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Review Article

Pediatric hallux valgus: An overview of history, examination, conservative, and surgical management

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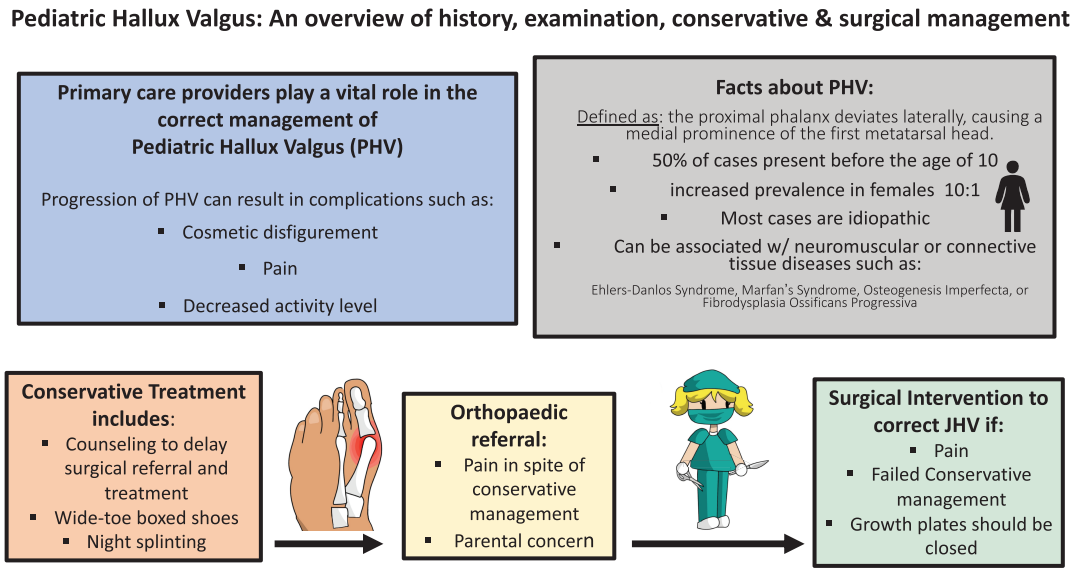
Abstract

Pediatric hallux valgus (PHV), while relatively rare, is still often encountered by general pediatricians. Herein, we concisely summarize the existing literature regarding the pathogenesis, associated conditions, clinical diagnosis, radiographic characteristics, conservative management, and surgical management of PVH. Though PHV is generally considered benign, the progression of hallux valgus can result in complications. The presence of an open physis in the pediatric age group delineates first line treatment choices, whenever possible, as nonoperative. The general exception to this recommendation is for children with neuromuscular and connective tissues disease who may benefit from earlier surgical management. If conservative approaches fail prior to skeletal maturity, the risk of recurrence and need for revision surgery should be discussed with patients and their families before surgical referral is made. The current review was conducted to aid primary care providers in better understanding the pathogenesis, associated conditions, and intervention options available to manage PHV.

Graphical Abstract



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Like its adult equivalent, pediatric hallux valgus (PHV) deformity occurs when the proximal phalanx deviates laterally, causing a medial prominence of the first metatarsal head. PHV can be separated into two main categories: juvenile hallux valgus (JHV), consisting of younger patients under the age of 13 and adolescent hallux valgus (AHV), comprising teenagers and young adults. This delineation is important in regard to management, JHV will generally be provided with conservative management, and surgical intervention will be considered with AHV patients. For the purpose of this review, PHV will be used when describing both populations unless otherwise noted. In PHV as opposed to adult HV, there is less valgus deformity of the MTP joint, no degenerative changes, a smaller medial eminence, and less bursal thickening. As a result of the nonanatomic alignment of the MPJ in PHV, patients' most common complaints are related to pain and cosmetic disfigurement (1).

Though PHV has been considered benign, progression of hallux valgus can result in complications such as subluxation of the MPJ, rotation of the great toe, pain, and decreased activity level (2). Progression of PHV is often thought to be secondary to the presence of an open physis (1). Furthermore, the presence of an open physis creates a level of uncertainty as to whether physeal growth after surgical correction could lead to recurrence or overcorrection. Lastly, surgery for hallux valgus could involve a proximal metatarsal osteotomy or a first metatarso-cuneiform fusion, both of which could result in physeal injury. For the above reasons, except with one minor exception discussed below, corrective hallux valgus surgery should be delayed until first metatarsal physeal closure (3). The gender distribution of PHV is similar to that noted in the adult literature with a female to male ratio of 10:1 (4). In certain neuromuscular and connective tissue disorders the etiology, severity, and treatment of PHV, can differ from the general population. For example, in Cerebral Palsy (CP), foot deformity and its effect on gait increases the likelihood of surgical intervention, when compared to the general population. PHV can also be seen in many musculoskeletal or connective tissue disorders, such as Ehlers-Danlos Syndrome (EDS), Marfan's Syndrome, Osteogenesis Imperfecta (OI), and Fibrodysplasia Ossificans Progressiva (FOP).

PHV is a prevalent condition that is associated with a number of comorbidities and genetic pathologies. The current review was conducted to aid primary care providers in better understanding the pathogenesis, associated conditions, intervention options available, and when to consider surgical referral for management of PVH.

PATHOGENESIS/GENETICS

Complete etiological understanding of PHV development remains elusive, however, predisposing factors include a strong family history, female gender, trauma, pes planus, and a long first metatarsal (4,5). In addition, the element of ongoing growth in children adds an extra layer of complexity to decision making. When present in infancy, it can be associated with ligamentous laxity, abnormal bone development, and pes planus (3,6). Hallux valgus in adults is strongly associated with constrictive footwear (7). In contrast, the role of constrictive footwear in the development of PHV was only noted in 24% of patients and is therefore unlikely to be of a significant factor (3,5,7–9). Another hallmark of PHV etiology is Metatarsus Primus Varus (MPV). MPV is defined by medial deviation of the first metatarsal, which causes deforming forces and subsequent mal-positioning of the MPJ. Although the cause of MPV remains controversial, it is generally considered a foundational condition in PHV.

PHV is a complex condition without a clearly established pattern of inheritance, however, most affected individuals have a positive family history. In adults with hallux valgus, the Framingham Foot Study (n=1,370) found a moderate to strong heritability that varied dependent upon age and sex (corrected heritability values ranging from 0.29 to 0.89), however, this study did not look at the timing of onset of the deformity (10). Another study of an adult hallux valgus found inconsistency in presentation across nuclear family members indicating a seemingly autosomal dominant inheritance pattern with incomplete penetrance of roughly 50% (7). Notably, the prior study by Vidal et al. also included 15 patients who were diagnosed with PVH of which 46.6% (7/15) had a family history of hallux valgus (7). To date there have been no linkage, candidate gene association, or genome-wide association studies on PHV, which would help provide further insight into the genetics of the condition.

PHV-ASSOCIATED CONDITIONS

Neuromuscular and connective tissue diseases commonly necessitate orthopedic consultation and, at times, intervention given the array of musculoskeletal pathologies encountered throughout the course of the patient's development (11). From an orthopaedic surgeon's prospective, the primary issues in patients with neuromuscular disorders are weakness, and muscle imbalance (11). As neuromuscular patients age these imbalances commonly lead to contractures, which often impedes the child's ability to ambulate and can lead to permanent joint dysfunction (11,12). In CP and spina bifida, for example, muscle imbalances can lead to pathologies such as pes valgus, foot drop, equinus contracture of the foot, tibial rotation, club foot, hallux valgus, and congenital vertical talus (12,13). Furthermore, connective tissue disorders such as Marfan's can lead to lower extremity pathologies such as medial displacement of the medial malleolus, developmental hip dysplasia, leg length discrepancies, pes planus, patellar instability, and hallux valgus.

PHV commonly present in both neuromuscular and connective tissue disorders (14). Foot deformities in CP are

considered a result of both extrinsic and/or intrinsic muscle imbalance of the feet (1,15). The external muscle abnormalities result in biomechanical changes in gait, which can contribute to hallux valgus development. The pathogenesis of PHV in CP is thought to be due to the collapse of the medial longitudinal arch and associated flat foot deformity causing pronation and axial rotation of the MPJ (16). In addition to PHV, other foot pathologies common in CP such as equinus, equinovarus, or planovalgus may be visualized (15).

Pediatric Hallux Valgus can be congenital in patients with underlying genetic disorder such as: EDS, Marfan's Syndrome, OI, and FOP (17). In these early onset cases, subtle skeletal or skin abnormalities may be the first clue to the underlying genetic abnormality. Marfan's and EDS are both inherited disorders that impact organization, structure, and function of connective tissue (18,19). Due to the increased flexibility of the joints in Marfan's and EDS, foot deformities such as pes planus, and PHV are common (19). In patients with OI, there is a decrease in the amount, and integrity of type 1 collagen, the foundational collagen of bone, making bones prone to fracture and angular deformity. Due to the underlying bone pathology, numerous joint problems are encountered including hallux valgus in addition to other foot deformities (20).

FOP is a rare autosomal recessive connective tissue disorder, characterized by progressive ossification of tendons, ligaments, fascia, and skeletal muscle, and congenital malformation of the great toes (17,21). In 2015, the presence of bilateral hallux valgus on ultrasound in the third trimester led to the first in utero diagnosis of FOP (22). This established hallux valgus as a primary skeletal abnormality in patients with FOP. Clinicians should be aware that this great toe deformity can be one of the earliest signs of FOP (23).

CLINICAL HISTORY/PRESENTATION

The clinical presentation of PHV includes pain, skin irritation, swelling, cosmetic deformity, and difficulty finding appropriate footwear (24). Patient age at first presentation can provide clues as to the etiology of PVH (Figure 1). In PHV, 50% of cases present before the age of 10, with an increased prevalence in females, a number quoted as high as 80% in the literature (3). One possible explanation for this discrepancy is that females may have a predisposition to increased soft tissue laxity (7,8). Females have a laxity peak at 15 years of age, aligning with the hormonal changes of puberty (25). Relaxin is a pro-laxity hormone hypothesized to be responsible for increasing ligament and tendon laxity seen during puberty and pregnancy (26). On

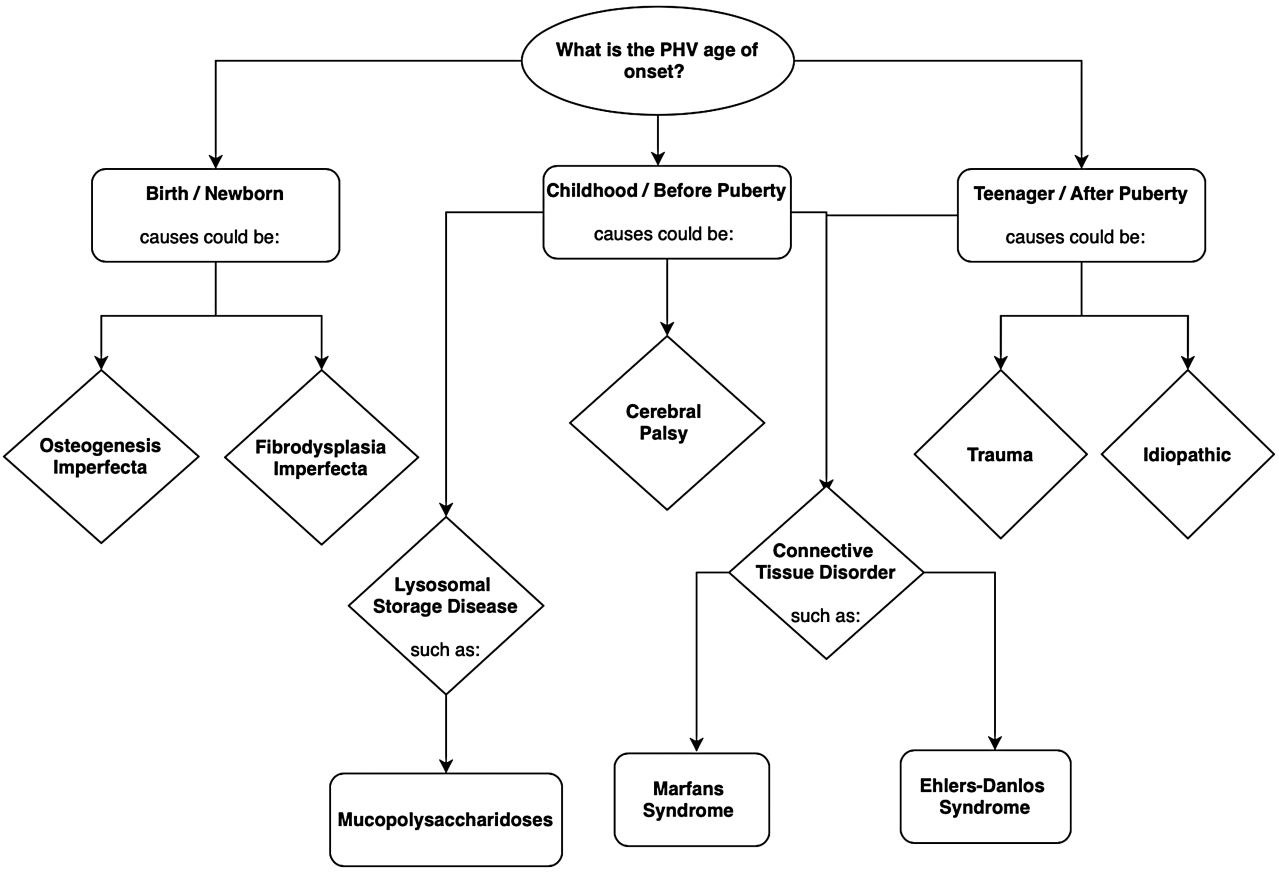

Figure 1. Potential etiologies of PVH by age of presentation.

the contrary, male patients have a decrease in laxity throughout adolescence. Thus, the endocrinological differences between males and females may help explain the discrepancy in incidence of both pediatric and adult hallux valgus.

PHYSICAL EXAM

The physical examination should begin with inspection of the bare feet in a standing position. The hindfoot and midfoot are inspected for valgus or planus, respectively, and an observational gait analysis is performed (27). The lower extremities are inspected for deformity such as genu valgum or varum. Lower extremity deformities, that alter normal joint alignment or weight distribution, can increase the risk of downstream deformities such as hallux valgus. This is particularly true of deformities such as knee valgus, ankle valgus, or hindfoot planovalgus (3–5). The forefoot and hallux are inspected in a standing position paying particular attention to medial deviation of the first metatarsal and valgus of the MPJ. Signs of previous trauma or surgical intervention are noted, and analysis of the skin should focus on the MPJ region for ulcers and hyperkeratosis. Examination of the joint should be conducted in both a weight bearing and non-weight bearing position. Both passive and active ROM should be inspected, and any painful movements should be thoroughly documented (27).

RADIOGRAPHIC ANALYSIS

All patients with suspected PHV should undergo standard weight bearing radiographs including anteroposterior, oblique, and lateral views. There are three radiographic measurements commonly used to measure the extent of deformity including: The hallux valgus angle (HVA), first and second intermetatarsal angle (IMA), and the distal metatarsal articular angle (DMAA) (Supplementary Appendix 1). The HVA is considered normal if <15 degrees and is defined as the angle between the longitudinal axis of the first metatarsal and the proximal phalanx (28). A normal IMA is considered to be less than nine degrees and describes the angle between the longitudinal axis of the first and second metatarsals (28). Finally, the DMAA describes the angle between the longitudinal axis of the first metatarsal and the axis of the distal articular cap. A DMAA <6 degrees is considered normal (29). The HVA and IMA have both been shown to have excellent intra- and inter-reviewer reliabilities with kappa values greater than 0.85 (30,31). However, measurement of the DMAA is less reliable with kappa values ranging from 0.4 to 0.8 (30,32,33). The HVA and IMA are used together to gauge the severity of the overall deformity, while the DMAA is used to provide additional information about the degree of articular incongruency. Together, these radiographic measurements delineate the components of the complex, three-dimensional hallux valgus deformity and help in selecting the specific surgical procedure for a given foot.

CONSERVATIVE TREATMENT

Due to the high incidence of recurrence in operatively treated PHV, nonoperative treatment is the mainstay of hallux valgus management in the pediatric population (3). Conservative treatment allows time for skeletally immature individuals to complete growth which is felt to mitigate recurrence (3). If the deformity is asymptomatic, no intervention is necessary (3). Nonoperative therapeutic modalities aimed at pain reduction include bracing, physical therapy, activity modification, and shoes modification (wide toe box shoes) (34). Orthotic inserts are useful when painful hallux valgus is present concomitantly with flexible pes planus. Stabilization of pes planus often decreases hallux valgus pain although care should be taken to avoid excessive pressure on the medial prominence which could increase pain (3,34,35). However, the utility of orthotics in isolated hallux valgus cases under the age of 13 is questionable, as orthotics have been shown to not slow the progression of the hallux valgus angle in these patients (Supplementary Appendix 2) (35). Although literature has shown progression of adolescent hallux valgus despite orthoses or well-fitting shoes, it is thought noncompliance plays some part in deformity progression (35).

Nonsurgical treatment may also be beneficial in patients with neuromuscular disorders, ligamentous laxity, or inability to maintain non-weight bearing (34). Groiso et al. also found that nighttime splintage used in combination with passive and active stretching exercises improved both the intermetatarsal and metatarsophalangeal angle in 50% of cases with no recurrence observed among patients who had improved. Most studies, however, consider bracing as an option for symptomatic relief but note that they do not provide long-term correction or prevention of progression of the deformity (3). Many providers report a problem with compliance in the conservative management, as pediatric patients do not want to wear the unaesthetic braces (3).

Pediatric hallux valgus has also been associated with gastrocnemius tightness, which exerts a deforming force on the hallux (36). Nonsurgical management includes stretching the gastrocnemius which has been found to have a positive effect. Unfortunately, upon cessation of these exercises the benefits appear to wane (36). Therefore, this option requires long-term compliance and if not feasible, surgical lengthening of the gastrocnemius should be considered (36).

Despite these aforementioned challenges, nonsurgical approaches are recommended prior to surgical intervention in all patients given the high rate of recurrence after surgery (34). If conservative approaches fail prior to skeletal maturity, the risk of recurrence and need for revision surgery should be discussed with patients and their families before surgical referral is made (3). Practicing pediatricians should only consider orthopaedic referral for surgical evaluation after patients have failed

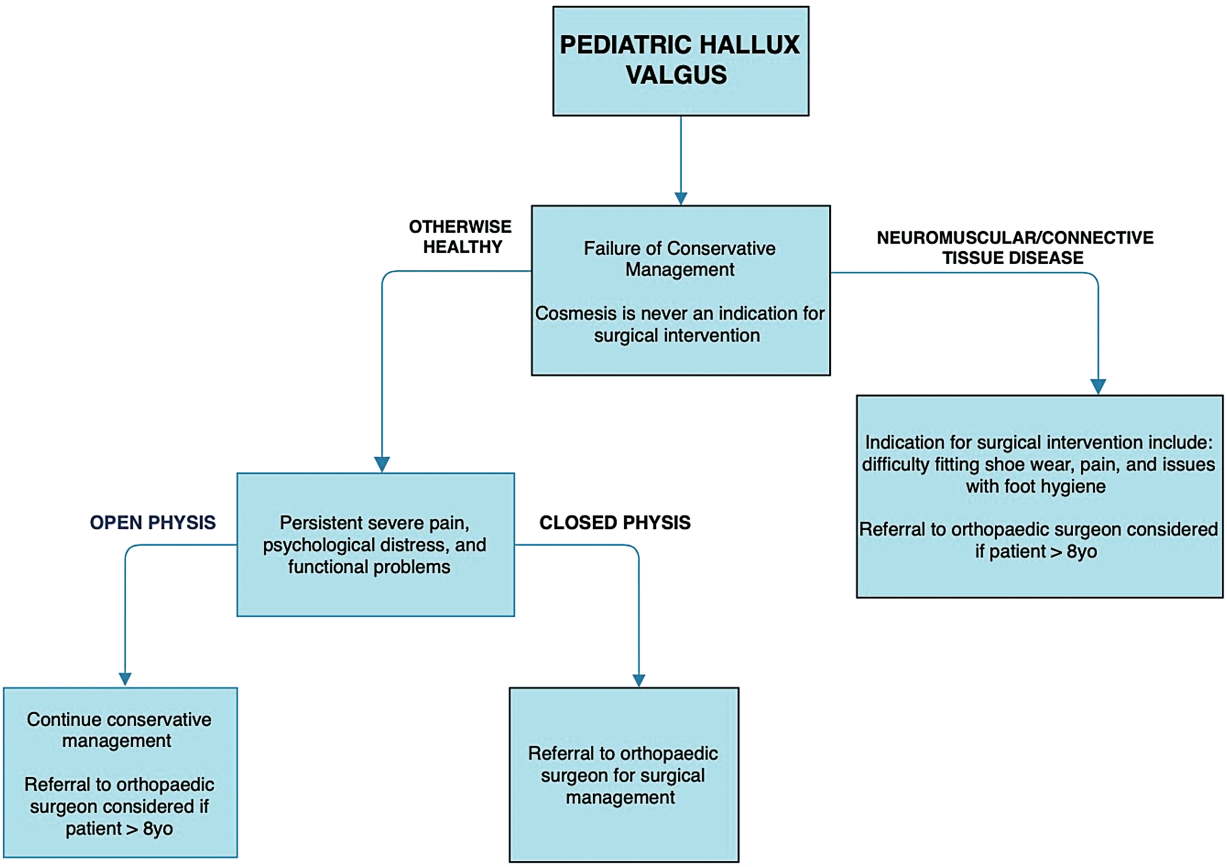

Figure 2. Recommendations for orthopaedic referral.

attempts at conservative management. We have created a guide for appropriate timing of orthopaedic referral based on the surgical techniques discussed below in Figure 2.

SURGICAL TREATMENT

The role of surgical correction in children without neuromuscular disorders and open physes is limited and should be delayed at or beyond the point of skeletal maturity (3). While new surgical techniques, particularly lateral hemiepiphyseodesis, may allow for earlier intervention, these techniques are not yet widely utilized by the orthopaedic community. The primary indications for surgical intervention in AHV are unrelenting pain with failure of nonoperative measures (3). Currently, there are more than 130 surgical procedures described for the management of this condition with no single superior treatment option (3). Surgical management falls into four primary categories: proximal metatarsal osteotomy, distal metatarsal osteotomy, soft-tissue procedures, and combined (3). Medial cuneiform-first metatarsal fusion (Lapidus procedure) can also be considered and is generally combined with a distal soft tissue realignment. Presently, it is unclear what role this should play in the surgical treatment of AHV, but it would likely be indicated in cases with hypermobility of the first ray (37,38). In general, AHV has been associated with recurrence rates after surgery up to 61% (39). Additional complications include infection and avascular necrosis (40,41).

In cerebral palsy and other neuromuscular disorders, surgical correction of hallux valgus deformity is indicated to address pain of the MPJ, discomfort with shoe wear and hygiene issues related to toe compression (15). This is in contrast to the more conservative and noninvasive primary treatment in the general pediatric population (16). Clinically, it is important to delineate and correct abnormalities elsewhere in the foot in addition to treating the hallux valgus in this patient population. MPJ arthrodesis (Fusion) is generally necessary for hallux valgus correction in cerebral palsy (15). Due to the proximal location of the physis of the proximal phalanx, MPJ fusion is reserved for older children with no more than 2 years of growth remaining (15). The radiographic results of AHV surgical correction in a 15-year-old female are shown in Figure 3. It is also important to correct gastrocnemius tightness with recession.

An alternative surgical approach for symptomatic and progressive PHV is lateral hemiepiphyseodesis of the great toe metatarsal physis (1). Hemiepiphyseodesis fixes the lateral portion of the proximal first metatarsal's physis aiming to cause asymmetric bone growth resulting in correction of the deformity. This approach facilitates gradual correction of PHV by

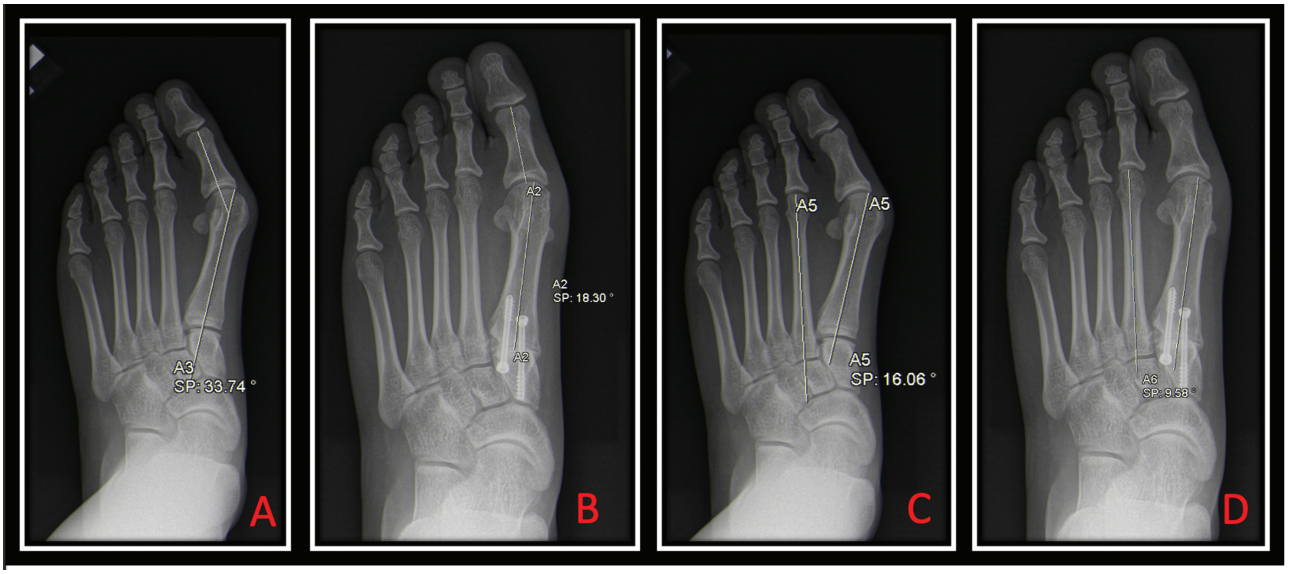

Figure 3. Standing AP pre- and postoperative radiographs of a 15-year-old female with hallux valgus who underwent a medial cuneiform/first MT fusion (Lapidus procedure) and distal soft tissue realignment. (A) Preoperative AP view shows HVA of 30 degrees. (B) Postoperative AP view shows HVA of 18 degrees. (C) Preoperative AP view shows IMA of 16 degrees. (D) Postoperative AP view shows IMA of 10 degrees.

guiding the growth of the physis at the base of the first metatarsal and has been recommended in children with 2 or more years of growth remaining (1). While this new technique is promising, lateral hemiepiphyseodesis only has several small cohorts of evidence in literature and is yet to become common practice among pediatric orthpaedists.

In general, due to the high complication and recurrence rates in PHV, surgical intervention should be reserved for individuals who have significant pain and have failed conservative treatment. Parents and patients should be informed of the high risk of recurrence of deformity. The surgical procedure chosen should be individualized to correct the underlying deformity noted after careful clinical examination and review of the radiographic parameters such as the IMA, HVA, and DMMA. Lastly, care should be taken to carefully assess more proximal deformities such as planovalgus and gastrocsoleus tightness.

SUPPLEMENTARY DATA

Supplementary data are available at *Paediatrics & Child Health* Online by searching for pxab074.

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