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UNIVERSITY OF THE WITWATERSRAND

A RADIOGRAPHIC ANALYSIS OF THE CONTRIBUTION OF HALLUX VALGUS INTERPHALANGEUS TO THE TOTAL VALGUS DEFORMITY OF THE HALLUX

Andrew Strydom

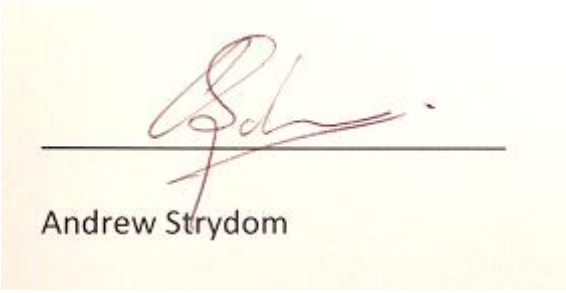
A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Orthopaedic Surgery

DECLARATION

I, Andrew Strydom, declare that this research report is my own work.

It is being submitted for the degree of Master of Medicine in the branch of Orthopaedic Surgery in the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination at this or any other University



__15th___ day of ____July_____2015

DEDICATION

This research report is dedicated in loving memory to my dearly departed mother, Carol Strydom (1956-2002), and her belief in me, and to my wife, Deanna Guidozzi, the source of my happiness.

ABSTRACT

Introduction: The hallux valgus interphalangeus deformity is described as rare, but improved outcomes in hallux valgus surgery is associated with its surgical correction via an Akin osteotomy. The hypothesis of this study is that hallux valgus interphalangeus makes a contribution to the total valgus deformity of the hallux.

Methods: A radiographic analysis of 285 foot x-rays utilising a standardised radiographic and measurement technique was performed.

Results: The average contribution of the interphalangeal angle (IPA) to the total valgus deformity of the hallux (TVDH) across the whole study population was a mean (SD) of 37.9% (21.2). The average contribution of IPA to TVDH was greater in feet without hallux valgus (58.0%) when compared to feet with hallux valgus (28.3%). Hallux valgus interphalangeus is common, particularly in Caucasians ($p=0.01$) and makes a significant contribution to the total valgus deformity of the hallux ($p <0.01$). The contribution to total valgus deformity of the hallux is more significant in mild hallux valgus. There is an inverse relationship between the interphalangeal angle and other angular measurements in the foot.

Conclusion: Hallux valgus interphalangeus is a common entity and its significant contribution to the total valgus deformity of the hallux dictates that hallux valgus interphalangeus must be incorporated in management algorithms. The total valgus deformity of the hallux should replace the isolated concepts of hallux valgus and hallux valgus interphalangeus.

ACKNOWLEDGEMENTS

I have many people to thank for their assistance in my life and in this research report.

First and foremost, I must thank my wife, Dr DF Guidozzi, for all her support and encouragement and understanding over the many hours I have spent on this project.

My gratitude to Dr NP Saragas is limitless. Thank you for the spark that grew into this study, for all your time and encouragement; of most value to me is your kindness and willingness to teach.

Dr C Truda is a friend and without your help with collecting x-rays and guiding my practical learning of hallux valgus my concept of this research report would be incomplete.

Thank you to my father-in-law, Prof F Guidozzi, for always being patient with me and guiding me in the writing of this report.

ABBREVIATIONS

HVA	Hallux valgus angle
IPA	Interphalangeal angle
IMA	Intermetatarsal angle
DMAA	Distal metatarsal articular angle
TVDH	Total valgus deformity of the hallux
SD	Standard deviation
FHL	Flexor hallucis longus
FHB	Flexor hallucis brevis
EHL	Extensor hallucis longus
EHB	Extensor hallucis brevis
ABH	Abductor hallucis
ADH	Adductor hallucis

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PREFACE

Despite the advances in the body of knowledge around hallux valgus and its operative management, there are still more ways to skin the proverbial cat than there is evidence to back up the decision making.

Of particular interest is the role of the Akin osteotomy for the correction of hallux valgus interphalangeus, the popularity of which has waxed and waned over the past 70 years. The current resurgence in popularity of this procedure is due to a slowly growing evidence base that its incorporation in the surgical management of hallux valgus is associated with better outcomes.

To this end my supervisor and mentor, Dr NP Saragas, is a fervent proponent of correcting hallux valgus interphalangeus during the correction of hallux valgus. What is not clear is the role of hallux valgus interphalangeus in the pathology of hallux valgus and whether its contribution to valgus of the great toe warrants its surgical attention. Whether this deformity is a common enough entity to warrant vigilance in the examination of the foot is not clear.

This study will attempt to answer some of these questions and justify the place of hallux valgus interphalangeus and its surgical counterpart, the Akin osteotomy.

The first chapter reviews and summarises the body of knowledge on hallux valgus for the reader to have insight as to why this study was performed.

1.0 Introduction to Hallux Valgus

1.1 Definitions

1.1.1 Hallux Valgus

This is a common deformity of the first ray of the foot characterised by lateral deviation of the big toe and medial deviation of the first metatarsal head[1-3]. Characteristic of the condition is a painful eminence over the medial aspect of the 1st metatarsal head[4]. This deformity is also known as hallux abducto valgus.

1.1.2 Hallux Valgus Interphalangeus

This is a deformity of the first ray produced by valgus angulation of the distal phalanx on the proximal phalanx[4]. This deformity is also known as hallux abductus interphalangeus.

1.2 Epidemiology

Hallux valgus is one of, if not the most common foot complaint presenting to orthopaedic surgeons and foot and ankle specialists [5, 6]. Not only does it contribute to health care costs, but to functional disability due to pain, abnormal gait and falls in the elderly[2, 4-6].

The exact prevalence has been cited with controversy across different publications, but a 2010 meta-analysis reports pooled prevalence estimates of 23% for adults between the ages of 18 and 65 years[5]. The disease is more common in females[7-9] with an estimated prevalence of 30%, as opposed to 13% in males[5]. In males the onset of symptoms occurs at a younger age and the deformities are more severe[9].

The disease becomes more common with advancing age, has a wide variation amongst population groups and has been shown to be exceedingly more common in people who wear shoes[1, 2, 5, 10].

In South Africa the prevalence and severity of hallux valgus has previously been shown to be more common in Caucasians than Africans, but with no difference between rural and urban African groups[7]. Nevertheless, no exact estimate can be extrapolated across different populations and epidemiological studies are confounded by methodological differences and diagnostic criteria[5].

Most patients with hallux valgus are affected bilaterally, with the incidence of bilateral disease ranging from 87 to 97%[11, 12]. Some patients with unilateral deformity may progress to bilateral deformities with longer follow-up[12]. Hallux valgus may present as an isolated foot deformity or with other foot deformities; pes planus (flatfeet) and lesser toe deformities are common associations and may be a predisposing factor or a sequel to hallux valgus[1-3].

In particular the relationship between hallux valgus and the hallux valgus interphalangeus deformity has not been well explored and epidemiological reports of the hallux valgus interphalangeus deformity are limited[13, 14].

1.3 Risk Factors

Much research into identifying risk factors for hallux valgus has been reported. Risk factors may be considered to be extrinsic (related to foot environ) or intrinsic[2] (related to the structure of the foot) (see Table 1).

Sim-Fook and Hodgson described a 33% prevalence in shod feet as opposed to 2% in unshod feet[15], but not all shod feet develop hallux valgus and not all hallux valgus occurs in shod-feet[2]. The role of shoe-wear as a primary cause is

controversial, but it undoubtedly plays a role in the progression of the deformity and inflammation over the medial eminence[11, 16-18].

Hallux valgus is inherited in an autosomal dominant pattern with variable penetrance with phenotypic expression in the form of altered metatarsal morphology and mobility[2, 17, 18]. A positive family history has been reported as high as 90% in females and 68% in males[2, 9].

Table 1 Risk Factors for hallux valgus

Extrinsic	Intrinsic
• High-heeled narrow shoes	• Genetics
• Excessive weight-bearing	• Ligamentous laxity
	• Metatarsus primus varus
	• Pes planus
	• Functional hallux limitus
	• Sexual dimorphism
	• Age
	• Metatarsal morphology
	• First ray hypermobility
	• Tight Achilles tendon

Table 1 Reproduced from Perera AM, Mason L, Stephens MM. The pathogenesis of hallux valgus. *J Bone Joint Surg Am*. 2011;93(17):1650-61

No sole identifiable cause has been proven and the condition should be viewed as multifactorial in origin and progression[2, 18, 19].

There are no reported risk factors for hallux valgus interphalangeus either as an isolated deformity or in conjunction with hallux valgus.

1.4 Anatomy Of The Hallux

An understanding of the anatomy of the 1st metatarsophalangeal joint is central to understanding the pathology.

1.4.1 Normal Anatomy of the First Metatarsophalangeal Joint

The 1st metatarsophalangeal joint is a synovial condyloid joint and comprises the larger round metatarsal head articulating with the smaller concavity of the base of the proximal phalanx[1, 20]. The exact shape of the articular surface varies and may be implicated in the pathogenesis of hallux valgus (see figure 1)[1].

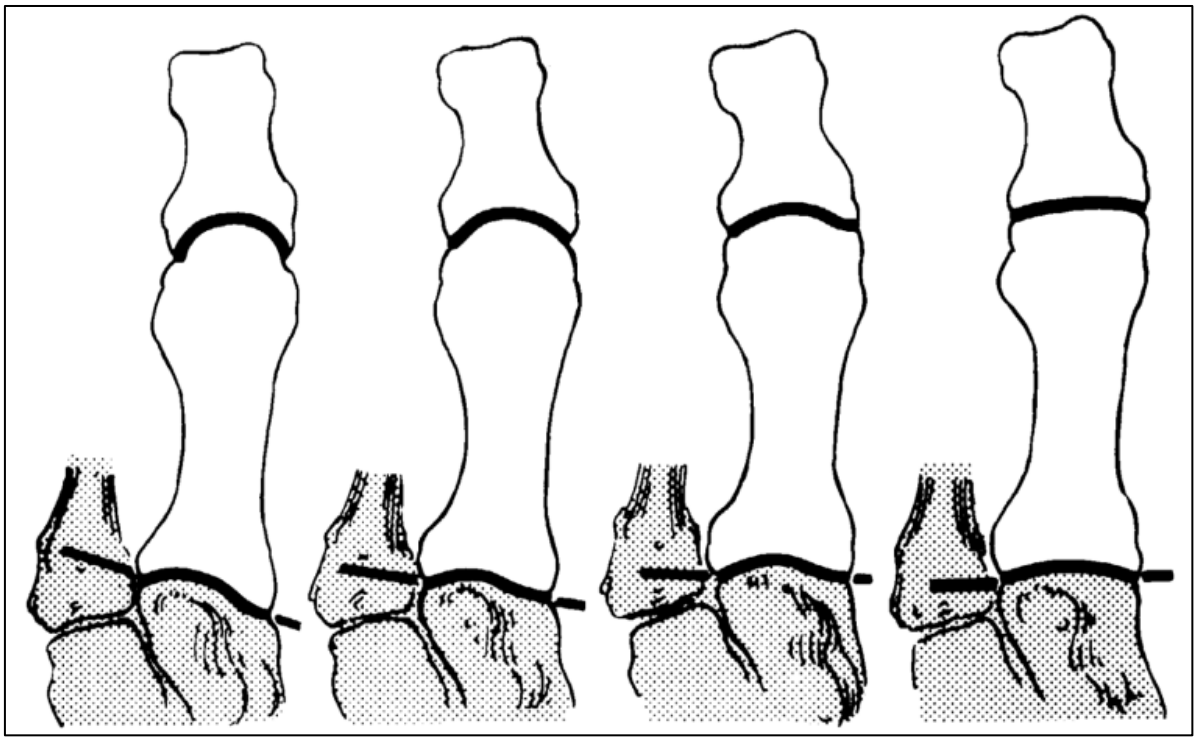


Figure 1. Anatomical variations in the shape of the 1st metatarsophalangeal and metatarso-cuneiform joints. A flatter joint surface as opposed to a round joint surface is proposed to resist deforming forces more effectively. Reproduced from Mann RA, Coughlin MJ. Hallux valgus - etiology, anatomy, treatment and surgical considerations. *Clin Orthop Relat Res*. 1981(157):31-41.

The plantar aspect of the 1st metatarsal head is supported by medial and lateral sesamoid bones intrinsic to the flexor hallucis brevis tendons[1-3].These sesamoid bones are accommodated in two plantar grooves on the metatarsal head separated by a central ridge or crista[1, 3] and are connected to the base of the proximal phalanx and the metatarsal head via the phalangealsesamoid and metatarsosesamoid ligaments respectively[2, 10]. This sesamoid complex's attachment to the phalanx forms part of a thick fibrous plantar pad which allows the sesamoid to follow any movement of hallux[1, 10]. The transverse metatarsal ligament is thought to serve as an additional stabiliser between the lateral sesamoid and the 2nd metatarsal head[21].

Dynamic stability and movement is provided by a group of 6 muscles & their tendons essentially encircling the 1st metatarsophalangeal joint (see Fig. 2)[10, 19].

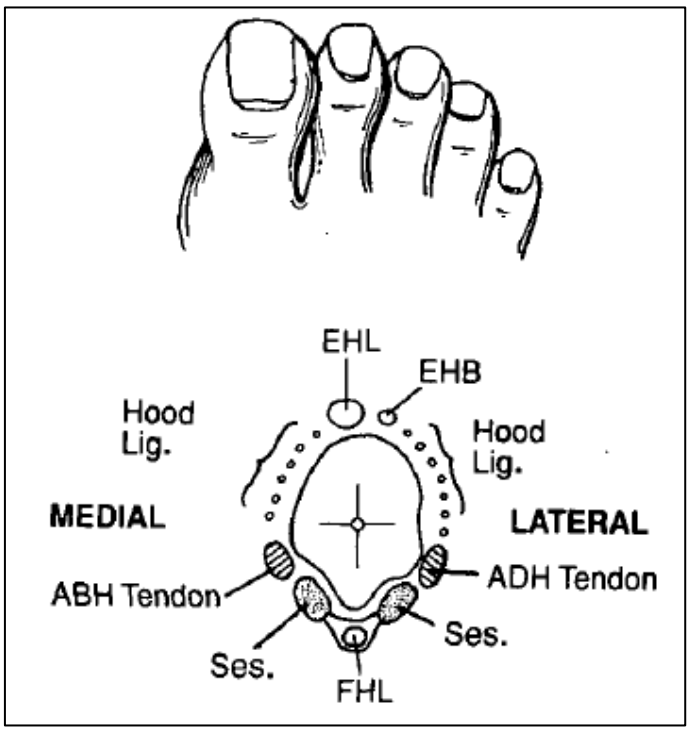


Figure 2. Schematic cross-sectional anatomy of the normal 1st metatarsophalangeal joint at the level of the sesamoid complex, reproduced from Coughlin MJ. Hallux valgus. *J Bone Joint Surg Am*.1996;78(6):932-66. EHL = Extensor hallucis longus; EHB = Extensor hallucis brevis; ADH = Adductor hallucis; ABH = Abductor hallucis; FHL = Flexor hallucis longus

The extensor hallucis longus (EHL) and flexor hallucis longus (FHL) muscles form part of the extrinsic musculature of the foot (muscles originate in the anterior and deep posterior compartments of the leg respectively)[20] and insert on the central aspect of the distal phalanx on the dorsal and plantar surfaces respectively[10].

The extensor hallucis brevis (EHB), flexor hallucis brevis (FHB) abductor hallucis (ABH) and adductor hallucis (ADH) muscles for part of the intrinsic musculature of the foot (muscles originate in the foot)[20]. The tendons of ABH and ADH reinforce the plantar-medial and plantar-lateral aspects of the capsule and insert on the respective sesamoids and base of the proximal phalanx [10, 19].

The hood ligaments expand from the EHL and EHB tendons over the medial and lateral aspect of the joint and interdigitate with the sesamoid and collateral ligaments to form the bulk of the joint capsule[10]. The dorsal half of the joint capsule is thin when compared to the plantar half[10].

The joint capsule is strengthened by medial and lateral collateral ligaments running from the metatarsal epicondyles, in a distal and plantar direction, to the base of the proximal phalanx [1, 2, 10]. In particular the medial capsule integrity is crucial to the stability of the joint[21].

The dorsal sensory nerve of the big toe is located medial to the EHL tendon on the dorsomedial aspect of the 1st ray and is an important landmark to identify and protect during corrective surgery[20].

The blood supply to the big toe is from the dorsal and plantar digital arteries which are terminal branches of the first dorsal metatarsal artery & plantar metatarsal arteries respectively[20].

1.4.2 Pathology Of Hallux Valgus

The pathology of hallux valgus is well described in 4 articles by Coughlin, Mann, Perera and Stephens[2, 10, 18, 22].

With abnormal joint loading, whether from extrinsic or intrinsic factors, the medial collateral ligaments, which are the primary determinants of medial stability, elongate and weaken[2, 18, 21]. The integrity of the lateral collateral ligaments is maintained and the proximal phalanx drifts into a valgus position[18].

The 1st metatarsal head drifts into a varus (medial) position possibly due to hypermobility or an oblique joint line at the 1st tarso-metatarsal joint, or simply may be present as a primary deformity (metatarsus primus varus)[2, 18].

As the sesamoids are strongly attached to the base of the proximal phalanx they follow the valgus drift, and as the metatarsal head deviates into varus they dislodge from their respective grooves and come to lie in abnormal positions[2, 10].

With progressive and severe deformity the medial sesamoid erodes the crista and the lateral sesamoid adopts a dislocated position on the lateral side of the metatarsal head (see Figure 3)[1]. Throughout the disease process the sesamoids occupy a relatively fixed position and it is the varus and valgus deviation of the metatarsal head and proximal phalanx respectively which dictate their position [1, 18].

The metatarsal head essentially drops off the sesamoid complex and the hallux pronates due to the deforming forces of the muscles acting across the joint[2]. The role of the ABH and ADH muscles in the pathogenesis has been widely studied with conflicting reports, but it is proposed that ADH plays a role in pronation of the hallux in the diseased state[2, 16].

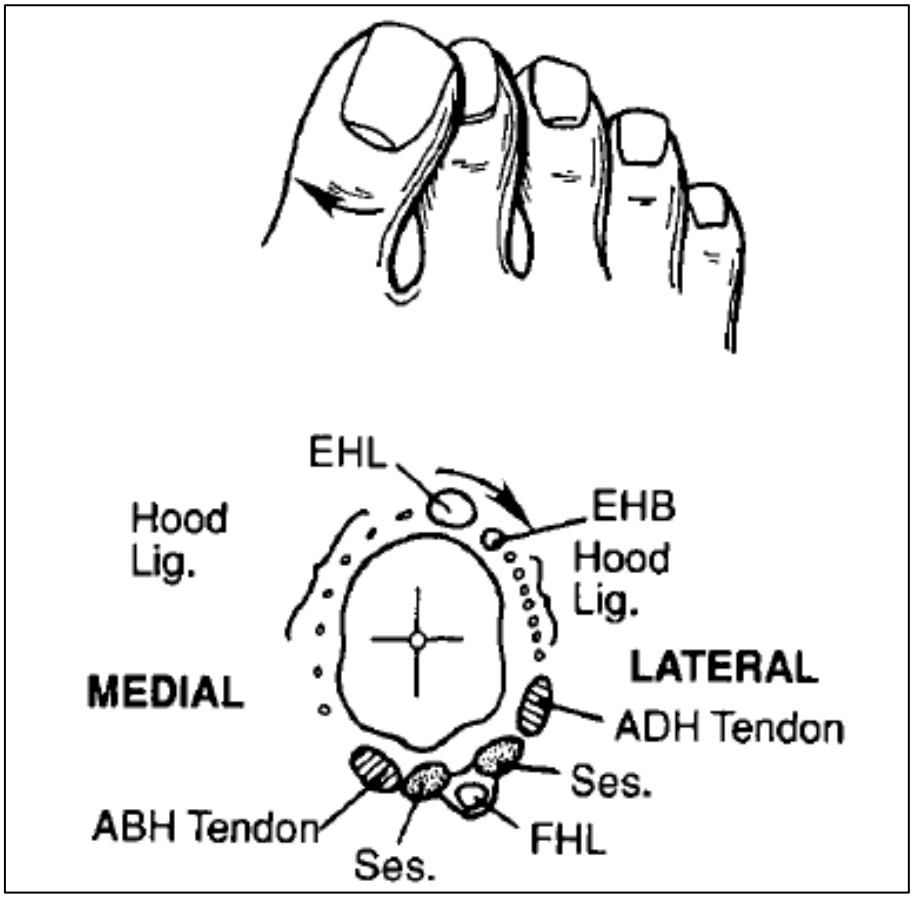


Figure 3. Schematic cross-sectional anatomy of the pathological 1st metatarsophalangeal joint at the level of the sesamoid complex, reproduced from Coughlin MJ. Hallux valgus*. J Bone Joint Surg Am*.1996;78(6):932-66. EHL = Extensor hallucis longus; EHB = Extensor halluces brevis; ADH = Adductor hallucis; ABH = Abductor halluces; FHL = Flexor halluces longus

With the ensuing abnormal pressure over the medial aspect of the metatarsal head a medial eminence develops, enlarges and develops an inflamed overlying bursa[(1)]. A medial groove develops on the metatarsal head due to lack of trophic stimulation of the cartilage as the phalanx migrates into valgus[(1, 18)].

Ultimately the deformity comprises varus deviation and pronation of the 1st metatarsal, valgus deviation of the proximal phalanx, sub-/dislocation of the sesamoid complex and a medial eminence comprising bony exostosis and inflamed bursa[(2, 10, 11, 17, 18)].

1.4.3 Anatomy of the Interphalangeal Joint

The interphalangeal joint is a synovial condyloid joint between the proximal and distal phalanges of the hallux. As described above the only tendons crossing the interphalangeal joint are the FHL tendon and EHL in the form of the extensor expansion. The joint is surrounded by a capsule deriving its structure in a similar pattern to the metatarsophalangeal joint[20].

1.4.4 Pathology Of Hallux Valgus Interphalangeus

Very little has been described with regards to the pathological mechanisms involved in hallux valgus interphalangeus. One described mechanism postulates that pressure on the lateral side of the articular surface of the distal phalanx during normal walking leads to hypoplasia of the phalangeal condyle and the subsequent valgus deformity[23]. There is no real evidence to support this statement; there is a paucity of research in this regard. Essentially the valgus deformity at the interphalangeal joint is an unexplored entity with regards to patho-anatomy.

1.5 Radiological Assessment Of Hallux Valgus

Radiographic measurements of specific angles about the hallux are of critical importance to management and surgical decision making[1, 4, 10, 17, 24, 25].

1.5.1 Hallux Valgus Angles

The standard angular measurements performed on an antero-posterior radiograph are described in Table 2[10, 24, 26] and illustrated in Fig. 4:

Table 2 Radiographic angular measurements in hallux valgus

Angle	Definition	Normal Value
Hallux valgus angle (HVA)	Angle between the long axes of the 1st metatarsal and the 1st proximal phalanx	< 15˚
Intermetatarsal angle (IMA)	Angle between the long axes of the 1st and 2nd metatarsals	< 10˚
Distal metatarsal articular angle (DMAA)	Angle between the distal articular surface and the long axis of the 1st metatarsal	< 10˚
Hallux valgus interphalangeus angle (IPA)	Angle between the long axes of the proximal and distal phalanges of the hallux	< 10˚

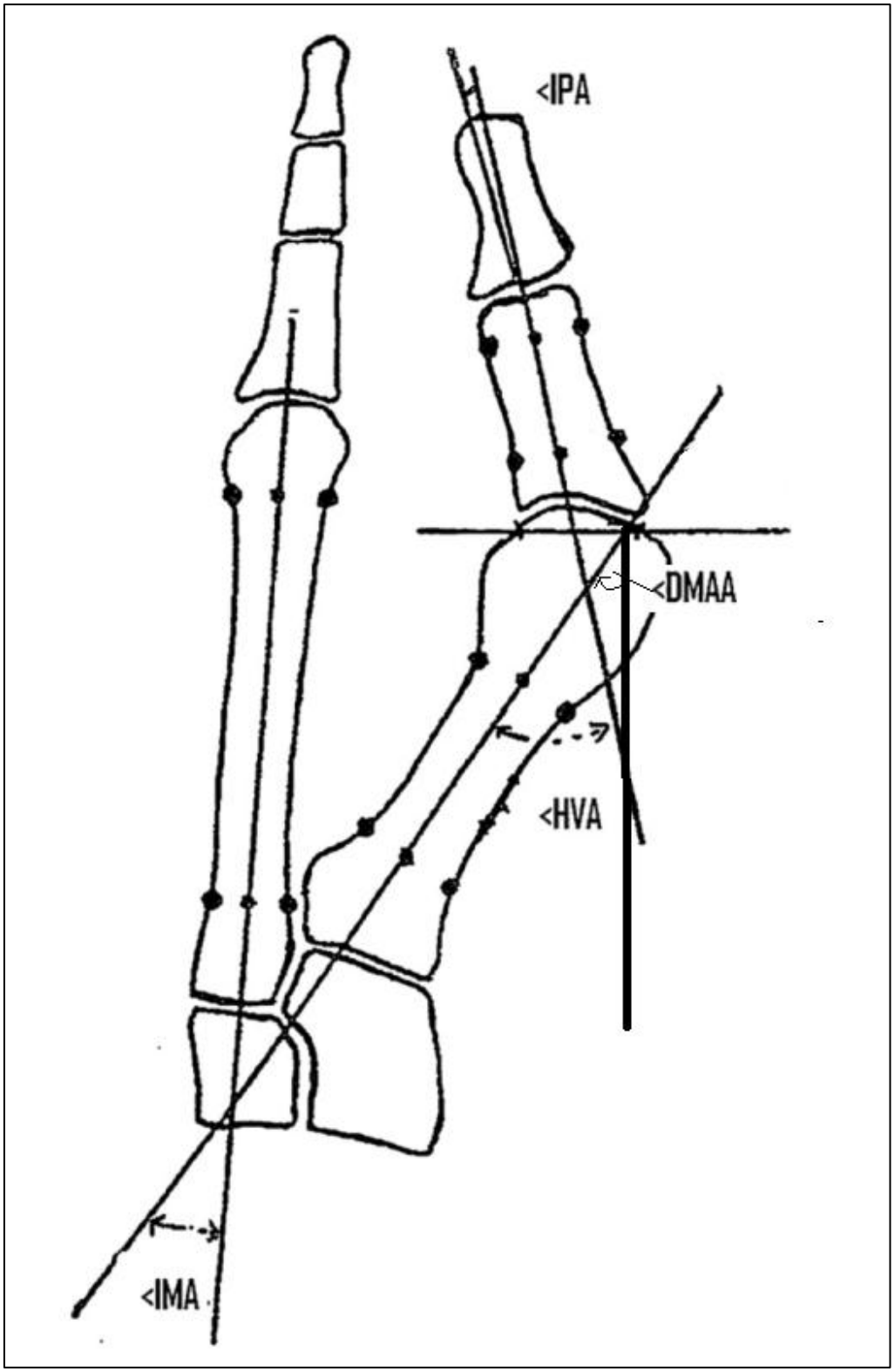


Figure 4. Schematic representation of radiographic measurements in hallux valgus, modified[10] from Srivastava S, Chockalingam N, El Fakhri T. Radiographic measurements of hallux angles: a review of current techniques. *Foot.* 2010;20(1):27-31.

1.5.2 Measurement Technique

Radiographs of the foot must be obtained in the full weight-bearing standing position as this is the functional position of the foot[10, 19, 25].

The inter- & intra-observer reliability of angular measurements is improved utilising a standardised radiographic technique of full weight bearing antero-posterior foot x-rays with the beam 1 metre from the imaging cassette, directed 15 degrees cephalad and centred on the midfoot[3, 24, 27].

It has been demonstrated that the accuracy of the intermetatarsal angle(IMA), which depends on the long axis of the 1st metatarsal, is increased by utilising a standardised radiographic & measurement technique[28].

The reproducibility of pre-operative radiographic measurements utilizing standardised diaphyseal reference points to determine longitudinal axes of foot bones has been reported to be 96.7% within a 5 degree range, and has been advocated for use by the American Orthopaedic Foot and Ankle Society[24, 29]. This standardised technique involves bisecting the width of the bones at two points within a specific distance range from the articular surfaces and joining these points to produce the lines used for angular measurement (see Fig. 5).

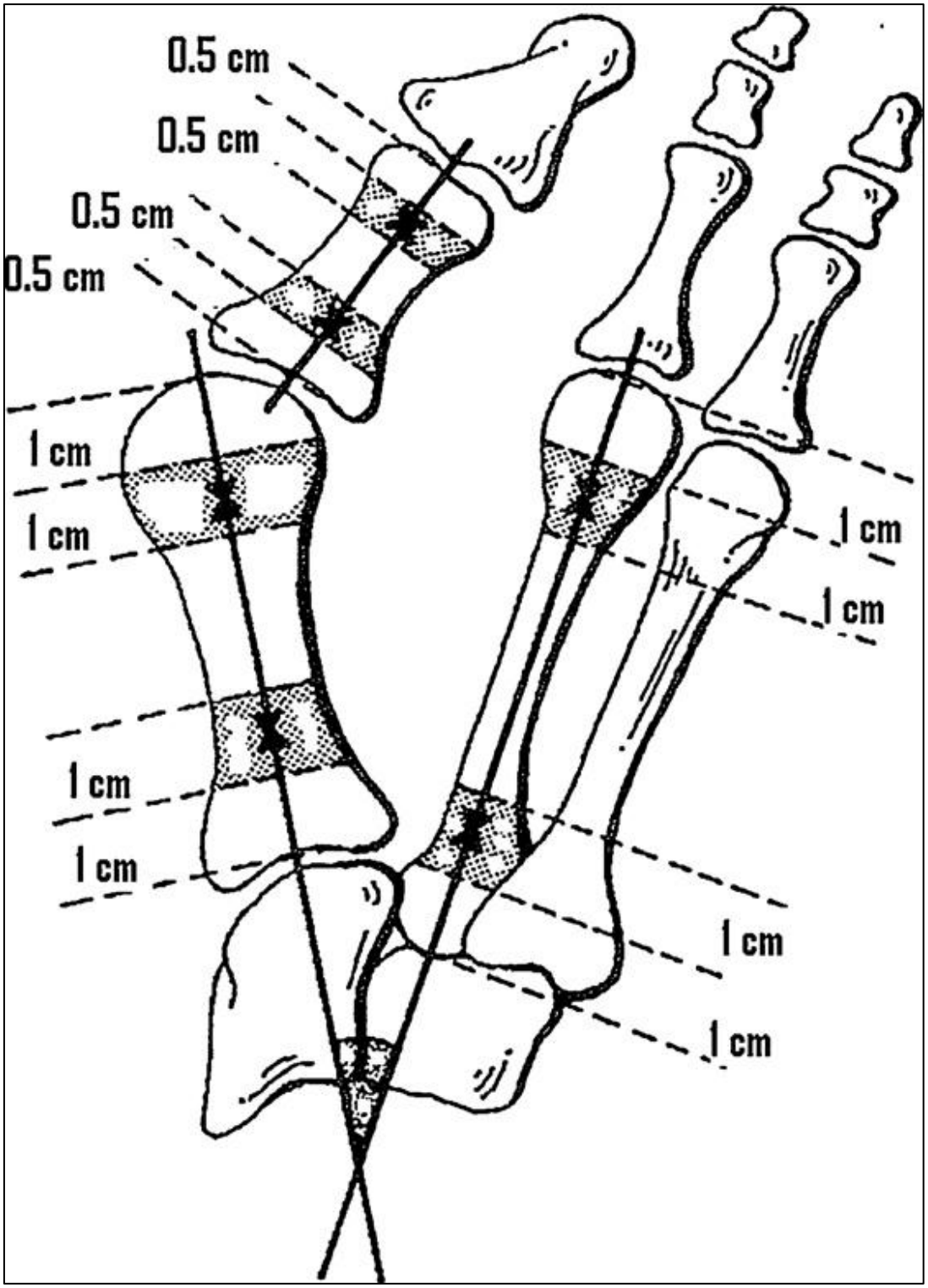


Figure 5. Schematic representation of the standardised technique for angular measurements in hallux valgus, reproduced from Coughlin MJ, Saltzman CL, Nunley JA. Angular Measurements in the Evaluation of Hallux Valgus Deformities: A Report of the Ad Hoc Committee of the American Orthopaedic Foot & Ankle Society on Angular Measurements. *Foot Ankle Int*. 2002;23(1):68-74.

The reliability of measuring the hallux valgus angle(HVA) and IMA has been well validated[30]. The distal metatarsal articular angle (DMAA) has the poorest inter- & intra-observer reliability as the reference points are the most medial and lateral limits of the distal articular surface which are subject to observer interpretation of the x-ray films[4, 30]. The DMAA has been shown to correlate well with the severity of the deformity both clinically and radiographically[31] and remains an important consideration in management protocols.

No accepted standardised technique for the measurement of the interphalangeal angle (IPA) has been described.

Comparison between manual and computer assisted measurement techniques have been reported with conflicting results and the standard technique for measurement remains manual measurement with a goniometer[32-35].

1.5.3 Severity Classification

Utilising the aforementioned angles, the severity of the deformity is stratified into mild, moderate or severe as per the parameters in Table 3[4, 19].

Table 3. Severity classification of hallux valgus

Severity	**HVA**	**IMA**
Mild	15-30˚	≤ 13˚
Moderate	31-40˚	14-20˚
Severe	>40˚	>20˚

1.5.4 Congruency

Crucial to the surgical decision making process is the congruency of the metatarsophalangeal joint[4]. The term congruency refers to the articular surfaces of a joint being parallel to each other. Incongruency implies subluxation of the articular surfaces and must be evaluated on the standard foot radiographs by drawing a line through the articular surfaces of the metatarsal head and proximal phalanx; if the lines are parallel then the joints are congruent[25].

1.5.5 Sesamoid Position

The degree of sesamoid subluxation correlates with the severity of deformity[10]. The degree of subluxation can be measured with various techniques, the easiest of which is relating the percentage of the tibial (medial) sesamoid visible lateral to the axis of the 1st metatarsal[26, 36].

1.5.6 Arthritis Of The Metatarsophalangeal Joint

The presence of arthritis can be determined by examining the joint for degenerative changes such as the presence of osteophytes and joint space narrowing[10, 19, 25, 26].

1.5.7 Size Of The Medial Eminence

The size of the medial eminence is estimated by drawing a line in continuation of the medial cortex of the 1st metatarsal and measuring the bony mass medial to this line[26]. The degree of deformity does not correlate with the size of the medial eminence and the radiographic measurement does not incorporate the soft tissue component[17, 25, 26].

1.6 Clinical Assessment

The reasons patients present to orthopaedic surgeons typically relate to pain, cosmesis and/or difficulty with shoe wear[4, 6, 25].

Pain may be related directly to inflammation of the medial eminence, arthritis of the metatarsophalangeal joint, sesamoid pain due to abnormal weight bearing, transfer metatarsalgia of the 2nd metatarsal head and / or lesser toe deformities, particularly of the 2nd toe[1, 10, 19].

Difficulty with shoe wear is related to splaying of the forefoot. Inability to wear high-heeled or narrow shoes is often the major complaint and reason for presentation to the orthopaedic surgeon[19].

Often cosmetic concerns over the unsightly medial eminence or skew hallux may be the sole reason for seeking surgical advice[19].

1.6.1 History

A thorough and exhaustive history should include[4, 22, 25, 37]:

a) The main complaint and reason for presentation
b) Onset and progression of deformity
c) Family history of hallux valgus
d) Athletic / recreational history (running, dancing etc.)
e) Occupational history and the deformity's effect on daily activity
f) Shoe wear
g) Patient expectations
h) Previous corrective surgery

In particular patient expectations from the surgeon need to be carefully assessed and managed; expectations with regards to post-operative shoe wear, pain resolution and foot function need to be managed on an individual basis[22]. Up to

one third of patients may not be able to wear the desired foot-wear following surgical correction and athletes, dancers and manual labourers may have difficulty in returning to their previous level of function[10, 19, 22].

1.6.2 Physical Examination

The deformity should be assessed in the standing position as weight-bearing shows the full extent of the deformity. The standing position will also elucidate the presence of pes planus or equinus deformities which may be associated with hallux valgus[19]. Once the patient is seated the foot should be assessed for[1, 3, 4, 10, 17, 19, 22]:

a) Severity of deformity
b) Correctability of deformity
c) Presence of hallux valgus interphalangeus
d) Lesser toe deformities – hammer toes, overriding toes, subluxation of metatarsophalangeal joints
e) Inflammation / ulceration over the medial eminence
f) Range of motion & tenderness of the metatarsophalangeal joint
g) Mobility of the first ray
h) Plantar callosities
i) Sesamoid tenderness
j) Sensation
k) Vascular competence

A general physical examination as part of the pre-operative workup should not be neglected. Features of ligamentous laxity or systemic inflammatory conditions such as rheumatoid arthritis may alter further management[19].

1.7 Management

1.7.1 Introduction

The management of hallux valgus is a topic of much research, debate and controversy. Hallux valgus is steeped in history and there are more than 130 described surgical procedures for its correction. In quoting my mentor "the number of operative procedures available for a specific problem is inversely proportional to the understanding of the basic pathology and to the success of these procedures"[36]. Perhaps with the progress of technology and the addition of tight-rope procedures, proximal metatarsal wedge plates and arthrodesis plates this statement may now be truer than ever, although the basic pathology is clearer now than 20 years ago.

The purpose of this chapter is not to provide an exhaustive review of available surgical procedures but to give the reader insight into the management of hallux valgus and the thinking which has provoked this study.

1.7.2 Non-Operative Management

A trial of non-operative management should be exhausted before surgery is considered[1]. Counselling with regards to the natural history of the deformity is vital. Patients often invest in self-directed over the counter remedies such as bunion pads, shoe inserts and non-prescription medication[37].

Shoe wear should be modified to suit the foot and this involves the wearing of shoes with a low heel, wider toe box and soft uppers[17, 19, 37, 38]. Prescription analgesics may be necessary for inflammation over the medial eminence[37]. There is a lack of evidence to support the use of orthoses[37].

There is no consensus on the duration of this non-operative trial, but 6 to 9 months without satisfactory improvement for the patient is a justifiable reason for considering surgical alternatives.

1.7.3 Operative Management

Just as hallux valgus is a complex deformity, so the surgical management and choice of surgical procedure follows suit. Within the surgical decision making process, the surgeon needs to consider the patient's lifestyle & expectations, the severity and components of the deformity and any associated foot deformities[1, 10, 17, 19, 22].

1.7.3.1 Indications for Hallux Valgus Surgery

Accepted indications for hallux valgus surgery are identical to the major reasons for presentation to an orthopaedic surgeon[1, 10, 22, 37, 38]:

a) Failure of or patient dissatisfaction with non-operative management
b) Pain (major indication)
c) Cosmesis
d) Difficulty with shoe-wear

1.7.3.2 Overview of Surgical Procedures for Hallux Valgus

With such a vast number of surgical procedures available it is beyond the scope of this paper to provide details on the surgical techniques, advantages & disadvantages and complications for each procedure. Instead this section will compartmentalise the different procedures based on their principles for a basic understanding of surgical options.

a) Soft-tissue procedures

The principles behind the distal soft tissue reconstruction procedures follow the understanding of the patho-anatomy. The medial eminence is resected and the medial capsular structures are plicated to re-establish medial stability while the tight lateral capsule and adductor tendon are released[10]. In isolation this does not provide the complete solution, particularly in cases with an increased IMA and a congruent joint, as the resulting correction will produce an incongruent reduction[19]. This correction of the distal soft tissue abnormalities is instead used in conjunction with bony corrective procedures[19].

b) Metatarsal osteotomies

The bulk of corrective procedures for hallux valgus fall into this group. These procedures are based on performing one or more cuts in the metatarsal, correcting the varus deviation and providing stable fixation to prevent loss of reduction. The osteotomies may be performed proximally (basal opening wedge, closing wedge, crescentic or chevron osteotomies), in the diaphysis (scarf and Ludloff osteotomies) or distally (chevron, Wilson, Mitchell osteotomies) in the metatarsal. Osteotomies performed more proximally provide greater correction of deformity[3]. The choice of osteotomy is dictated by the severity of the deformity and surgeon preference. There are a number of principles which may be used in selecting a metatarsal osteotomy[19]:

i. Degree of technical difficulty
ii. Correction of IMA and HVA
iii. Reproducibility of results and long term outcomes
iv. Maintenance of metatarsal length
v. Preservation of metatarsal blood supply

There is no single osteotomy suitable for all cases[3].

c) Metatarsophalangeal arthrodesis

In a simple description, this procedure removes the cartilage covered articular surfaces of the MTPJ, corrects the hallux valgus deformity and provides stable fixation across the denuded joint to allow for bony-fusion between the metatarsal and phalanx. Accepted indications include[39]:

i. Failed hallux valgus surgery
ii. Severe deformity
iii. Arthritis of the metatarsophalangeal joint
iv. Rheumatoid arthritis
v. Pain

d) Tarso-metatarsal arthrodesis:

Described by Lapidus in 1934, fusion of the first tarso-metatarsal joint follows similar principles to MTPJ fusion[3]. Accepted indications for this procedure include[10, 40, 41]:

i. Hypermobility of the 1st tarso-metatarsal joint
ii. Severe hallux valgus deformity
iii. Revision hallux valgus surgery

It has been shown that this procedure in isolation is very effective at reducing the IMA and a secondary procedure to correct the IMA is usually not needed[42-44].

e) Resection arthroplasty

The procedure popularised by Keller involves resection of the proximal third of the proximal phalanx of the hallux[19]. Typically this is combined with medial eminence resection and medial capsular plication[10]. Limiting the use of this procedure to elderly, low functional demand patients with an

arthritic MTPJ and mild hallux valgus deformity generally produces acceptable functional results[10, 19, 45].

f) Arthroplasty

Replacement of the metatarsophalangeal joint surfaces with a prosthetic implant in hallux valgus is not widely practiced due to high risk of post-operative failure. If performed the IMA must be adequately corrected before the arthroplasty[10].

g) Tight-rope procedures

Utilising a suture button / fibre-wire device to pull the metatarsal heads closer together thereby reducing the IMA and HVA and potentially avoiding a tarso-metatarsal fusion has shown good short-term results[46, 47].

h) Akin osteotomy

Described in 1925 as a medial closing wedge osteotomy of the proximal phalanx of the hallux, the major indication for this procedure is the presence of hallux valgus interphalangeus. This procedure has gained a resurgence in popularity in recent literature[48] as multiple studies have proven that it provides an advantage in terms of additional correction of hallux valgus and is associated with improved clinical outcomes and patient satisfaction[49-51].

1.7.3. Decision Making In Hallux Valgus Surgery

Due to the variety in clinical presentation and the plethora of surgical procedures, many authors advocate the use of management algorithms to simplify decision making. One such algorithm is shown in Figure 6. The principles of the decision making hinge on the congruency of the joint, the severity of the deformity and the presence or absence of arthrosis in the MTPJ. A common theme within many of these decision making algorithms is that if the hallux valgus interphalangeus deformity is noted it may be corrected at the time of surgery with an Akin osteotomy[4, 17, 19, 25, 37].

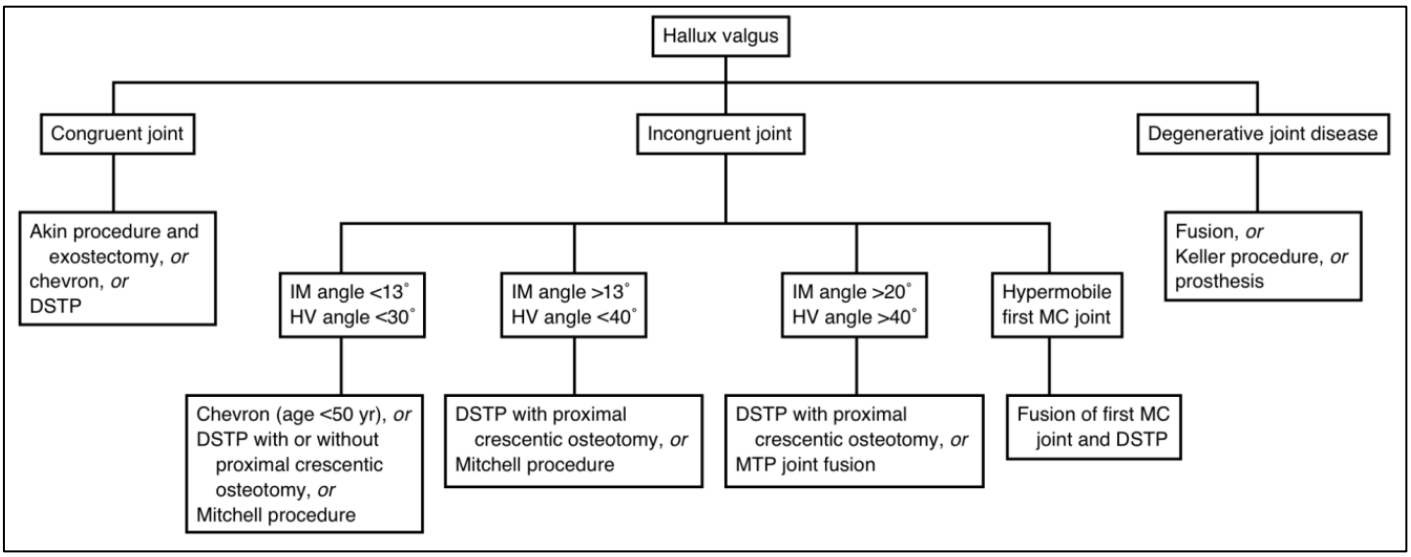


Figure 6. Hallux valgus management algorithm, reproduced from Mann RA. Disorders of the First Metatarsophalangeal Joint. *J Am Acad Orthop Surg*. 1995;3(1):34-43.

1.8 Hallux Valgus Interphalangeus: The Current Literature

The main focus of this research is examining hallux valgus interphalangeus and its overall contribution to the total valgus deformity of the hallux. The reason for this question becomes apparent when reviewing the literature in that there is a paucity of epidemiological data and no clearly identified relationship between hallux valgus and hallux valgus interphalangeus.

1.8.1 Literature Search

The Pubmed/Medline Database was searched utilising keywords on the conditions of interest to identify publications which may directly or indirectly discuss the hallux valgus interphalangeus deformity, its epidemiology and any potential relationship to the hallux valgus deformity.

Search strings utilised:

a) Hallux abductus interphalangeus
b) Hallux valgus AND interphalangeus
c) Hallux abducto valgus AND interphalangeus
d) Hallux valgus AND Akin AND osteotomy
e) Hallux valgus interphalangeus AND Akin AND osteotomy
f) Akin osteotomy

Reference lists of the papers included as references in this study were “hand-searched” to identify any potential papers which may have been missed by the electronic search.

Only two papers were identified where the focus of the study was an epidemiological assessment of hallux valgus.

The balance of the papers identified focussed more on the surgical management of the hallux valgus interphalangeus deformity and were searched for any epidemiological references within the body of the text.

The results of the literature assessment follow.

1.8.2 Hallux Valgus Interphalangeus

Duke and colleagues in 1982 examined the relationship between the presence of the hallux interphalangeus deformity and other measurements in 93 feet. Of relevance to this study, an inverse relationship between the IPA and HVA was described. Similarly an inverse relationship between the IPA and IMA was described.[52] When critically analysed this information is found to be misleading.

The study is methodologically flawed in that no standardised technique of radiography or of measuring the angles was used. There is no demographic data provided as to the age, race or gender of the patients studied.

The inverse relationship described between the IPA and HVA / IMA respectively is described correctly, but interpreted incorrectly when utilising less than 10 degrees as a normal value for the IPA. The data presented actually shows that the hallux valgus interphalangeus deformity was present for all degrees of hallux valgus deformity, whilst the severity of the hallux valgus interphalangeus had an inverse relation to the severity of hallux valgus.

Similarly, when interpreting the relationship between IPA and IMA, utilising the modern definition of hallux valgus interphalangeus, the average deformity was described as 14.5 degrees in feet with abnormal IMA of 10 degrees or more, showing a more direct relationship between the presence of deformity and an increased IMA.

In 2014 Castillo-Lopez and colleagues sought to compare the incidence of hallux valgus interphalangeus in normal feet (45 patients) and feet with hallux valgus (49 patients) or hallux limitus deformity (48 patients). The premise of this study was that there should be no significant difference in the IPA between the 3 groups. They utilised antero-posterior weight-bearing radiographs and digital measuring software. The statistical analysis proved no significant correlation between the IPA and the HVA[53]. Critically, this paper compares 3 relatively small groups and the feet within the deformity groups were all in early/mild stages of disease.

Apart from these two papers no direct epidemiological studies evaluating the incidence of hallux valgus interphalangeus in hallux valgus deformity exist.

It has been proven that during surgical correction of moderate to severe hallux valgus with a proximal metatarsal osteotomy and distal soft tissue procedure that the IPA increases acutely by an average 4.3 degrees. The addition of an Akin osteotomy to correct the hallux valgus interphalangeus has been associated with improved clinical outcomes[14].

Hallux valgus interphalangeus may form part of a more distinct genetic syndrome known as Hand-Foot-Genital syndrome, but the literature is currently limited to a single case report in a 13-year old female[54].

A few case reports on hallux valgus interphalangeus exist within the paediatric population and one as a post-traumatic deformity but these have no direct extrapolation to adult acquired deformities[13, 55].

It is the belief of some researchers that the hallux valgus interphalangeus deformity in isolation or in conjunction with hallux valgus is rare[10, 19].

The majority of surgical algorithms simply state that if the hallux valgus interphalangeus deformity exists it can be corrected with an osteotomy[10, 17, 25, 37].

1.8.3 The Gaps in the Evidence

After reviewing the body of knowledge on hallux valgus, the following questions and problems were identified:

a) The contribution of hallux valgus interphalangeus to the total valgus deformity of the hallux has not been explored. This despite many studies proving the benefit of treating the deformity concurrently in hallux valgus surgery

b) From the literature review it is clear that hallux valgus interphalangeus is lacking in good quality epidemiological literature.

c) There is no recent epidemiological study of hallux valgus or hallux valgus interphalangeus which is contextually relevant to the local South African Population.

The investigation undertaken arises due to the inadequacy of available research and intends to contribute to the available body of knowledge.

2.0 Materials and Methods

2.1 Hypothesis

The hallux valgus interphalangeus deformity makes a contribution to the total valgus deformity of the hallux

2.2 Objectives

2.2.1 Primary Objective

1. To evaluate the contribution of hallux valgus interphalangeus to the total valgus deformity of the hallux.

2.2.2 Secondary Objectives

1. To assess the prevalence of the hallux valgus interphalangeus and hallux valgus deformities in local African and Caucasian populations

2. To compare the biometric data obtained between local African and Caucasian populations

3. To determine any statistical relevance between the hallux valgus interphalangeus angle and the other angular measurements in hallux valgus.

2.3 Study Design

A retrospective comparative study of x-rays from patients with and without hallux valgus.

2.4 Population Sample

The appropriate population size for this study based on the international prevalence estimate was calculated to be 287 feet in order to make population based inferences.

2.4.1 Inclusion Criteria

a) 18yrs and older

b) No previous hallux valgus surgery

c) Weight-bearing x-rays

2.4.2 Exclusion criteria

a) Younger than 18 years

b) Previous hallux valgus surgery

c) Non-weight bearing films

d) Hallux varus interphalangeus deformity

2.5 Study Methodology

300 randomly selected antero-posterior foot X-rays from existing collections within a private foot and ankle surgery practice at Netcare Linksfield Hospital (155) and the Department of Orthopaedic Surgery at Chris Hani Baragwanath Academic Hospital (145) are included in this study. All x-rays were obtained between January 2006 and December 2014. The x-rays were obtained from patients presenting to the respective facilities for various foot and ankle complaints.

All x-rays included in the study were obtained according to international standardised protocol of full weight-bearing AP views with the beam 1 metre from the cassette, directed 15 degrees cephalad and centred on the mid-foot.

Each foot X-ray was measured once, manually using a goniometer by a single researcher. Four angles as described in Chapter 1.5.1 were measured utilising the standardised technique as advocated by the American Orthopaedic Foot and Ankle Society as described in Chapter 1.5.2.

No standardised measurement technique for hallux valgus interphalangeus is described. In discussion with my supervisor, the decision was made to use mid-diaphyseal reference points for the long axis of the distal phalanx measured 5mm from the articular surface of the base and the tip of the phalanx respectively; 5mm was chosen as this provides two reference points which are easily reproducible and still far enough apart to provide a reproducible diaphyseal reference point.

Each patient was assigned a numerical identifier to protect confidentiality. Basic demographic data (age, race, gender) along with the side of the foot (left or right) was recorded along with the 4 angular measurements in an Excel spreadsheet.

Patients were grouped according to the presence of hallux valgus (HVA ≥ 15 degrees) or normal feet (HVA < 15 degrees)

For each patient the total valgus deformity of the hallux (TVDH) was calculated from the hallux valgus angle (HVA) and hallux valgus interphalangeus angle (IPA) as follows:

HVA + IPA = TVDH

2.6 Pilot Study Results

A pilot study of 10 feet with and without hallux valgus from files at Linksfield Hospital was performed.

4 out of 10 feet were found to have hallux valgus angles consistent with a hallux valgus deformity.

The IPA was ≥ 10˚ in 6 out of 10 feet - 2 with hallux valgus deformity and 4 without. In the 2 feet with hallux valgus the hallux valgus interphalangeus deformity formed 28.2% and 27.7% of the total valgus deformity of the hallux.

6 out of 10 feet (4 with hallux valgus deformity) were found to have a TVDH ≥25˚. 2 out of 10 feet were found to have both a hallux valgus and hallux interphalangeus deformity.

2 out of 3 feet with an abnormal DMAA were found to have an IPA ≥ 10˚. 3 out of 5 patients with an abnormal IMA were found to have an IPA ≥ 10˚

The preliminary data from this pilot study suggested that the hallux valgus interphalangeus deformity makes a contribution to the total valgus deformity of the hallux and may show a statistically significant correlation with other abnormal angles in feet with the hallux valgus deformity.

2.7 Statistical Analysis

The data were analysed using STATA 11 statistical software (STATA Corporation, College Station, TX USA).

The following variables were included in the analysis:

i. Age
ii. Gender
iii. Side – left or right
iv. Race – Caucasian or African or Indian
v. Hallux valgus angle (HVA)
vi. Hallux interphalangeus angle (IPA)
vii. Distal metatarsal articular angle (DMAA)
viii. Intermetatarsal angle (IMA)
ix. Total valgus deformity of the hallux (TVDH)
x. Presence of deformity – hallux valgus or normal
xi. Severity of the deformity.

Exploratory data analysis of categorical and continuous variables included frequency tables and histograms of continuous variables to determine distribution and scatter diagrams to determine linear relationships between continuous variables.

Simple descriptive statistics were used to characterise the study population; normally distributed continuous data were summarised by mean and standard deviation (SD), non-normally distributed continuous data by median and interquartile range (IQR). Categorical data were summarized as number and proportion.

Statistical tests included chi-square test (adjusted if number less than 5), Pearson correlation coefficient and t-test for the comparison of means. Statistical tests were two-sided at $\alpha = 0.05$.

3.0 Results

Foot x-rays from 192 patients were included in the study. The study population consisted of 290 foot x-rays, 5 reported a negative value for the IPA and were excluded from this analysis, resulting in the total study population analysed n = 285 feet.

3.1 Demographics

The characteristics of the study population are summarised in Table 4.

The mean age of the 192 patients was 50.6 years (SD 15.9) and 152 (79.2%) were female (236 feet). 114 (59.4%) patients were Caucasian, 76 (39.6%) African and 2 (1%) Indian, see Graph 1.

Of the 285 feet included in this analysis, 142 (49.8%) were left feet and 143 (50.2%) were right feet. For the study population the mean (SD) of the age was 50.5 years (15.5) and this was similar and not statistically different between those with an abnormal IPA 49.5 years (16.2) compared to normal IPA 52.0 years (14.1), p = 0.19.

14/285 (4.9%) of the foot x-rays reported normal angles for all of IPA, HVA, IMA and DMAA.

236 (82.8%) of the study population were female and there was no statistically significant difference between the proportion reported with an abnormal IPA 147/177 (83.1%) compared to a normal IPA 89/108 (82.4%), p = 0.89.

163 (57.2%) of the study population were Caucasian, 119 (41.8%) African and 3 Indian (1.0%), see Graph 2.

There was a statistically significant difference in the proportion of abnormal IPA in the Caucasian population 112 (68.7%) compared to the proportion of abnormal IPA in the African population 64 (53.8%), p = 0.01.

There was no statistically significant difference (p=0.26) in the prevalence of hallux valgus between African 85/119 (71.4%) and Caucasian patients 106/163 (65.0%).

Table 4 Characteristics of the study population

	All	**Normal IPA** (N = 108)	**Abnormal IPA** (N = 177)	**P value**
Age **Mean (SD)**	50.5 (15.5)	52.0 (14.1)	49.5 (16.2)	0.19
Gender **N (%) female**	236 (82.8%)	89 (82.4%)	147 (83.1%)	0.89
Race				
Caucasian	163	51 (31.3%)	112 (68.7%)	
African	119	55 (46.2%)	64 (53.8%)	0.01*
Indian	3	Too few observations		

* The comparison was between Caucasian and African race (3 of Indian race were excluded)

3.2 Prevalence Of Radiographic Deformities

The prevalence of abnormal angular measurements are summarised in Table 5.

The overall prevalence of abnormal IPA was 177/285 (62.1%), abnormal HVA 193/285 (67.7%), abnormal IMA 146/285 (51.2%) and abnormal DMAA 122/285 (42.8%). The proportion of the population with an abnormal TVDH was 205/285 (71.9%).

Table 5 Prevalence of radiographic deformities (n=285)

Angle	Normal	Abnormal	Proportion abnormal
IPA	108	177	62.1%
HVA	92	193	67.7%
IMA	139	146	51.2%
DMAA	163	122	42.8%
TVDH	80	205	71.9%

Overall 193 (67.7%) of the feet x-rayed reported a HVA of >15° (classified as feet with hallux valgus deformity). The prevalence of hallux valgus interphalangeus in the feet with hallux valgus was 109/193 (56.5%) compared to the prevalence of hallux valgus interphalangeus in feet without hallux valgus 68/92 (73.9%), p=0.005; Table 6.

Table 6 Prevalence of abnormal IPA in relation to the presence of hallux valgus (HVA ≥ 15°)

	Presence of hallux valgus (n = 193)	**No hallux valgus (n = 92)**	**P value**
Abnormal IPA	109/193 (56.5%)	68/92 (73.9%)	0.005

3.3 Contribution of IPA to TVDH

The average contribution of IPA to TVDH across the whole study population was a mean (SD) of 37.9% (21.2). In feet with hallux valgus the average contribution of IPA to TVDH was a mean (SD) of 28.3% (15.2) and the average contribution of IPA to TVDH in feet without hallux valgus was 58.0 (17.8).

There is a positive linear relationship (see figure 7) between IPA and TVDH, Pearson's coefficient of 0.24, p value of <0.01, which indicates that this relationship is statistically significantly different to zero (no effect).

In the 146 patients with mild hallux valgus, IPA contributes a mean (sd) of 32.2 % (14.1) compared to 58.0% (17.8) in patients with no hallux valgus and 16.0% (11.6) in patients in the moderate/sever group. If we compare the mean contribution of IPA in mild HV to those of moderate/severe group there is a statistically significant difference in the means, p <0.0001.

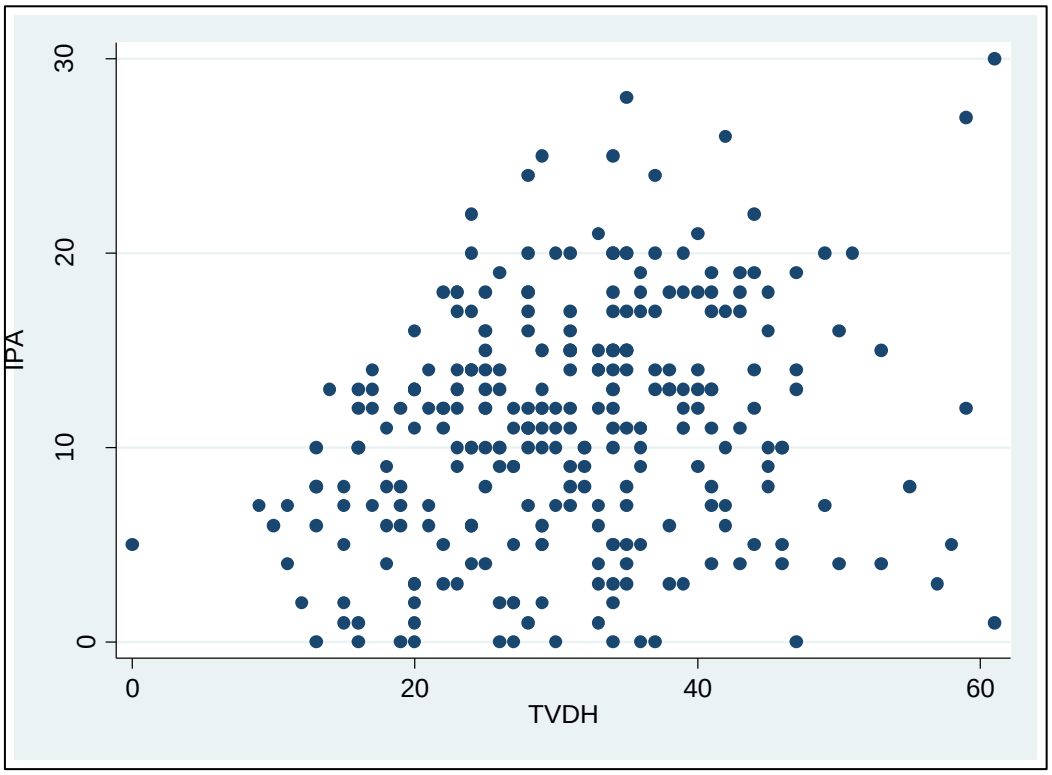


Figure 7. Scatter diagram between IPA and TVDH

3.4 Relationship Of IPA To Severity Of Hallux Valgus

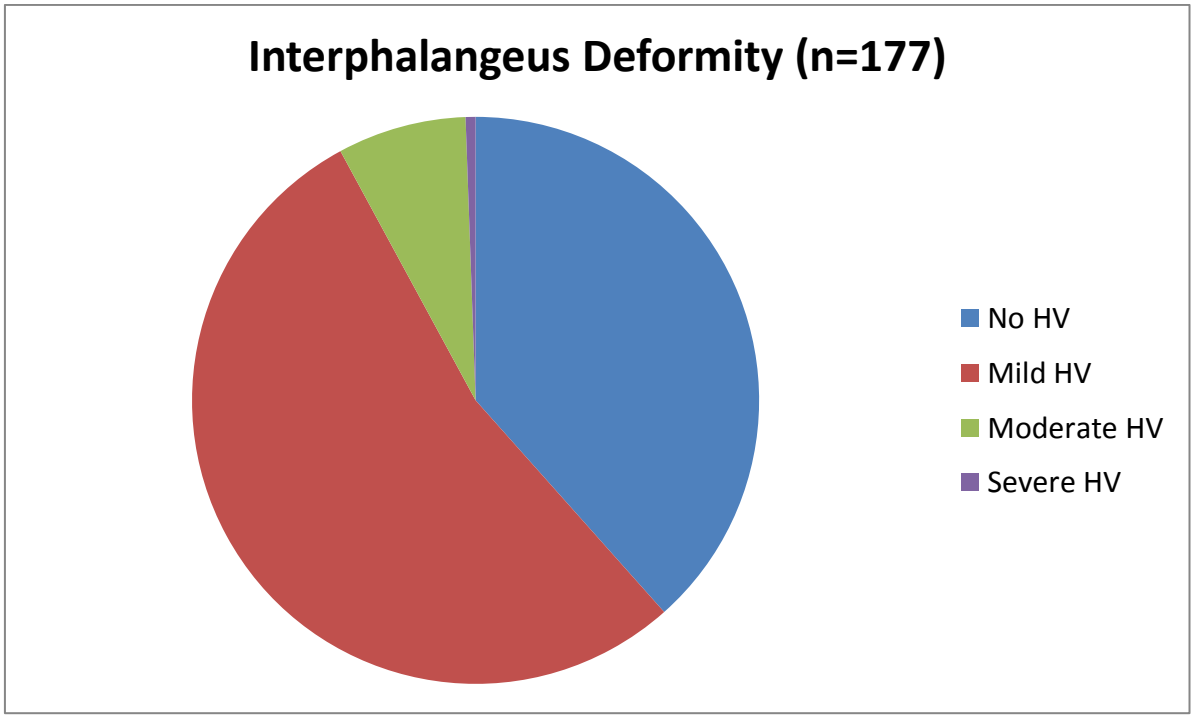
Of the 193 feet with hallux valgus, 146 (75.7%) were classified as mild, 35 (18.1%) as moderate and 12 (6.2%) as severe.

Of the feet with hallux valgus interphalangeus deformity (n=177), 68 (38.4%) had a normal HVA, 95 (53.6%) were in the mild hallux valgus category, 13 (7.3%) in the moderate hallux valgus category and 1/177 (0.6%) in the severe category (see graph 3).

There is a negative linear relationship between IPA and HVA, as the IPA increases the HVA decreases, (Pearson's correlation coefficient of -0.35), figure 8.

Conversely, 95 (65.1%) of mild HVA possessed an abnormal IPA.

The mean IPA in feet with both deformities was 16.6 degrees (range 10 to 27 degrees).



Graph 1 Hallux valgus interphalangeus and hallux valgus.

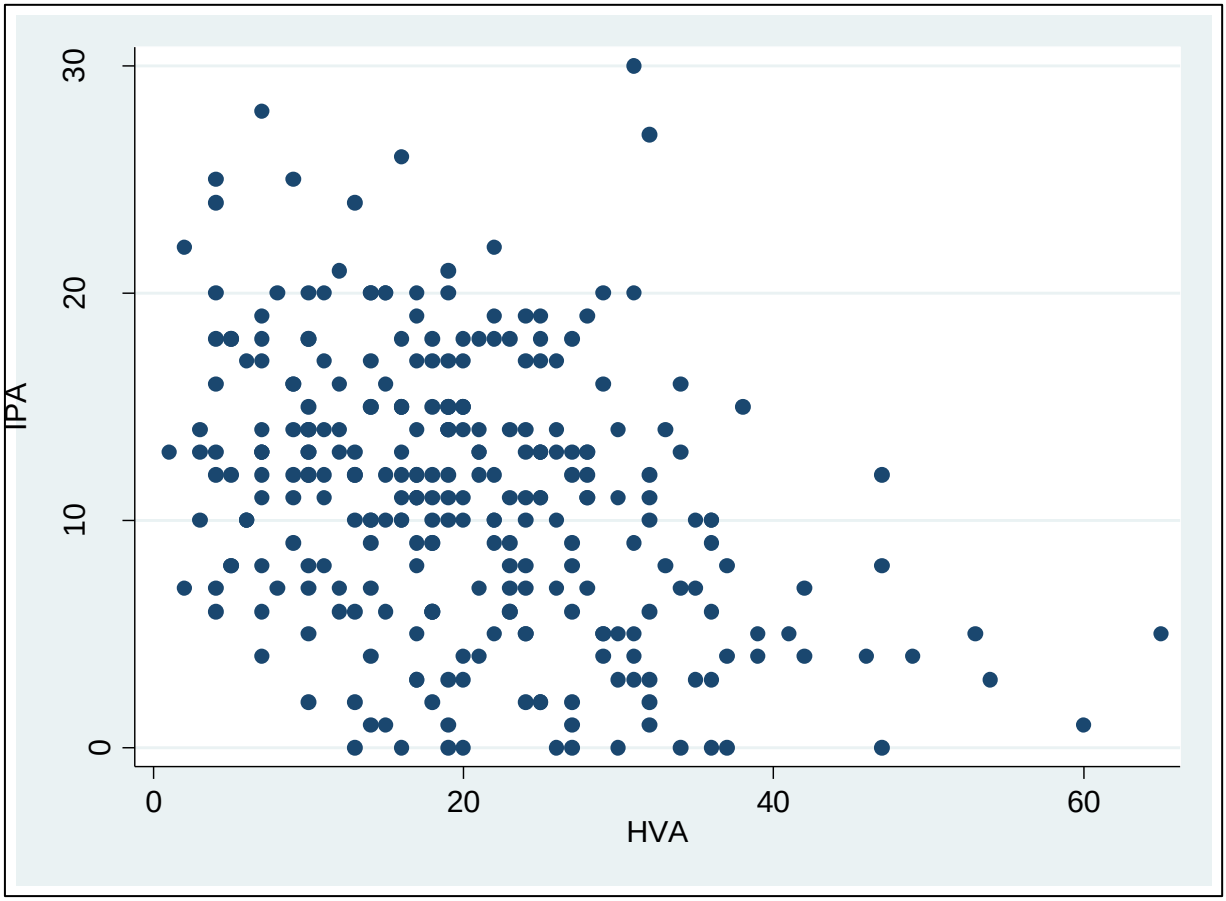


Figure 8. Scatter diagram between IPA and HVA

3.5 Relationship of IPA to DMAA and IMA

Of the 122 feet with an abnormal DMAA, 63 (51.6 %) had the hallux valgus interphalangeus deformity. There is a negative linear relationship between IPA and DMAA, as the IPA increases the DMAA decreases, (Pearson's correlation coefficient of (-0.22), figure 9..

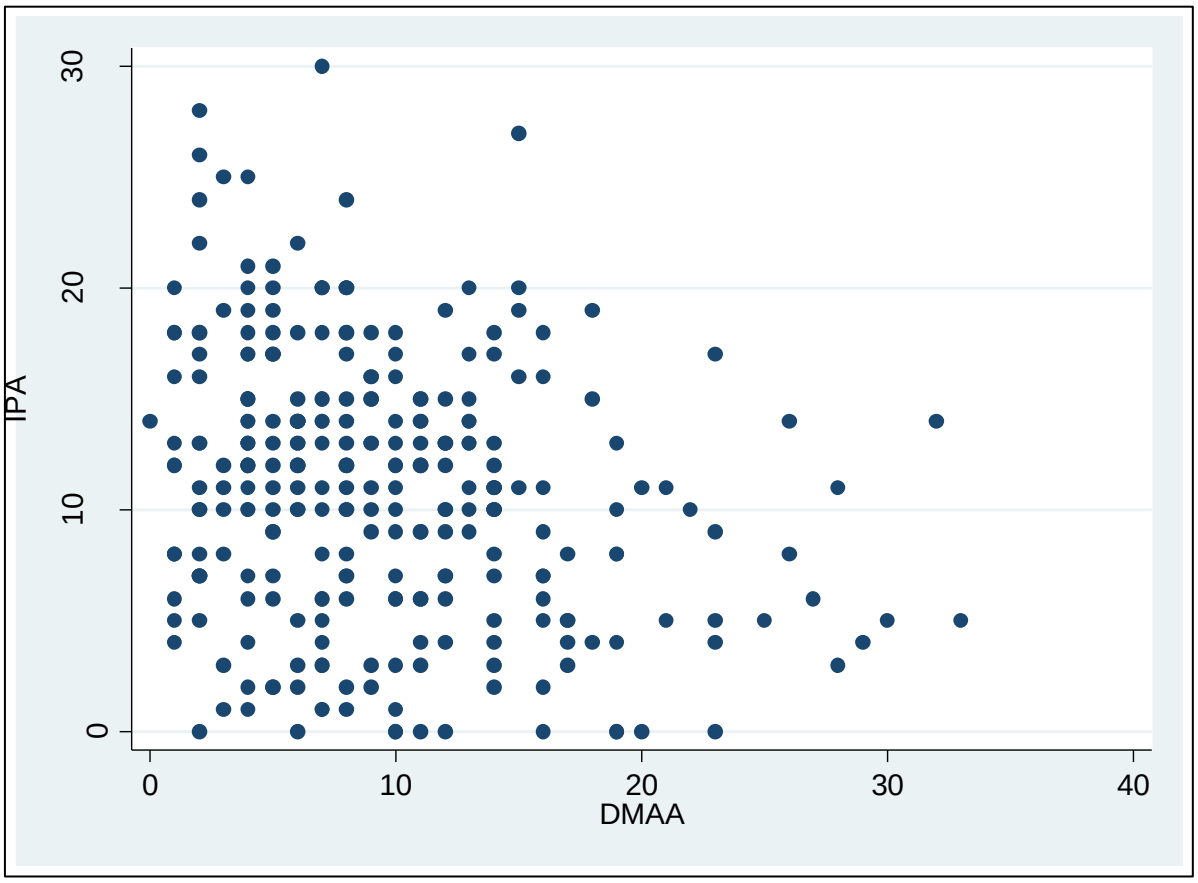


Figure 9. Scatter diagram between IPA & DMAA

Of the 146 feet with an abnormal IMA, 73 (50.0%) had the hallux valgus interphalangeus deformity. There is a negative linear relationship between IPA and IMA, as the IPA increases the IMA decreases, (Pearson's correlation coefficient of (-0.34), figure 10.

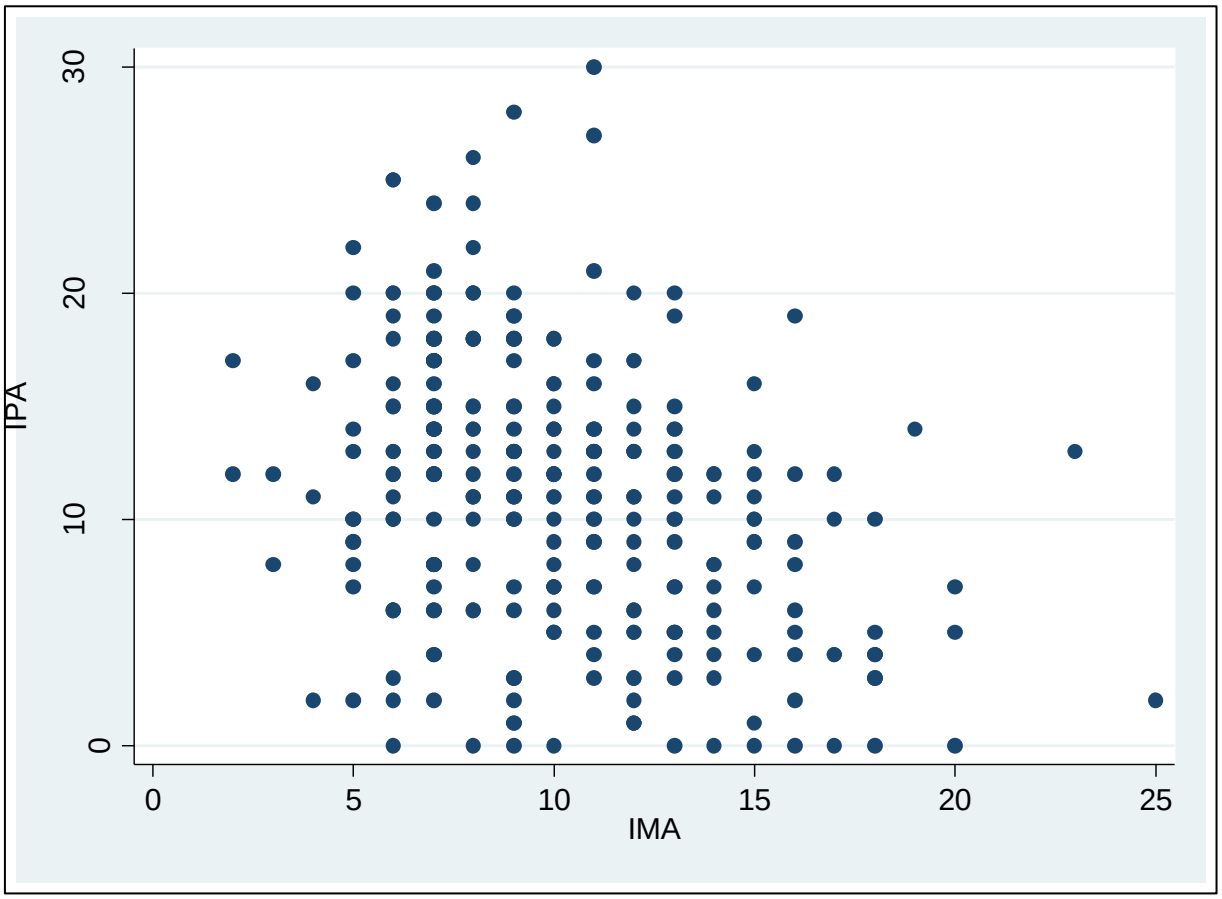


Figure 10. Scatter diagram between IPA and IMA

4.0 Discussion

4.1 The Contribution Of IPA To TVDH

The concept of a total valgus deformity is novel thinking and based upon the evidence that correcting residual interphalangeal valgus improves outcomes in hallux valgus surgery[49, 50]. The statistically significant ($p < 0.01$) positive linear relationship between the IPA and TVDH proven in this study validates this.

The data analysis shows that patients who would receive corrective surgery for hallux valgus without addressing the hallux valgus interphalangeus would, on average, still have almost one third (28.3%) of the original valgus deformity uncorrected. It is even possible that correcting the hallux valgus without addressing the interphalangeal deformity would make this residual deformity even worse[14], but this may depend on surgical technique.

The IPA contribution to TVDH is greatest in the mild hallux valgus deformity, where 65.1% of feet had both deformities and an abnormal TVDH. The impact of IPA on the TVDH is less when considering moderate and severe deformities as a group, but the IPA must still be considered when managing these cases.

The negative linear relationship between IPA and HVA in this study has been described[52] and is confirmed in this study. This must be interpreted correctly, as it does not mean that the IPA gets smaller as the HVA increases; instead the HVA increases without a corresponding increase in IPA.

This does not mean that the interphalangeal deformity in cases with more severe hallux valgus is any smaller as the mean IPA of feet with both deformities is 16.6 degrees.

Based on this, it is postulated that the hallux valgus interphalangeus deformity is generally limited to a few degrees above the normal value by the structure of the joint. The articular surfaces of the interphalangeal joint are intimately congruent

and as such a limited amount of “space” exists whereby the distal phalanx can tilt into valgus, before the lateral joint surfaces abut.

The pathological mechanism involved in producing the hallux valgus interphalangeus deformity is essentially unknown, but it stands to reason that if the FHL tendon were to pull on the distal phalanx in an eccentric fashion, it could well be a factor in its development. It is logical then that the high prevalence of hallux valgus interphalangeus, particularly in the feet without hallux valgus and mild hallux valgus, may be alluding to hallux valgus interphalangeus being a predecessor to, or even a cause of, hallux valgus. Subsequently if hallux valgus interphalangeus is not corrected, its persistence may then be a predictor of recurrence of hallux valgus.

It is crucial to note that both hallux valgus and hallux valgus interphalangeus are three dimensional deformities; with rotation of the toe into pronation there may be a false radiographic interpretation of minimal or no interphalangeal angulation[56]. Studies have shown that with the correction of pronation the pre-existing interphalangeal valgus is unmasked and necessitates correction[14, 56].

Clearly, the contribution of hallux valgus interphalangeus to the total valgus deformity is significant. This study dictates that interphalangeal valgus must be actively sought out and corrected surgically, rather than simply considered as a *possible* treatment arm.

Further studies to determine the exact or multifactorial origin of hallux valgus interphalangeus, the role of the FHL tendon as a deforming force and the validity of residual interphalangeal valgus as a predictor of recurrence are necessary to fully understand its impact on hallux valgus surgery.

4.2 Epidemiology of Angular Deformities

The prevalence of hallux valgus in this study population is 67.7%, far above the quoted meta-analysis prevalence of 23% [5]. Previous data for the South African population set prevalence estimates at ±50%. The prevalence in this study may figure may be skewed as:

a) this study sample came from collection of x-rays belonging to patients presenting with foot and ankle complaints who are more likely to have hallux valgus
b) the majority of the study sample are Caucasian females (57.2%) in whom hallux valgus is more common[5, 7]
c) the mean age for the population is 50.6 years, and hallux valgus is more common in advancing age[5].

It is possible that using the strict methodology of standardised weight-bearing x-rays with a standardised measurement technique may have exposed more radiographic abnormalities than in other studies, and this figure may be more correct. A true comparison between population groups would require a larger amount of data from multiple centres utilising the same methodology.

The prevalence of hallux valgus interphalangeus is 62.1%. This is in direct contradiction to the published body of work which claims its rarity[10, 17, 25, 37]. In normal feet the prevalence of an abnormal IPA is more common than in feet with hallux valgus (p=0.005). This may suggest that the normal value for IPA may need to be revised, but this would need to be proven on a larger sample.

This data proves that hallux valgus interphalangeus is common, based on science and not opinion, and confirms its importance in a treatment algorithm.

The prevalence of an abnormal TVDH is 71.9%, higher than the prevalence of hallux valgus and hallux valgus interphalangeus. When viewing valgus deformity of the hallux as a composite of these two deformities, the combined effect is more

than just a sum of the two parts. A true test of the value of this calculation would require clinical correlation of the radiographic deformity with symptoms in the affected feet.

4.3 Relationships Between Angular Measurements

It has been proposed that the hallux valgus interphalangeus deformity is related to the stability of the 1st metatarsophalangeal joint. In those joints where the articular morphology allows for inherent stability, walking may place pressure on the lateral side of the distal phalanx leading to hypoplasia[52] and the resulting deformity. This proposed pathological mechanism was originally proposed to explain the inverse relationship between the IPA and HVA[23].

Contrary to this idea is the evidence that hallux valgus interphalangeus has been found in children and foetuses[52], suggesting the deformity is not due to changes in articular morphology due to walking, but rather may be inherited.

The IPA has a negative linear relationship with the HVA, IMA and DMAA. Severity of deformity in the IMA and DMAA are known to directly affect the severity of hallux valgus and its surgical management[17, 22, 37]. The interpretation of this relationship is the same as discussed Chapter 4.1: as the hallux valgus deformity increases, the hallux valgus interphalangeus does not show a corresponding increase.

The natural history of the hallux interphalangeus deformity is not known and it may correct as the hallux valgus deformity worsens or remain as a pre-determined fixed value. Deciding whether the deformity is related to the inherent stability of the rest of the first ray components or is simply a standalone entity with a genetic basis would require further study. The increased prevalence of hallux valgus interphalangeus in feet without hallux valgus is in favour of a genetic determinant.

4.4 Racial Comparison of Angular Measurements

Hallux valgus interphalangeus is significantly more prevalent in Caucasian feet when compared to African feet (p =0.01). In both groups the prevalence was greater than 50%. This re-affirms that hallux valgus interphalangeus is more common than previously thought and probably has partially genetic aetiology.

In contrast to other epidemiological studies there is no significant difference in the prevalence of hallux valgus between African and Caucasian patients. This is the second study from South Africa to report this finding[7]. This information would yield real significance if the radiologically apparent and clinically symptomatic hallux valgus cases were correlated.

5.0 Conclusion

Hallux valgus interphalangeus is a common deformity, with or without the presence of hallux valgus. By conceptualising the valgus deformity of the hallux as a sum of two deformities this study has quantified the relative contributions of each and highlights the importance of correcting the residual interphalangeal valgus. This relationship is strongest in the mild hallux valgus deformity, particularly in Caucasian patients. Hallux valgus interphalangeus must be incorporated as an integral part of the management algorithm in hallux valgus.

The relationship between the two deformities is so important that I feel the use of the terms hallux valgus and hallux valgus interphalangeus in isolation should be abandoned and instead the total valgus deformity of the hallux must be the ultimate consideration.

APPENDICES

Appendix A: Ethics Approval

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130645

NAME: (Principal Investigator)	Dr Andrew Strydom
DEPARTMENT:	Division of Orthopaedic Surgery Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	A Radiographic Analysis of the Contribution of Hallux Interphalangeus to the total valgus deformity of the Hallux
DATE CONSIDERED:	28/06/2013
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr N Saragass/Dr C Truda

APPROVED BY: Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 24/03/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

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