusion distances compared to controls and concluded that subjects with a long first metatarsal are likely to develop hallux valgus [23]. Coughlin noted the preoperative hallux valgus angle averaged 5° more with a long first metatarsal, but it did not directly increase the risk for postoperative recurrence [7]. A hallux abductus angle greater than 15° is considered pathologic [23, 37]. The authors do not believe that long and short first metatarsals exist in cases of feet without previous trauma or surgery except in cases of brachymetatarsals. Often when short and long first metatarsals are discussed, it is the given position of a snapshot view of the first metatarsal. At the time of the radiograph, one needs to ask was the patient full weight bearing, was the patient fully loaded on their foot, was the angle and base of gait accurate, and did the X-ray technician have the appropriate angle at the time of the X-ray? It has been the experience of the authors that when a first metatarsal appears long on an AP X-ray, the metatarsal is elevated or more parallel to the ground (often seen with a flatfoot deformity). When it appears short, the first metatarsal is positioned more in a plantar-flexed position (often seen with a cavus foot) (Fig. 15.6).

Fig. 15.5 This is an AP radiograph of a patient who suffers from a met primus varus deformity

Fig. 15.6 This is an AP radiograph of a juvenile HAV abnormality that demonstrates a "long first metatarsal." Except in cases with brachymetatarsal and other congenital defects or in cases with previous history of trauma or surgery, the authors have noted that there is not a true long first metatarsal. It is a positional abnormality at the time of the "snapshot" of a radiograph. Rather than a "long first metatarsal," the authors submit it is a positional issue demonstrating instability of the first metatarsal. With instability and hypermobility, the first metatarsal is more parallel to the ground, and it appears long; hence it is not physically long, but the position of a fully weight-bearing X-ray gives this impression. Opposite of a long first metatarsal is a short appearing metatarsal radiographically. This occurs in conditions of a stable and plantar-flexed first metatarsal in conditions of a pes caves deformity

In an extensive review by Ferrari et al., a sexual dimorphism was observed, predominantly proving male bones and joints were larger than females [13]. Articular surface measurements suggested high potential for adductory movement in females, which could produce a more adducted first metatarsal than in males [13]. Women also demonstrated greater curvature in the first metatarsal head, which is related significantly to the degree of hallux valgus. This allows for decreased stability at the metatarsophalangeal joint and increased abduction of the proximal phalanx. Ferrari reported that if an abductory force were equal between men and women, the female hallux would buckle more easily than in men. Females are known to be more flexible than males and may lead to greater hallux valgus deformity [14]. This hypermobility is may be due to ligament laxity, but the joint laxity may precede soft tissue influence. The talar head also had larger functional angles in females in which greater motion can occur. Both the first metatarsal head curvature and talar functional angle in females are postulated to increase occurrence of hallux valgus [13]. A full clinical and radiographic assessment including rearfoot deformities or triplanar abnormalities must be considered to determine effective treatment options.

Nonsurgical Treatment

Though controversial, nonsurgical measures may not be helpful in moderate-severe juvenile hallux valgus with progressive deformity. A prospective trial of foot orthoses for juvenile hallux valgus questioned the role of pronation as a causative factor in juvenile hallux valgus [37]. Kilmartin et al. found that orthoses should not be used to treat juvenile hallux valgus as they appear to increase the rate of deformity progression. Interestingly, several of the contralateral normal feet developed hallux valgus despite orthotic use. Hallux valgus increases in children regardless of whether they wear biomechanical orthoses or well-fitting shoes [29]. However, nonsurgical treatment may be amenable in patients with neuromuscular disorders, ligamentous laxity, or inability to remain non-weight bearing (Groiso). Non-operative treatment options that include wider shoe gear, bunion pads, orthotics, and bracing may relieve symptoms of deformities that are mild, minimally painful, and flexible. Although the patient population is generally not compliant with these modalities, they should be attempted given the high rate of recurrence from surgery and are effective in treating other compounding deformities like metatarsus adductus, pesplanovalgus, and equinus [21].

Operative Considerations/Approach/Procedures

Surgery should be discussed when conservative measures have failed or when these measures are determined to be unlikely to be effective. Additionally rapid progression of the deformity with visible joint adaptation is a reasonable indication for correction in younger patients. The goals of surgery are to relieve pain, restore function, prevent worsening deformity, and improve cosmesis. Value of these factors should be placed in this order. If cosmesis is the main focus, reassessment should be performed and directed toward conservative measures given the high rate of recurrence [53].

Several important factors must be evaluated in the preoperative period. These include the patients' age, growth plate status, coexisting deformity, progression of deformity, family history, functional impairment, and expectations. Severe impairment with pain and dysfunction and progression of the deformity despite conservative measures are clear indications for surgical correction.

Ideal timing for surgical correction is between the ages of 11 and 15 years as the patient approaches skeletal maturity. It is important that growth plates should be closed to allow procedures that can produce optimum deformity correction.

Surgical correction options are vast and include head procedures, base procedures, soft tissue procedures, epiphysiodesis, and first metatarsocuneiform fusion. The decision as to which procedure or procedures is warranted depends on several factors: the severity of the deformity, correction needed, growth plate status, and patients' capacity. Frequently, definitive surgical planning doesn't finish until intraoperative evaluation can be performed of the articular surface of the first metatarsophalangeal joint [41]. Soft tissue procedures are generally insufficient in treating the deformity successfully. It is this authors' approach to not violate the joint unless completely necessary to avoid potential risks of AVN, arthritis, or adhesions. The exception of any abnormal soft tissue contractures contributing to the deformity should be addressed.

Distal metatarsal osteotomies are typically performed on juveniles with only mild to moderate deformity. The most commonly used are the Austin, Kalish, and Reverdin along with its various modifications [6]. The Reverdin and its modifications are especially useful given its ability to not only correct the IM but also for PASA correction [3]. Given this flexibility, it is often combined with more proximal procedures for patients with severe deformity where there have been adaptive changes to the metatarsal head. In these cases, the proximal osteotomy is performed first, followed by the distal procedure to assure proper alignment of the articular surface and joint function. Relocating the sesamoid apparatus beneath the metatarsal head and aligning the FHL restore normal sagittal plane motion of the first MPJ decreasing long-term arthritis risk [22, 45].

Base procedures include opening or closing wedges and the Lapidus fusion. These procedures are generally utilized in those juveniles with more severe deformity and higher IM angles [50]. The goal of these procedures is to correct the severe deformity and restore the parallel relationship between the first and second metatarsal while avoiding plantar or dorsiflexion of the metatarsal. The OBWO and CBWO are typically performed more distal to avoid open growth plates [34]. The OBWO is less often used given its predisposal to lengthening the first metatarsal thus exacerbating the deformity at the first metatarsophalangeal joint [5]. Additionally the results from OBWO have not been as favorable as other procedures. The CBWO on the other hand has proven quite useful and when combined with a head procedure as necessary has shown long-lasting results [24] (Fig. 15.7).

There is little reported use of cuneiform osteotomies in surgical repair of juvenile hallux valgus deformity. The first use was by Riedl in 1908 in which he described a closing wedge osteotomy of the medial cuneiform to reduce the "atavistic" joint surface. This procedure was followed by Young in 1910 who advocated an opening wedge of the medial cuneiform. In 1935,

Fig. 15.7 This is AP radiograph of a patient who presents with a reoccurrence of an HAV deformity. Years earlier, when the patient's growth plate was open (skeletal immature), a transverse closing base wedge was performed demonstrating the deformity is much more complex and needs to be addressed

Cotton described an opening wedge osteotomy of the medial cuneiform dorsally to address sagittal plane deformity in the correction of medial column depression seen in pes planus deformity [54]. This led many physicians to use this procedure in combination with the CBWO or OBWO to address the juvenile hallux valgus deformity. In 1986, Bicardi and Frankel reported on the use of a biplane cuneiform osteotomy in which a dorsal medial-based graft was inserted. The thought was that this procedure addressed the apex of the deformity, which was the obliquity of the metatarsocuneiform joint. Additionally, it preserved length of the first metatarsal and by increasing inclination of the joint surface in the sagittal plane enhanced the durability of the correction. Overall, it was proved to be a safe procedure that allowed the surgeon to address the deformity in multiple planes while preserving the growth center [55] (Fig. 15.8).

Fig. 15.8 It has been the experience of the authors that Cotton osteotomies have not been successful in complete/overall correction of HAV deformities alone. The authors have experience inadequate reduction of the transverse plane. The authors do advocate using the Cotton osteotomy in juvenile HAV surgery in the sagittal plane to enhance stability if the patient cannot have a Lapidus procedure due to skeletal immaturity

Fig. 15.9 This is a patient who had a Lapidus procedure performed at skeletal maturity

Lapidus fusion is ideal for patients with severe deformity and in patients with a high true IMA and metatarsus adductus. This procedure has received negative connotations due to its potential for shortening and growth plate compromise or sacrifice [16]. When performed correctly, it has been shown to have the lowest incidence of recurrence among all other procedures through elimination of hypermobility and addressing the deformity at its apex [19]. Given its ability to correct large deformities, and improvement in stability of the first ray, its long-term benefit should be considered in all candidates where it's a feasible surgical option (Fig. 15.9).

Epiphysiodesis is a different approach to hallux valgus correction. The principle is based on utilizing the patients' inherent growth ability to aid in correction of the deformity. By arresting the lateral portion of the physis, the medial physis continues to grow thus correcting the IM angle and reducing the deformity. Due to this procedure causing possible irreversible physeal arrest, very careful planning and timing must be performed to assure an acceptable reduction of the deformity [10, 15]. Surgery should be performed between ages 10–12 for females and 11–14 in males, although radiographic age dictates specific restrictions. Upon determining skeletal age, potential growth must be calculated utilizing Nelson's growth chart [38]. Timing for the procedure is determined when the amount of anticipated growth is equivalent to the amount of correction needed. Recent fixation technology, such as staples, has now allowed for correction of the deformity, without compromise of the growth center. This allows for earlier surgical correction, although it remains to be seen and studied if this is beneficial in the long term [15].

Authors' Experience and Recommendations

Based on many discussions with family members and in the authors' experience, HAV deformity appears to have a direct correlation with the parents and/or grandparents in terms of similar conditions demonstrating this is a congenital, inherited deformity. In most cases, foot deformities are no different than a parent being tall and the children also being tall, the parents having light eyes and the children also having light eyes, etc., The authors have found in juvenile HAV pathology that distal metaphysical osteotomies have not been successful long term as it does not address the underlying pathology. The authors have experienced a high rate of reoccurrence. Also, the authors no longer advocate performing a lateral release or a medial eminence resection as this has been found to be ineffective long term as well.

The authors challenge the thought of a long and short metatarsal. In the authors' experience, no such thing exists outside of patients who truly suffer from a congenital deformity or patients who have experience previous surgery or trauma at the site. The appearance of a long metatarsal or short metatarsal radiographically is a radiographic instant projection of the position of the first metatarsal. For instance, in a patient who experiences instability of the first ray (often associated with a flat foot), oftentimes the first metatarsal will be more parallel to the ground suggesting there is an appearance of a "long metatarsal"; however it is merely the position and not the anatomic finding. The same issue exists for what appears to be a "short metatarsal." What may appear as a "short metatarsal" on an AP radiograph is a patient who demonstrates a more plantar-flexed metatarsal. For example, a patient with a cavus foot type will often appear to have a short metatarsal.

The authors advocate a thorough evaluation in order to appropriately evaluate and treat the entire lower extremity. This includes having the patient evaluated both standing and seated. A Silfverskiold test is a must in order to determine if the patient suffers from an equinus deformity. If there is a contracture, the surgeon must address this by performing the appropriate posterior muscle lengthening. Additionally, X-rays of the foot, ankle, and calcaneal axial should be obtained in order to provide a complete assessment. Furthermore, the stability or instability/hypermobility of first ray should be evaluated. It is the authors' experience that nearly all HAV deformities have a form of instability/hypermobility. Often associated with instability/hypermobility of the first ray and a HAV deformity are pes planus (flatfoot) conditions. In the author's experience, stabilization of the first ray is imperative in order to obtain a more predictable and long-term outcome (Fig. 15.10).

The authors recommend delaying surgery as long as possible in hopes the patient can have a tarsal metatarsal arthrodesis for a correction in all three planes (Lapidus procedure) once the patient has reached skeletal maturity. It has been the author's experience that the deformity can be corrected in all three planes with a Lapidus procedure, and by stabilizing the first ray and an achieving anatomic alignment, the long-term results are superior to other procedures.

As long as the reduction of the Lapidus is parallel or close to parallel, the clinical results have been pleasing to the patient and patient's family. In performing more aggressive procedures to address the metatarsal adducts deformity, it is not as predictable, and it is much more invasive for the patient and much more difficult for the

Fig. 15.10 A weight-bearing photo demonstrates the first ray insufficiency (instability/hypermobility) of both feet in a pediatric patient who has been diagnosed with juvenile HAV

surgeon to obtain an excellent reduction. In essence the authors do not perform these procedure except in very specific scenarios and have found them to be unnecessary.

It has been the author's experience to address a notable flatfoot deformity if it does in fact coexist with an HAV condition. When the authors have failed to address a flatfoot deformity with an HAV condition, we have identified a high rate of reoccurrence. The patient continues to pronate through the corrected HAV deformity subjecting the patient to a reoccurrence.

The authors recommend, evaluate, and address all deformities that are present when the patient is symptomatic and all non-operative care has failed. Start proximal and address the posterior muscle lengthening as determined by the Silfverskiold test. If a unstable and flatfoot deformity is present, the authors urge the correction of the flatfoot with calcaneal osteotomies (single or double as indicated) as well as stabilization of the first ray and medial column. In cases of where a juvenile HAV deformity that has not responded to non-operative care and skeletal immaturity, the authors have used the Cotton osteotomy to provide increase stabilization in the sagittal plane. In addition, a closing base wedge osteotomy just distal to the growth plate can be performed to address the HAV deformity. The surgeon should aim to make the first metatarsal as parallel to the second metatarsal. The Cotton osteotomy enhances the stabilization of the first ray and addresses the transverse plane to correct the HAV. Please note this cannot correct the deformity in all three planes (Fig. 15.11).

Complications from juvenile hallux valgus include recurrence of the deformity and pain. Although previously associated with recurrence rates over 30%, accurate procedure selection has decreased this rate to more acceptable levels [17]. Additionally, correction of contributory deformities such as pesplanovalgus, equinus, and metatarsus adductus has also been shown to decrease recurrence rates and improve overall pain and function [1, 18, 27, 48, 53]. Underestimation by the provider or selection of the wrong corrective procedure generally is at the root of complications.

Careful preoperative planning is paramount in addressing the deformity accurately. Ideally, one surgery should be performed to correct the deformity and provide long-standing correction and prevention of recurrence. The authors have found that distal metaphyseal osteotomies do not work long term and therefore do not perform this type of procedure. It has been the experience of the authors that improved results are expected when both the primary deformity and secondary mechanical problems such as instability and flatfoot deformity are globally addressed. The authors have found that the Lapidus procedure provides the best long-term and most predictable results as this can address the deformity in all three planes and corrected at the site of pathology. If the patient has not reached skeletal maturity and is symptomatic, the authors typically perform a transverse closing base wedge osteotomy with a Cotton procedure. A Cotton procedure is utilized to provide stability to the medial column (sagittal plane) – to "stiffen" the hypermobile foot. The transverse closing base wedge osteotomy can address the transverse plane deformity closing down the intermetatarsal angle. Because it is well known that recurrence rates are high with osteotomy procedures, patients must be advised of the possibility of recurrence and need for further surgery (Figs. 15.12, 15.13, and 15.14).

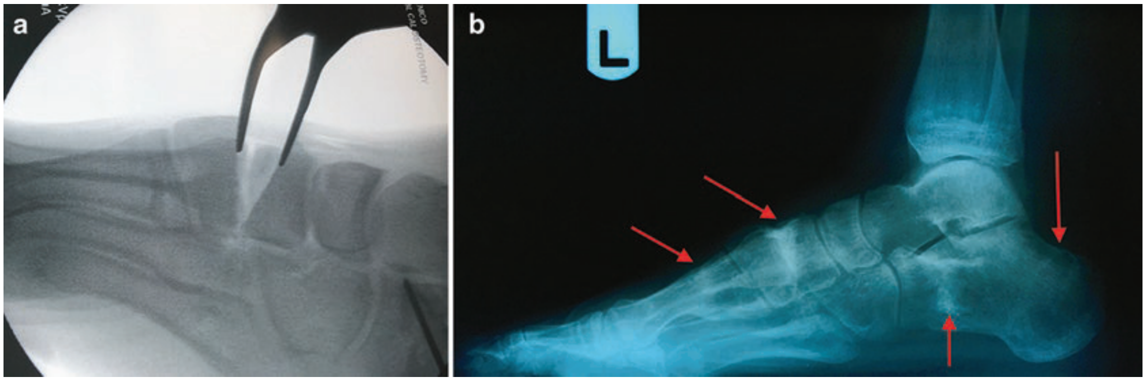

Fig. 15.11 (**a**) This is an intraoperative lateral view of a Cotton osteotomy demonstrating the sagittal plane correction gained through a Cotton osteotomy. Note the plantar flexion of the first metatarsal relative to second metatarsal. (**b**) A lateral radiographic projection of a patient who had not reached skeletal maturity prior to surgery. Preoperatively, the patient was diagnosed with a pes planus deformity as well as an HAV deformity. This patient had an endoscopic gastrocnemius recession, a double calcaneal osteotomy, a Cotton osteotomy, and a closing base wedge osteotomy to address all the pathologies

Fig. 15.12 This is a postoperative AP view of a pediatric patient who preoperatively had a flatfoot deformity associated with a HAV condition. This patient had an endoscopic gastrocnemius recession, a double calcaneal osteotomy, a Cotton osteotomy, and a closing base wedge osteotomy

Fig. 15.13 An AP radiograph of a patient who had a closing base wedge osteotomy prior to skeletal maturity. The HAV deformity reoccurred

Fig. 15.14 (**a**) An AP radiograph of an 16-year-old skeletal mature patient who had a painful, symptomatic HAV deformity. The patient was able tolerate the symptoms until she reached skeletal maturity. The patient had a concomitant flatfoot deformity. The surgical procedures included an endoscopic gastrocnemius recession, a percutaneous calcaneal displacement osteotomy, and a Lapidus bunionectomy. (**b**) This is the lateral X-ray projection of the patient who had an endoscopic gastrocnemius recession, a percutaneous calcaneal displacement osteotomy, and a Lapidus bunionectomy once skeletal maturity has occurred

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