© *Foot and Ankle Research Consortium, Inc*
Peachtree Plantation - West
Suite # 5901 Wilbanks Drive
Norcross, Georgia, 30092.

1.770.448.0769 (voice mail)
1.775-361-8831 (facsimile)
www.PodiatryPrep.com
sales@podiatryprep.com

THE COMPLEX DEFORMITY KNOWN AS HALLUX ABDUCTO VALGUS

According to most historical authorities, such as Kellikian, Gianestrass, DuVries, and Reverdin, as well as newer though leaders, such as Jahss, McGlamry, Ruch, Gudas, LaPorta, and DE. Marcinko in 2005, the deformity known as Hallux abducto valgus (HAV) denotes a relationship of the hallux to the first metatarso-phalangeal joint.

There is an angulation of the great toe away from the midline of the body, which may ride under or over the lesser digits. Root described HAV has a progressive subluxation of the first metatarsoªphalangeal joint in which the first metatarsal inverts relative to the hallux, followed by subluxation of the hallux into valgus. Abduction of the hallux is followed by subluxation of the first ray and adduction of the first metatarsal, increasing the inter metatarsal angle Mann and Coughlin described HAV as a static subluxation of the first metatarsophalangeal joint, with medial deviation of the first metatarsal and lateral deviation of the great toe. Gerbert defined HAV as a hallucal relationship to the first metatarsal head, encompassing deviations of the entire MPJ, in all three planes. HAV is, in fact, a triplanar deformity lying on the frontal, transverse and sagittal planes.

- Frontal plane: valgus rotation of the hallux rotated so that its plantar aspect is more prominent laterally.
- Transverse plane: hallux is laterally deviated toward lesser toes.
- Sagittal plane: hallux is rotated with dorsal or plantar deviation. It is characterized by abduction of the hallux from the midline of the body, progressive rotation of the hallux at the first MPJ and adduction of the first metatarsal with prominence of the head medially. Additionally, shoe irritation at the level of the first metatarsophalangeal joint may cause a fluid-filled bursa to form at the dorsal medial prominence

EPIDEMIOLOGY AND ETIOLOGY OF HALLUX VALGUS DEFORMITY

Hallux abducto valgus is one of the most common deformities encountered in the lower extremities.

A great deal of research has been conducted to estimate the incidence of HAV deformity. Both the entire populations as well as specific groups based on sex, age, or race have been examined resulting in a wide range of estimates. One such study, conducted by the National Center for Health Statistics, determined that ten percent of the population suffered from some type of foot pathology and HAV was one of the 13 musculoskeletal conditions researched. 42,000 households, containing 134,000 people, were interviewed and the prevalence rate of HAV was determined as 12.3/1000 or a total of 2,420,000 people. The female to male ratio was 3.8:1.0, regardless of age. The greatest prevalence, according to geographic location, was found in the Southern USA. Comparison of the deformity by race was difficult to ascertain since all non-white participants were grouped into a single cohort.

Other studies have been performed, on a lesser scale, or in relation to certain subsets such as age or race. For example, Craigmile, in a study of 12,765 schoolchildren

- In the 5-7 year age group, 4.3% of males and 4.7% of females were affected with hallux valgus.
- In the 8-11 year age group, 6.1% of males and 11.7% of females were affected with hallux valgus.
- At the 12-16 year age group, 4.0% of males and 22.4% of females were affected with hallux valgus. Later, Notari and Mittler examined a population of 508 schoolchildren, ranging in age from 6-12 years, and noted a prevalence of five percent HAV formation.

Gould performed another survey that was sent to 45,000 families, with a 33% completion rate. His data indicated that 40% of the population had foot problems and the incidence of HAV appeared to follow those previously stated, demonstrating an increase with age and an approximate 3:1 female-to-male ratio. James studied barefoot natives of the Solomon Islands and found the deformity to be primarily non-existent. Shine examined the population of the island of St. Helen and found a prevalence ranging from 2-48%, depending on whether or not the population was shod. In our own podiatric studies, 8-10% of the female population and 1-2% of the male population, is affected by juvenile HAV. When juvenile HAV is present, the deformity seems to occur more rapidly and necessitates earlier treatment than adult onset HAV, which usually occurs at the age of thirty years in females, with progression reaching a peak at age 45. The examination of ten years of surgical statistics, at the University of Chicago, revealed that approximately 88% of all HAV surgeries were on females, with an average age of 43.5 years.

Hereditary Factors

Historical evaluations indicate hereditary factors involve from 60-80% of all patients with HAV deformity. They indicate that inheritance of hallux valgus is an autosomal dominant propagation with incomplete penetrance. The deformity appears to be sex-inked (possibly dominant in females, possibly recessive in males), which could imply a purely genetic axis.

However, there are other obvious variables including shoes, childbirth, and biomechanical abnormalities which may also account for the statistical over-balance in favor of females. DuVries stated that any anatomical variant, in which the deformity was found, was considered hereditary. Hardy and Clapham demonstrated that, in a group of 91 cases of hallux valgus, there was a 63% positive familial background. Sadelin studied 536 cases of HAV and determined a 54% incidence of hereditary history. It therefore appears that there is predisposition to HAV when family history is examined. In general, it is now accepted that hereditary factors play either a direct or indirect role in the development of HAV deformity.

Shoegear Contribution

The issue of shoegear contribution to HAV formation has long been discussed. Fook and Hodges believed that foot deformities are of recent origin in human history and date back to the introduction of footwear. This hypothesis is reinforced by their study on a portion of the Chinese population, half of which wore shoes and half of which did not. In the shod population, 33% were found to have HAV. The barefoot population demonstrated a frequency of only 1.9%. They concluded that restrictions of the foot by a shoe can cause an alteration in its natural form, with the development of static deformities.

Gottschalk surveyed females of three South African populations between the ages of 2-20 years. The three groups included an urban white community, an urban black community and a rural black community. The results of the study demonstrated that, up to age five years, there was no significant difference in the hallux abductus angle. After age five, the white population had an abrupt increase in the angle. This was significant in that, once formal education began, the children wore shoes on a regular basis. The researchers noted that a progressive deviation of the hallux was then observed.

Kato and Watanabe examined the foot prints of ancient Japanese which were found without evidence of HAV. These footprints were believed to be from the Johmon period from 6,000 BC to nearly 300 B.C., well before any type of constrictive shoes were worn. Within the Japanese population, the same authors noted a definite increase of HAV subsequent to the wearing of leather shoes, in1972, with resultant increase in the deformity. This was especially seen in the female group, between the ages of 12-15 years, who experienced a 2.7% incidence of deformity compared to a 14.2% incidence in the population with ill-fitting shoes. Mechanically, Hiss stated that improperly proportioned shoes will mold the foot into the direction of eversion, producing an unbalanced foot and medially directed weight-bearing. Other studies however, have not supported shoegear as the etiology of HAV formation. For example, Root and Hardy and Clapham found an inverse relationship between shoegear and HAV deformity while McElvenny felt that HAV would be universally present in the modern Western female population if shoes were a major causative factor.

Barnicott and Hardy studied a West African population and found occasional abductus deformity of more than 20 degrees, among the barefoot Africans, while a deviation of more than ten degrees was not infrequent in the population sample below the age of twenty-five years.

Neuromuscular Causes

Neuromuscular disease has been documented as an etiologic factor in the formation of HAV and multiple neurological diseases may contribute to development of the deformity. These deficits include poliomyelitis, cerebral vascular incidents, Charcot arthropathy, myotonic dystrophy or any other condition causing weakness or flaccid paralysis in the peroneus longus muscle complex. Cerebral palsy, as an etiologic factor, has been well established and Goldner stated that even minimal contractures can become severe when growth and development occur, leading to first MPJ aberrations due to an associated equinovalgus deformity, metatarsus primus adductus deformity, or both. Especially important is adductor hallucis spasticity which may adduct the first ray and place excessive weightbearing on the medial first ray segment.

Myotonic dystrophy, a congenital progressive multisystem disorder, has also been shown to produce HAV, even in the neonatal period. Multiple sclerosis is another causative factor and lower motor neuron disorders, such as muscular dystrophy, may be implicated. Combined other etiologic factors include ligamentous laxity, plasticity, functional pronation of the foot resulting in hypermobility of the first ray and first metatarsocuneiform joint, rheumatoid arthritis or osteoarthritis. Other causes include Williams syndrome, Saethre-Chatzen syndrome, Marfan syndrome, Down syndrome, multiple synostosis syndrome and fibrodysplasia ossificans progressiva. Structural metatarsal length pattern abnormalities may also contribute to the deformity.

Deformity Development

Regardless of etiology, in HAV deformity, the first MPJ becomes mechanically unbalanced resulting in medial protrusion of the first metatarsal with the great toe being forced laterally by extrinsic and intrinsic forces. The metatarsal head begins to slide off the sesamoid complex in a medial direction, stretching the medial capsule and displacing the extensor hallucis longus tendon laterally with a plantarward deviation of the abductor hallucis muscle. Sesamoidal migration laterally results in erosion of the intersesamoidal ridge or crista with further lateral displacement of the sesamoids. There is an effective retrograde force on the first metatarsal head, from the hallux, resulting in an increased intermetatarsal angle. With moderate to severe deformity, the base of the proximal phalanx rotates in the frontal plane into a valgus position. With progressive hallux valgus, the first metatarsal is destabilized, causing a shift or roll off type gait to the medial side of the great toe joint. Excessive valgus thrust of the hallux during the gait cycle leads to frontal plane deviation with callus formation on the medial plantar surface of the joint and hallux.

ANATOMY OF THE PEDAL FIRST RAY SEGMENT

Soft Tissue Structures of the First MetatarsoPhalangeal Joint

- The Extensor Hallucis Longus (EHL) tendon is centralized over the first metatarso-phalangeal (MPJ) joint with no connection to the underlying first metatarsal bone. It is held in place by the extensor hood apparatus that consists of two portions. a. The hood ligament (sling) holds the EHL tendon over the first MPJ with attachments plantarly to the sesamoid apparatus. b. The extensor wing allows the Flexor Hallucis Brevis tendon (FHB), Abductor Hallucis tendon (AbH) and the two heads of the Adductor Hallucis tendon (AdH), by the sesamoid pad, to exert an extension movement on the EHL producing extension of the inter-phalangeal (IPJ) joint.
- The Flexor Hallucis Longus (FHL) tendon is centrally located beneath the first MPJ and courses plantar to sesamoid pad below the intersesamoidal ligament.
- MPJ ligaments are absent dorsally and their function is replaced by the joint capsule and expansion of the extensor tendons: a. The plantar first MPJ ligaments course from the first metatarsal head to the base of proximal phalanx. b. The collateral MPJ ligaments attach dorso-medially and laterally from the epicondyles of first metatarsal to base of the proximal phalanx. c. The deep transverse intermetatarsal-ligament bears a common origin with the medial aspect of the second metatarsal, and a separate attachment to the lateral aspect of the first MPJ, joint capsule and sesamoid apparatus. The conjoined tendon of the adductor hallucis passes between this bifurcation.
- Sesamoidal ligaments: a. Inter-sesamoidal ligament (intracapsular) b. Fibular sesamoid ligament (intracapsular) c. Tibial sesamoid ligament (intracapsular) d. Medial collateral joint ligament (intracapsular) e. Lateral collateral joint ligament (intracapsular) f. Metatarsal-tibial sesamoid ligament g. Metatarsal-fibular sesamoid ligamentB.

Muscular Insertions of the First Metatarso-Phalangeal Joint

- The EHL tendon courses distally to insert into the base of the distal phalanx of the hallux.
- The EDB tendon courses obliquely from lateral to medial and inserts into the dorsal surface of the base of the proximal phalanx.
- The AbH tendon courses distally to insert into the medio-plantar aspect of the base of the proximal phalanx with some fibers blending with the FHB tendon.
- The AdH conjoined tendon (oblique and transverse heads) inserts into the lateral-plantar side of the base of the proximal phalanx, lateral sesamoid terminating in the fibrous sheath of the FHL and passing between the superficial and deep bifurcations of the medial deep transverse intermetatarsal ligament.
- The FHB tendon courses distally to divide into two heads at the level of the sesamoidal apparatus and inserts into the sesamoid pad and base of the proximal phalanx.

- The FHL tendon courses distally to insert on the plantar aspect of the base of the distal phalanx of the hallux.

Osseous Structures

- *First metatarsal shaft*
- a. The shaft is the shortest and strongest of all metatarsals. b. It is triangular in shape. i. three surfaces-dorsomedial, lateral and inferior. ii. Three borders-superolateral, inferolateral and inferomedial. The shaft tapers from the tarsus to its distal end. d. The shaft is curved with a concavity inferiorly and convexity dorsally.
- *First Metatarsal Head*
- a. Shape is large and quadrilateral in general contour. b. The transverse diameter exceeds its vertical dimension. c. The articular surface has two fields of articulation. i. superior articular surface - phalangeal ii. inferior articular - sesamoidal- two grooved facets for articulation with the sesamoids. - facets separated by elevation known as the crista.
- *Base of the First Metatarsal*
- The proximal surface presents a kidney-shaped articular surface for articulation with the first (medial) cuneiform bone. Proximal phalanx a. The body is compressed side to side with a convex dorsal surface and concave plantar surface. b. The head has a trochlear surface for articulation with the distal phalanx. c. The base is concave to articulate with the metatarsal head while its plantar aspect is concave to allow passage of the FHL tendon. 5. Distal phalanx a. The base and shaft similar to that previously described. b. The head has no articular surface and is flattened surface to support the hallux toenail.
- *Sesamoid Bones*
- a. Overall configuration is variable i. may be semi-ovoid, circular or bean shaped. ii. medial usually larger and ovoid or elongated. iii. lateral is smaller and more round. b. The dorsal surface is covered with articular cartilage to seat the plantar articulating surface of the first metatarsal head. c. The plantar surface is convex.
- *First Metatarso-cuneiform (MCJ) Joint*
- a. The diarthrodial joint permits limited gliding motion. b. The joint is connected by dorsal and plantar ligaments. c. The base has no ligaments between the bases of the first and second metatarsals.

Vascular Supply of the First Metatarso-Phalangeal Joint

The vascular supply to the first metatarsal, as well as the first metatarsal-phalangeal joint, must be well understood when considering surgery upon the first ray, especially surgical correction of hallux valgus. There have been numerous studies concerning the vascular supply. Schereff performed a cadaveric study of the arterial supply to the first metatarsal and metatarsophalangeal joint using 32 fresh-frozen below-the-knee or ankle disarticulation specimens that were injected with Mercox red acrylic to delineate the arterial supply.

The first metatarso-phalangeal segment receives its blood supply from:

- *First dorsal and plantar metatarsal arteries*
- Superficial branch of the medial plantar artery. The vascular supply to the first metatarsal and metatarsal phalangeal joint is both extraosseous as well as intraosseous. The extraosseous supply is composed of: 1. First dorsal and plantar metatarsal arteries 2. Superficial branch of the medial plantar artery. These arteries provide branches to the head, shaft and base of the metatarsal, including capsular branches to the first metatarsal phalangeal joint. The first dorsal metatarsal artery originates as a continuation of the arcuate artery off the dorsalis pedis. It courses distally with the first intermetatarsal space, terminating into the two dorsal digital branches supplying adjacent sides of the hallux and second digit. As the artery courses distally within the first interspace, it gives off branches to the base, shaft and head of the first metatarsal. These branches then divide into finer vessels with spread over the periosteum. This is especially important when stripping the periosteum in preparation for correction utilizing an osteotomy. Care must be taken to preserve as much of the periosteum as possible so as to optimize vascular supply to the metatarsal after the osteotomy has been performed. At the level of the metatarsal head, these finer vessels form an extensive network of vascular supply to the dorsal and lateral aspects of the first metatarsal phalangeal capsular structures.
- The first plantar metatarsal artery originates from the perforating branch of the arcuate artery. It provides several branches to the base and shaft of the first metatarsal. Discrete branches are provided to the capsule of the first metatarsal phalangeal joint at both the plantar and lateral aspects. The first plantar metatarsal artery also aids in the formation of a plantar cruciate anastomosis at the level of the neck of the first metatarsal. At this region, the artery is joined by superficial branch of the medial plantar artery.
- These arteries anastomose for a second time at the level of the shaft of the proximal phalanx after forming their respective medial and lateral plantar hallucal arteries. The superficial branch of the medial plantar artery provides branches to the first metatarsal throughout its course, though on a less consistent basis. The artery also supplies branches to the plantar and medial aspect of the first metatarsal phalangeal joint. All of the above course beneath the deep portion of the transverse metatarsal ligament. As previously described, the first metatarsal phalangeal joint has three main arterial sources, the first dorsal and plantar metatarsal arteries, as well as the superficial branch of the medial plantar artery. The first dorsal metatarsal artery provides the most extensive and consistent supply to this area.
- Also, it is important to remember that the dorsal and the lateral aspects of the joint receive a greater number of branches than did the medial or plantar aspects. This is of particular importance when performing capsular dissection to obtain access to the metatarsal head. One must, therefore, preserve as much dorsal and lateral capsular attachments as is possible.
- The intraosseous vascular supply to the first metatarsal is one of an extensive network. The origin of this vascularity is comprised of three primary sources: The periosteal arterial system, the principal nutrient artery, and the metaphyseal and capital arteries.

- The periosteal arterial system spreads over the cortex of the diaphysis of the metatarsal. This arterial supply is derived from the first dorsal metatarsal artery, the first plantar metatarsal artery, as well as the superficial branch of the medial plantar artery. The periosteal vessels anastomose with branches from the nutrient artery at the endosteal level of the diaphysis. Excessive periosteal dissection is avoided, thereby maintaining a source of intraosseous supply. This may be especially important if other areas of intraosseous and extraosseous supply have been disrupted during correction. The principal nutrient artery enters the first metatarsal approximately at the level of the distal 1/3 of the shaft at the lateral cortex. This vessel originates from the first dorsal metatarsal artery and, upon penetrating the cortex, divides into distal and proximal branches. The proximal branch extends toward the base of the metatarsal and anastomoses with metaphyseal arteries at this level. The distal branch anastomoses with metaphyseal arteries at this level. The distal branch anastomoses with the metaphyseal and capital vessels. The anatomic location of this vessel is extremely important during surgical intervention. When performing the lateral release, this arterial supply can be easily disrupted if one dissects too proximal. The metaphyseal and capital arteries originate from extracapsular arteries. The metaphyseal arteries penetrate the capsule of the first metatarsal phalangeal joint and enter the bone at the level of the head and neck junction. Two metaphyseal arteries penetrate the dorsal and plantar surface of the metatarsal. The dorsal metaphyseal arteries supply the dorsal 2/3 of the head of the metatarsal, the plantar metaphyseal arteries supply the remaining 1/3 of the metatarsal head.
- The capital arteries penetrated the first metatarsal head at the non-articular surface from both the medial and lateral sides. These vessels were found to anastomose with the dorsal and plantar metaphyseal arteries. The capital arteries supply the medial and lateral 1/4 of the head of the metatarsal. The metaphyseal and capital arteries are of critical importance in supplying the first metatarsal head, especially when performing distal osteotomies. Excessive dissection at the level of the head and neck junction, dorsally, laterally, and plantarly, should be avoided so as to minimize the probability of avascular necrosis.

E. Innervation of the First Metatarso-Phalangeal Joint

- Innervation to the first metatarsophalangeal joint and hallux are from three primary sources: The deep peroneal nerve, the medial dorsocutaneous nerve, and the medial plantar nerve. One must be able to identify and protect these structures during dissection and, when considering surgical approaches, one must be aware of the course of innervation so as to reduce the probability of inadvertent denervation.
- The medial terminal division of the deep peroneal nerve follows the course of the dorsalis pedis distally into the first intermetatarsal space. The nerve divides distally to supply adjacent sides of the hallux and second digit. An intraosseous branch is given off prior to its digital division to supply the first metatarsal phalangeal joint.

- The medial division of the medial dorsocutaneous nerves courses dorsomedially along the first ray to supply the dorsomedial aspect of the hallux. This nerve will also send small branches to the dorsal and medial aspects of the first metatarsal phalangeal joint. The first digital nerve branch, or proper digital nerve, of the medial plantar nerve supplies the plantar medial aspect of the hallux as well as sending small branches to the plantar and medial aspects of the first metatarsal phalangeal joint. The second digital nerve, or first common digital, from the medial plantar nerve runs plantarly in the first intermetatarsal space and divides distally to supply adjacent sides of the hallux and second toe. This nerve will also supply innervation to the plantar and medial aspect of the first metatarsal phalangeal joint.

F. Functional Anatomy of the First Metatarso-Phalangeal Joint

- The first ray is a functional unit consisting of the first metatarsal, first cuneiform, navicular and phalanges of the hallux. The first MPJ has two distinct axes of motion – transverse axis and vertical axis. The transverse axis that provides pure plantarflexion and dorsiflexion of the hallux. The vertical axis that provides pure adduction and abduction. Normally there is very little or no frontal plane movement at the MPJ that may sublux the joint.

- Functional joint types during normal ambulation:
- Transverse plane - first MPJ functions as a ginglymus type joint that simulates hinge-like motion.
- Sagittal plane motion very important in normal locomotion - functions as a ginglymoarthrodial type of joint. a. In plantarflexion and the initial 20-30 degrees of dorsiflexion, the MPJ functions as a ginglymus joint (hinge) in which the hallux can rotate on the first MPJ without movement of the metatarsal. Dorsiflexion of the first MPJ, beyond 20-30 degrees, requires an arthrodial type of motion at the joint with plantarflexion of the first metatarsal head that must glide in a plantar direction relative to the base of the proximal phalanx. This motion results in a shift of the axes of rotation in a dorsoplantar direction. The dorsal articular surface of the 1st meta-tarsal head then articulates with the base of the proximal phalanx to provide substantially greater MPJ dorsiflexion.
- The motion of the 1st MPJ goes through three distinct phases during ambulation: 1. Distraction begins at the first phase of dorsiflexion that increases joint space for the next phase. 2. Gliding as the metatarsal plantarflexes and the hallux oves to increase dorsiflexion and extension of the MPJ. 3. Compression occurs at the end range of motion as the proximal phalanx compresses against the dorsal surface of the metatarsal head allowing the rigid lever to become complete.
- Sesamoid function is necessary for stabilization of the 1st MPJ during propulsion. Sesamoids serve a pulley function for the first MPJ with muscle insertion to stabilize the hallux against the ground during propulsion. 2. During propulsion, as the heel raises, the first metatarsal head moves in a posterior direction as the first ray plantarflexes and the sesamoids move in a more distal position beneath the articular surface. 3. Sesamoidal ridge providing transverse stability for the sesamoids during the propulsive phase of gait. Instability of the first MPJ secondary

to hallux valgus may cause wearing down of the crista which, in combination with the other pathological entities involved with the deformity, can lead to dysfunction of the sesamoids, thus decreasing propulsive stability of the hallux during gait.

Contact or Stance Phase Gait Analysis (Effect on the First Ray)

Forefoot contact with midtarsal joint compensation for subtalar joint pronation without first ray motion during contact phase. b. Midtarsal joint possesses two 2 axes of motion around which pronation-supination may occur: Oblique Axis = dorsiflexion and abduction. Longitudinal Axis = inversion and eversion. Theoretical locking occurs at the midtarsal joint, causing stability of the lateral column, especially the cuboid that serves as a fulcrum for the peroneus longus tendon. Peroneus longus pull, relative to the first ray, with plantar-lateral stabilization of the first ray against the tarsus. As forefoot contact increases, plantarflexion increases, thus creating a stable base for propulsion

Functional Abnormalities Leading to Hallux Valgus Formation

- Abnormal subtalar joint pronation that may lead to pronation with "unlocking" of the midtarsal joint.
- Midtarsal joint unlocking causes lateral column instability.
- The cuboid becomes unstable and the peroneus longus cannot stabilize and plantarflex the first ray, resulting in hypermobility with subsequent dorsiflexion adduction and inversion of the first metatarsal.
- Continued inversion causes stretching of the tibial sesamoid ligament.

EVALUATION OF HALLUX VALGUS DEFORMITY

Physical Findings

It is estimated that from 50-70% of patients suffering from hallux valgus have some pain or irritation associated with the deformity. The severity of the deformity, however, is not a good indicator of pain. Often patients with severe hallux valgus will have very little or no pain upon ambulation or with shoes. The moderate bunion is often more painful and irritating in shoes than severe bunion formation. Disturbance may be manifested in many ways. There is often a burning type pain present when the patient is in bed or resting, which does not occur upon ambulation. Other symptoms may include partial or complete anesthesia along a course of the medial dorsal cutaneous nerve. Erythema around the bunion may indicate low grade joint inflammation or bursae formation which is usually painful to the patient and in some cases may cause extreme difficulty inshoe fitting and ambulation.

Shoe Fitting Difficulty

Not all patients with hallux valgus formation have shoe-fitting difficulty. In general, patients with more flexible feet seem to tolerate shoes better than the patient with a more rigid non-flexible foot.

The inflexible patient seems to have difficulty, especially at the junction of the shoe and the deformed medial side of the joint. Many patients seem to accommodate deformity well by purchasing wide and soft shoes with a heel not extending above 1-1/2". Generally, most females begin to wear comfortable shoes approximately at age 45, and this change alone may often decrease symptomatology.

Age Factors:

It has been estimated that up to 20% of females between the ages of 16-18 may be afflicted with hallux valgus formation. In this age group, symptomatic hallux valgus often begins before the ageof 30. These symptoms seem to reach their peak between the ages of 45-60, with a gradual decrease seen after the age of 60.

Foot Type:

Inman and others have linked hallux valgus formation to excess pronation of the foot. It is important to assess the foot type, whether the patient has a pronated foot, or a flexible plantarflexedfirst ray that may often lead to severe hallux valgus formation due to the extreme ranges of motion the joint undergoes throughout the gait cycle. One must ascertain if the first ray is hypermobile or if there are any muscle weaknesses that may be present.

RADIOGRAPHIC FINDINGS

Hardy and Clapham (1951) determined normal and abnormal intermetatarsal angles in a controlled study. They determined normal and abnormal sesamoid positions, as well as normal medial longitudinal arch height and declination of the first metatarsal. They also ascertained the mean hallux valgus angle, and hypothesized about relative first metatarsal protrusion and the formation of hallux valgus. Piggott, in 1960, was the first to classify articular deviation of the first metatarso-phalangeal joint into three distinct morphological entities. He classified joints as congruous, deviated, or subluxed. Smith and LaPorta, 1970-74, merged the Hardy, Clapham and Piggott observations into a standard criteria for X-ray evaluation of hallux valgus. Sorto, in 1976, delineated deviation of the distal phalanx of the great toe. Specific angle and base of gait weightbearing measurements for etermination of hallux valgus severity include the following.

Transverse Plane Radiography

- *Intermetatarsal (Metatarsus Primus Adductus) Angle (IMA*). The relationship of a line bisecting the 1st and 2nd metatarsal shafts: normal = 6-8 degrees, but 8-10 degrees in the adducted foot. The second, third or fourth inter-metatarsal angles are generally not measured.

- *Metatarsus Adductus Angle (MAA).* Demonstrates the position of the metatarsals in relation to the lesser tarsus, and is important in the evaluation of the hallux valgus deformity for two reasons: 1.An increased metatarsus adductus angle has a higher susceptibility to hallux valgus formation. 2. An increased metatarsus adductus angle will cause a relative increase in the inter-metatarsal angle resulting in radiologic miscalculation of the intermetatarsal angle. The angle is determined by the lateral-medial most margins of the lesser tarsus, relative to its perpendicular bisector. A normal angle is about 15 degrees.
- *Hallux Abductus Angle (HAA).* The relationship of a line representing the bisection of the longitudinal axis of the shaft of the hallucal proximal phalanx and of the 1st metatarsal: normal 10-15 degrees.
- *Proximal Articular Set Angle (PASA).* Angle formed by the relationship of a line drawn representing the effective articular surface of the1st metatarsal head and a line perpendicular to a line bisecting the shaft of the 1st metatarsal: normal up to 8 degrees
- *Effective Proximal Articular Set Angle (ePASA*). Intra-operative proximal articular set angle that actually articulates with the hallux, following medial exostectomy. Usually greater than the radiographic PASA.
- *Distal Articular Set Angle (DASA).* Angle formed by a line drawn perpendicular to the effective articular cartilage of the base of the proximal phalanx and a line representing the longitudinal bisection of the proximal phalanx: normal up to 8 degrees.
- *Hallux Abductus Interphalangeal Angl.* Line representing the bisection of the shaft of theproximal phalanx in relationship to a line representing the bisection of the distal phalanx: normal = 0-10 degrees. Occasionally, when the shaft of the distal phalanx is small or irregular, the bisection of the bone must be approximated.
- *First Metatarso-phalangeal Joint Position.* Determined by a comparison of a line representing the effective articular cartilage of the base of the proximal phalanx and that of the head of the 1st metatarsal. a. Congruous joint. Lines drawn are parallel to each other. Ideal joint b. Deviated joint. Lines drawn intersect outside the joint spaces. Phalanx is deviated without base being displaced off the metatarsal head c. Subluxed joint. Lines drawn intersect within the joint space. Proximal phalanx base is not completely articular with 1st metatarsal head. Dislocated joint. Base of proximal phalanx in different plane, than that of first metatarsal head. Proximal phalanx base is not articulating with first metatarsal head.
- *Tibial Sesamoid Position (TSP).* Relative position of the tibial sesamoid to the longitudinal bisection of the shaft of the first metatarsal. A normal position is 3 but may increase with HAV progression. Position 4 indicates crista impingement and potential sesamoid removal or adductor tendon transfer with greater degrees of displacement.

- *The 7 Positions,* TSPs from medial to lateral, include. TSP 1 = Sesamoid rests medially clear of first metatarsal bisector. TSP 2 = Sesamoid laterally touches first metatarsal bisector. TSP 3 = Sesamoid laterally overlaps first metatarsal bisector. TSP 4 = Sesamoid equally halved by first metatarsal bisector. TSP 5 = Sesamoid medially overlaps first metatarsal bisector. TSP 6 = Sesamoid medially touches first metatarsal bisector. TSP 7 = Sesamoid rests laterally clear of first metatarsal bisector. Position 3 is regarded as normal. Hallucal Sesamoid Position. A dorsal view that may represent first metatarsal position in the sagittal plane. A proximally located sesamoidal position may indicate an elevated ray while a distall located apparatus may indicate a plantarflexed ray.
- *Metatarsal Break Angle (Parabola) (MBA.)* That proximal obtuse angle formed by points located at the distal centers of the first, second and fifth metatarsal heads. Normal = 142 degrees.
- *Metatarsal Protrusion Distance*. The relationship between the length of the 1^{st} and 2nd metatarsals b. The bisection of the 1st metatarsal is extended proximally to intersect the bisection of 2^{nd} metatarsal c. A compass is placed at the point of intersection and then set to the length of each metatarsal head, at which time an arc is created for each. The distance between the arc is the difference between metatarsal length, a (+) mm distance indicates 1st metatarsal is longer than the second. Normal range is +/© 2 mm.
- *Tangential Angle to the Second Metatarsal (TASA).* Created by the articular cartilage line of the first metatarsal and a line perpendicular to the axis of the second metatarsal. It measures the orientation of articular set relative to the second metatarsal and ranges from -5 to +5 degrees. Clinical relevance is questioned
- *First Metatarso©phalangeal Joint Assessment.* Overall assessment of metatarsophalangeal joint abnormalities such as cyst formation, erosions, osteophyte formation, both on the dorsal and lateral views and cartilage defects should be noted. A *positional* deformity is one in that the proximal articular set angle and the distal articular set angle are normal. Joint position is either deviated or subluxed. The HAA is normal. A *structural* deformity is one in which either the PASA, DASA, HAI or IMA is abnormal. Joint position is usually congruous and PASA + DASA = HAA. A *combined* deformity includes components of both of the above. PASA and DASA are abnormal and less than HAA.
- Furthermore, Haas ascertained that there were three types of metatarsal head configurations. a. A round unstable metatarsal head is the easiest type to correct but most difficult to achieve long lasting correction. b. A square stable metatarsal head is more amenable to hallux limitus or rigidus formation. c. A square metatarsal head with a central ridge, appears to be the most stable, but also may be associated with hallux limitus or rigidus formation.

Sagittal Plane Radiography

- *First Metatarsal Declination Angle (FMDA).* Relationship of the first metatarsal bisector to the plane of support. Normal is 10 degrees.

- *Hallux Dorsiflexion Angle (HDA).* Relationship between the first metatarsal bisector and the longitudinal bisector of the hallucal proximal phalanx.
- *Hallux Dorsiflexion Interphalangeus Angle (HDIA).* Relationship between the proximal and distal phalangeal bisectors.

Axial Radiography

An axial plantar radiograph is used to assess the frontal plane relationship of the sesamoids to the first metatarsal head. It will also allow evaluation of the crista that determines the relationship between the medial and lateral hallucal sesamoids.

NON-OPERATIVE TREATMENT OF HALLUX VALGUS DEFORMITY

The patient with a bunion should be made aware of options, other than surgery, that are possible to treat the deformity. The most classic advice is, "wear a wider, low-healed shoe." Other options include orthotic devices which may decrease medial protrusion of the first metatarsal head, bunion pads, moleskin applied directly to the irritated area, a change in shoe style to avoid irritation across the bunion, cortisone injections into the inflamed area, physical therapy, and shoe modification by stretching or other means. Non-operative measures may decease the symptoms dramatically in a beginning bunion or one which is non-operative because of circulatory or medical reasons. Most hallux valgus patients should be given the option of non-operative therapy before surgery is attempted.

Concluding Remarks

When all aspects of HAV deformity are respected, successful treatment can usually be obtained. And, it is hoped that the material outlined in this review proves valuable to those who study for board certification examinations.

References:

- Alvarez, R., Haddad, RJ and Gould, N.: The simple bunion. Anatomy at the metatarso-phalangeal joint of the great toe. Foot Ankle, 4: 229, 1984.
- Amarnek, DL, Mollica, A., Jacobs, AM and Oloff, LM: A statistical analysis on the reliability of the proximal articular set angle. JFS, 25: 39, 1986.
- Barnicott, TN and Hardy, RH: The position of valgus in the hallux in West Africans. J. Anat., 89: 355, 1955.
- Castellano, BD and Southerland, JT: Traditional Procedures for the repair of HAV McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. Lippincott, William and Wilkins, Baltimore, 2002.
- Cicchinelli, L: Juvenile HAV Deformity. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. Lippincott, William and Wilkins, Baltimore, 2002.
- Craigmile DA: Incidence, origin, and prevention of certain foot defects. Br. Med. J. 2: 749, 1953.
- Cralley, JC, McGonagle, W and Fitch, K.: The role of adductor hallucis in bunion deformity. PartI. JAPA, 66: 910, 1976 Part II. JAPA, 68: 473, 1978.

- DuVries, HL.: Surgery of the Foot. CV Mosby Co., Chicago, 1965.
- Dykyj, D.: Pathologic anatomy of hallux abducto valgus. Clinics in Podiatric Medicine and Surgery, 1: 1, 1989.
- Engle ET, Morton DJ: Notes on foot disorders among natives of the Belgian Congo. J Bone Joint Surgy 13: 311-318, 1931.
- Gerbert J, Sokiloff TH (eds): Textbook of Bunion Surgery. Mt. Kisco, NY, Futura Publishing Co, 1981.
- Goldner J, Gaines R: Adult and juvenile hallux valgus: analysis and treatment. Orthop Clin North Am 7: 863, 1976.
- Goldner, JC: Hallux valgus and hallux flexus associated with cerebral palsy; analysis and treatment. Clin. Orthop and Rel Research, 157: 35, 1981.
- Gottschalk FAB, Sallis JG, Beighton PH, Solomon L: A comparison of the prevalence of hallux valgus in three South African populations. S Afr Med J 57: 355-357, 1980.
- Gottschalk FAB, Beighton PH, Solomon L: The prevalence of hallux valgus in three South African populations. S Afr Med J 60: 655-656, 1981.
- Gottschalk FAB, Solomon L, Beighton PH: The prevalence of hallux valgus in South African males. S Afr Med J 65: 725 726, 1984.
- Gould N, Schneider W. Ashikaga T: Epidemiological survey of foot problems in the continental Untied States: 1978-1979. Foot Ankle 1:1, pp 8-10, 1980.
- Hardy RH, Clapham JCR: Observations on hallux valgus. J Bone Joint Surg 33B: 376-391, 1951.
- Hardy R, Clapham J: Hallux Valgus: predisposing anatomical causes. Lancet 1: 1180, 152.
- Haas M: Radiographic and biomechanical considerations of bunion surgery. In Gerbert J (ed): Textbook of Bunion Surgery. Mt. Textbook of Bunion Surgery, Futura Publishing, New York, 1981.
- Hiss MJ: Hallux valgus: its cause and simplified treatment Am JSurg 11: 51-57, 1931.
- Inmann VT: Hallux valgus: a review of etiologic factors. Orthop Clin North Am 5: 5-66, 1974.
- James CS: Footprints and feet of natives of the Soloman Islands.Lancet 2: 130, 1939.Jones AR: Hallux valgus in the adolescent. Proc Royal Soc Med 41: 392-393, 1948.
- Kato, T and Watanabe, S.: The etiology of hallux valgus in Japan. Clin Orthop, 157: 78, 1981.
- Lapidus PW: The elusive bunion: etiology, mechanics, treatment. Orthop Rev 3: 35-45, 19974.
- LaPorta, G., Melillo, T and Odinsky, D.: X-ray evaluation of hallux abducto valgus deformity. JAPA, 64: 544, 1974.
- Lam Sim-Fook AR and Hodgson, R.: A comparison of foot forms among the non-shoe and shoe-wearing Chinese population. JBJS, 40A: 1-58, 1958.
- Mann RA, Coughlin MJ: Hallux valgus - etiology, anatomy, treatment, and surgical considerations. Clin Orthop 157:31-41, 1981.

- Marcinko, David Edward (Editor): Comprehensive Textbook of Hallux Abducto Valgus Reconstruction.
- Mayo CH: The surgical treatment of bunion. Ann Surg 47: 300-302, 1908.
- McCarthy, DJ: The surgical anatomy of the first ray. Part I: the distal segment JAPA., 73: 111, 1983.
- McCarthy, DJ, and Grode, S.: The anatomical relationships of the first metatarso-phalangeal joint. JAPA, 70: 493, 1980.McGlamry, ED.; Hallucal sesamoids. JAPA, 55: 693, 1965.
- Meyer, M.: A comparison of hallux abducto valgus in two ancient populations. JAPA, 69: 65, 1979.
- Notari MA, Mittler BE: A study of the incidence of pedal pathology in children. JAPMA Vol 78, 10: 518-521, Oct. 1988.
- Piggot H: The natural history of hallux valgus in adolescent and early adult life. J Bone Joint Surg (Br) 42: 749-760, 1960.
- Rega, R., and Green, D.: The extensor hallucis longus and flexor hallucis longus tendon in HAV. JAPA, 68: 467, 1978.Reverdin J: De La deviation en dehors du gros orteil (hallusvalgus, vulg. "oignon bunions," "Bollen") et de son traitement chirurgical. Trans Internat Med Congress 2: 40, 1881.
- Root ML, Orien WP, Weed H: Forefoot deformity caused by abnormal subtalar joint pronation. In Normal and Abnormal Function of the Foot, Clinical Biomechanics, Vol 2., Los Angeles, Clinical Biomechanics Corp., 1977, pp 349-462.
- Sandelin, T.: Operative treatment of hallux valgus JAMA (abstract), 80: 736, 1923. Sarafian SK: Anatomy of the foot and ankle. Philadelphia, Lippincott, 1983, pp 68-74, 93, 201.
- Scranton, PE and Rutkowski, R.: Anatomic variations of the first ray. Part I. Anatomic aspects related to bunion surgery. Clin Orthop, 151: 244, 1980.
- Shereff MJ, Yang QM, Kummer FJ: Extraosseous and intraosseous arterial supply to the first metatarsal and metatarsophalangeal joint. Foot & Ankle 8: 2, Oct 1987.
- Shine, IB.: Incidence of hallux valgus in a partially shoe wearing community. Brit Med Journ, 6: 1648, 1965.
- Sim-Fook L, Hogdson AR: A comparison of foot forms among the non-shoe and shoe-wearing Chinese population. J Bone Joint Surg 40A: 105-1062, 15.
- Spinner, SM., Lipsman, S and Spector, F.; Radiographic criteria in the assessment of hallux abductus deformities. JFS, 23: 25, 1984.
- Valvo P, Hochman D, Reilly C: Anatomic and clinical significance of the first and most medial deep transverse metatarsal Ligament. J Foot Surg 26: 194-203, 1987.
- Whitney, AK: Radiographic Charting Technique. PCPM Press, Philadelphia, 1978.
- Wilder, MH: Prevalence of chronic skin and musculoskeletal conditions. Division of Health Interview Statistics. US Vital Health Statistics, Series 10, 90-100, 1974-1975.
- Wilson JN: Oblique displacement osteotomy for hallux valgus. J Bone Joint Surg 45B: 552-556, 1963.
- Shechter, DZ and Doll, PJ: Tangential angle to the second axis-a new angle with implications for bunion surgery. JAPA, 75:505, 1985.

- Shereff, MJ, Yang, QM and Kummer, FJ: Extra osseous and intra osseous arterial supply to the first metatarsal and metatarso-phalangeal joint. Foot and Ankle, 8: 81, 1987.
- Vega, M., Resnick, D and Black, J.: The intrinsic and extrinsic arterial supply to the proximal phalanx of the hallux. Foot and Ankle, 5: 257, 1985.
- Yu, GV, and Schnirring-Judge. Complications of HAV Surgery. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. Lippincott, William and Wilkins, Baltimore, 2002.

Acknowledgements

This material was originally prepared for FARC, Inc. by: By: Charles J. Gudas, DPM, James W. Mazzuca, DPM and Dr. David Edward Marcinko, MBA, CMP©, CFP©. Periodic updates and research has been continual by FARC medical professionals.

Peachtree Plantation - West
Suite # 5901 Wilbanks Drive
Norcross, Georgia, 30092.

1.770.448.0769 (voice mail)
1.775-361-8831 (facsimile)
www.PodiatryPrep.com
sales@podiatryprep.com
All rights reserved. USA