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Hallux Valgus Angle And 1st Intermetatarsal Angle of Human Foot

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ABSTRACT

Man's foot evolved from that of the ape's foot was mainly used for prehensile function1 and arboreal existence1. It was used to move on trees and to hold branches of trees. Ape's 1st ray and the hallux are mobile and opposable with greater movements at transverse tarsal joints for prehensile functions. It's first toe can be curled around one side of a bough and the 2nd to 5th toes on the other side During evolution, the ape acquired a large size and great weight which became actual handicaps for him to have an arboreal existence 1. So, the ape become a terrestrial animal and assumed a bipedal gait. The body weight became vertically supported and the feet had not only to support weight but had also to help in locomotion. This imposed additional stresses on the hind limb and on the foot, causing profound changes in the foot. It changed from a grasping organ to a supporting. Adduction of big toe brought the 1st and the 2nd metatarsals almost in line with each other and the 1st metatarsal could bear weight. It increased and doubled in girth, and become heavier2 as it now supported one third of the body weight in locomotion. Rigidity of human foot provided a strong anterior pillar for longitudinal arches and played an important role in giving medial stability to foot in standing, it permitted "heel to toe" gait and allowed body weight to carried on metatarsal heads. The rigid and adducted 1st metatarsal in human permitted final thrust by the great toe. Thus, man's foot become a specialized organ for terrestrial leverage. As foot problems and deformities came to be noticed, the foot which was considered an uninteresting part of human anatomy. Early historical background as reported by kelikian3

KEYWORDS : man's foot, ape's foot, bipedal gait, 1st intermetatarsal angle, angle of hallux valgus

INTRODUCTION

Hallux valgus is a common condition occurring mainly in individuals who have a genetic predisposition. Foot wear is implicated in this condition. Metatarsus primus varus,an adduction deformity of first metatarsal is commonly associated with hallux valgus[4] The 1st cuneometatarsal joint is between the base of the 1st metatarsal and distal facet of the medial cuneiform. Its joint cavity separates and its plane is oblique with a medial and backward slant[3] The 1st metatarsophalangeal joint is between the head of the 1st metatarsal and the concave, expanded base of the proximal phalynx. Dorsally the fibrous capsule is thin but there are dense ligaments on the plantar aspect continuous with the deep transverse metatarsal ligaments. The 1st metatarsal head has two sesamoid bones on its plantar aspect, these sesamoids, are covered by strong ligaments called collateral ligaments which run from the 1st metatarsal, to the side of the base of the proximal phalynx. These ligaments from an essential part of normal 1st metatarsophalangeal joint[5] .this is 'condyloid' type of synovial joint allowing flexion, extension , slight abduction and adduction and dorsiflexion which is of greater range than planter flexion. Dorsiflexion is possible up to 90^0 this is associated with requirement of walking, more active dorsiflexion especially at the 1st metatarsophalangeal joint, is required as during the " push off" phase of walking, toes extend and come in contact with the ground with their full length. Thus the toes helps in final thrust in the 'push off ' phase. When the toes extend , they are able to take some share of weight from the heads of metatarsal and can act as fulcrum to convert then foot into type 2 lever for propulsion during locomotion this joint therefore, plays a major role in transmission of body weight in locomotion.[6]In the normal human foot, the 1st metatarsal is not parallel to the 2nd metatarsal but is lightly divided to the medial side , consequent to plane of 1st cuneometatarsal joint which inclines medially and backwards. This gives a slight varus inclination to the 1st ray which is normal The angle between long axes of the 1st and 2nd metatarsal also called the 1st intermetatarsal angle, represents this normal slight varus of the 1st ray. It ranges between 8.5^0-10^0 [7,8,] Proximal phalynx of the big toe is not in line with the 1st metatarsal. It is deviated towards lateral toes which gives the proximal phalanx, its slight normal valgus position. This is represented by the angle formed by long axes of the 1st metatarsal and of the proximal phalanx of the big toe and is called the angle of hallux valgus normal maximum limit of this angle is$10^{0,}$ [9] There is a significant high correlation between the intermetatarsal angle and the angle of hallux valgus with a coefficient of 0.7.[7]The medial collateral ligament of the 1st metatarsophalangeal joint is stretched, the lateral collateral ligament contracts causing lateral subluxation of the proximal phalanx of the big toe and the tone of extensor hallucis longus causes gradul loosening of the soft connective tissue that binds the tendon to the dorsum of the 1st metatarsophalangeal joint . since there is no true tendon sheath in this region , the tendon gradually moves in a lateral position and begings to have a ' bow string' effect upon the big toe and causes hallux valgus. Altered line of pull of adductor hallucis with lateral head of flexor hallucis and extensor hallucis brevis, perpetuates the deformity.[10] The head of the 1st metatarsal protrudes medially, the sesamoids are displaced laterally and an adventitious subcutaneous bursa develops medially causing 'bunion' The angle of hallux valgus increases beyond 15-20^0 due to lateral deviation of the proximal phalanx The 1st intremetatarsal angle increases beyond 10^0due to medial deviation of the 1st metatarsal.[7]

MATERIALS AND METHODS

The present study was carried out on 58 healthy (ages of 18 to 23 years-43 males and 15 females). None of the volunteers had any foot complaints. There was no history of trauma. Their footwear consisted of chappals or open toed sandles. 50% of the walking hours. Occasionally some were closed toed shoes.

METHODS

Roentgenograms of both right and left feet of volunteers were taken on the same x-ray plate. are not taken under weight bearing conditions. Fig.1

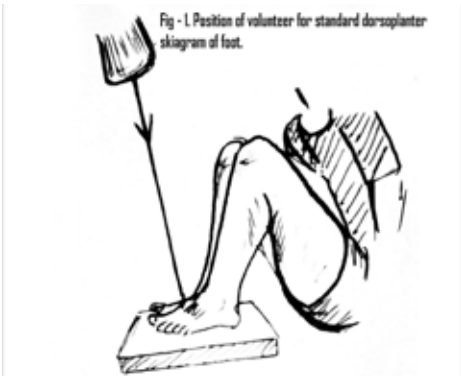


Fig.1

Measurements
The following two parameters were recorded to measure foot.

Measurement of the 1st intermetatarsal angle
The long axes of the 1st and 2nd metatarsal , as drawn above , are projected proximally till they meet each other . the angle (x) formed by these two lines is the 1st intermetatarsal angle.[11]

Measurement of the angle of hallux valgus.
The long axis of proximal phalanx of the big toe is drawn by the same method as for the 1st metatarsal. The angle opening out distally, between the long axes of the 1st metatarsal and proximal phalanx, when prolonged to meet, is the angle of hallux valgus.[10]

CALCULATIONS
Mean, standard error, Mode and Range are calculated for all the recorded values.

Statistical correlation coefficient 'r' showing interdependence is calculated between –

The 1st inter-metatarsal angle and angle of hallux valgus.

OBSERVATIONS
Total no. Of volunteers are 58 (15 females, 43 males).
Total no. Of feet studied is 116.
The 1st intermetatarsal angle (in degrees):

	Total	Male	Female	Sexual difference in mean
Mean	9.57	9.28	10.37	1.09
SE	2.777	2.36	1.847	
Mode	9.35	9.32	9.40	
Range	5-19	5-19	7-15	
Mean+2SE	4.02-15.12	4.56-14.00	6.58-14.06	
% of feet	98.2	96.5	96.6	

The angle of hallux valgus (in degrees):

	Total
Mean	9.93
SE	4.666
Mode	9.56
Range	0-22
Mean+2SE	0.60-19.25
% of feet	93.9%

Coefficient of correlation (r) between the 1st intermetatarsal angle and the angle of hallux valgus is r=0.54, t=6.84. As this value of 't' is significant, there is a positive significant correlation between these two angles.

DISCUSSION
The aim of this study is to find out and confirm the factors influencing the angle of hallux valgus. Hallux valgus is a common and disabling disorder, where there is lateral deviation of the big toe with consequent effect on dynamic weight bearing. Mitchell.[11]suggested that in such cases, the medially deviated 1st metatarsal fails to assume its proper role in weight bearing, partly due to inefficient "push off" of a laterally displaced hallux. Fig.2,A,B, The angle of hallux valgus is the usual metatarsaophalangeal angle denoting lateral deviation of the proximal phalanx. Clinically, hallux valgus develops after this angle has crossed a critical degree. Therefore, it is important to know what is the expected range of this angle in a population and the factors affecting it. Fig.2,C,D, The factors affecting the angle of hallux valgus are-Intrinsic factors – bony, ligamentous and muscular.

Extrinsic factors – unhealthy footwear.

Intrinsic factors:
Bony Factors- These are important as they make the foot unstable and predisposed to valgus of the big toe,among these, the important ones is- Metatarsus primus varus.[12]

The role of ligaments- their role in the mechanism is a small one.

The role of muscles – There is hardly any need to break up the role of intrinsic and extrinsic muscles- All the tendons surrounding the 1st ray are not attached to the 1st metatarsal head but are attached to the phalanges.[5]as the majority of muscles acting o the big toe do so from the fibular side and if there is muscular imbalance, will pull the hallux laterally and increase the angle of hallux valgus. Extensor hallucis longus plays a primary role as there is no extensor expansion on the dorsum of the big toe. Therefore, this muscle loses its soft tissue connection from the dorsum of the 1st phalanx and becomes the chief muscle to have a 'bow-string' action on the big toe and initiate its lateral deviation, which is maintained by other muscles coming from the fibular side. As these muscles are attached to the phalanx and not to the metatarsal head, only the phalanx of the big toe is pulled laterally. This mechanism comes into play when either the 1st metatarsal shifts medially or the proximal phalanx shifts laterally.

Extrinsic Factor- (pointed toed shoes)
Fashionable tight toed shoes push the hallux laterally. If this occurs over a long period of time, the medial collateral ligament of the 1st metatarsophalangeal joint is stretched and the lateral one contracts. The extensor hallucis longus tendon brings about hallux valgus. This change is progressive and the phalynx becomes fixed in a permanent laterally deviated position

The angle of hallux valgus:
This angle shows wide variation with a mean of 9.93^0 + 9.34 in this study. This range includes 93.9 % of observations. The reduced angle will make the phalanx more stable. Therefore, these are not important in causing hallux valgux and hence are included an along with cases falling in the above range which now covers 97.4%. Fig.2

Table No:3 : The angle of hallux valgus (in degrees) A Comparison.

	Preaent study	Hardy & Clapham's study
Mean	9.93	15.7
Mode	9.56	12-16
Range	0-22	4-28

When the mean angle of hallux valgus of the present study is compared with that found by Hardy et al,value in the former is less. The explanation for this difference may be due to bad shoes, The clinical opinion in India, regarding the shoe wearing habits and types of patients coming with hallux valgus suggests that, the patients of hallux valgus belong to Parsi and Govan communities. Both these communities are known to be influenced by western culture and wear tight toed shoes during most of their waking hours Hardy et al7 study wrote that shoes most of their waking hours, due to their culture as well as due to the cold climatic conditions. Our climate does not permit us to wear close shoes for long hours. As the group for the present study uses open toed sandals or Chappals only 50% of the daytime, the mean angle of hallux valgus is less than that found by Hardy et al7 and hence our footwear habits seem to be healthy.

Correlation between the angle of hallux valgus and the 1st intermetatarsal angle.

When these angles are statistically correlated, a significant positive correlation is found between the two. This shows that these angles are interdependent, if the value of one angle increases, the other angle increases too. This correlation was also studied by Hardy et al7 and their results are as follows:

	Present study	Hardy & Clampham's[22] study
R	0.54	0.7
t	6.84	

The present study in this respect corresponds with their findings. This finding is also in agreement with the view of Piggot[10], that metatarsus primus varus and hallux valgus go hand in hand. The mechanism of increased intermetatarsal angle influencing the angle of hallux valgus and causing lateral deviation of hallux Piggot[10] suggested that the above mechanism would apply in a similar fashion if the lateral deviation of the proximal phalynx is the primary change. The muscles would pull the base of the 1st phalanx laterally between the heads of the 1st and the 2nd metatarsals widening the anterior end of the space and produce medial deviation of the 1st metatarsal. Piggst[10] postulated that the 1st metatarsal did not have any muscles attached to it and it is difficult to explain why it would swing medially. So, it is suggested that, it must be the hallux which subluxated laterally initially, resulting in widening of 1st intermetatarsal angle. Fig.3, A,B, In the present study, when cases are analysed individually, there combinations of cases were observed. 95.68% cases the angle of hallux valgus ($0\text{-}19^0$) and the 1st intermetatarsal angle ($0\text{-}15^0$)are within normal range. This was expected as none of the cases had any foot symptom or complaints. In 2.58% cases where the angle of hallux valgus is more than 19^0 while the 1st intermetatarsal angle is within normal limits. In two of these cases the 1st intermetatarsal angles are 14^0 and 11^0 which are on the higher side of the normal. These feets are predisposed to hallux valgus and may manifest symptoms in later age, as changes are gradual and progressive with the advancing age. Symptomatic hallux valgus is more common after 40 years[3] There is an individual with both feet (1.72%) Showing 19^0 and17^0 of 1st intermetatarsal angle and having normal angle of hallux valgus. This indicates that there is some degree of metatarsus primus varus (Metatarsus adductus).[13]Since these two feet have all other observations such as the slant of distal facet or medial cuneiform and the shape of the base of the 1st metatarsal, in normal limits, there may be a soft tissue reason like contracted medial ligaments of the 1stcuneometatarsal joint or weak intrinsic muscles on lateral side of foot leading to contracture of the medial ligaments. It is reported that all cases of metatarsus adductors do not present with hallux valgus even in later life.[14] As these two feet do not show much change in the angle of hallux valgus, they are not necessarily predisposed to clinical hallux valgus. According to Lapidus,[12] metatarsus primus varus reflected in increased 1st intermetatarsal angle, was the primary cause of hallux valgus. Later, Piggot[10], Hardy & Clapham[7] said that hallux valgus is the cause of the increased 1st intermetatarsal angle. Modern view agrees with the latter opinion. In the particular age group of cases observed in this study, it is difficult to come to any confident conclusion about which is the cause and which its effect. This is also affirmed by statisticians.[15].However, it can be said that the present study indicates their interdependence.

Fig - 2 A - Hallux valgus - diagrammatic representation

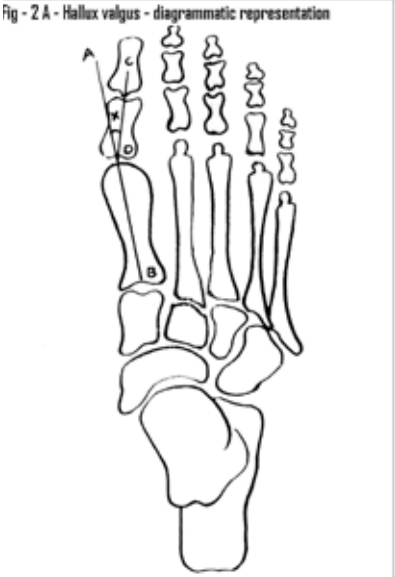


Fig - 2 B - Hallux valgus - showing normal angle in x-ray

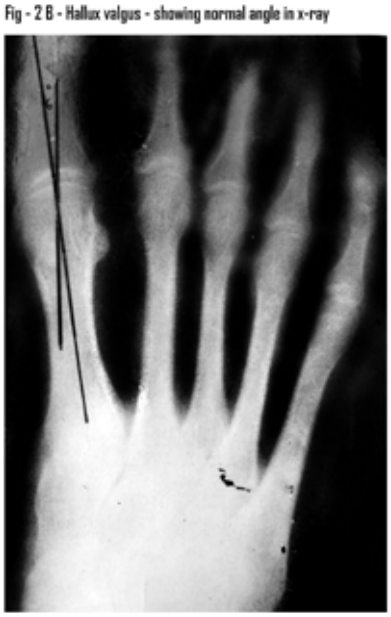


Fig - 2 C - Hallux valgus - showing abnormal angle in x-ray

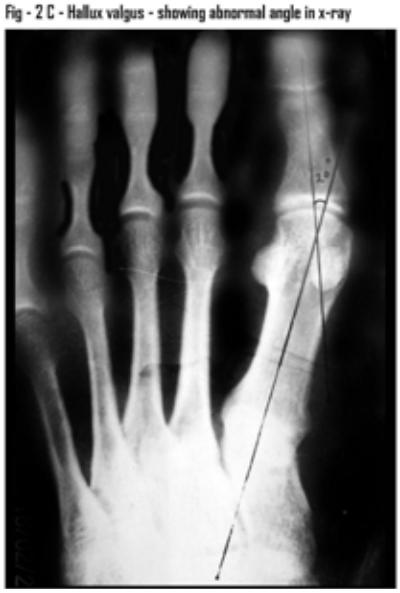


Fig - 2 D - Hallux valgus - x-ray of foot with shoes

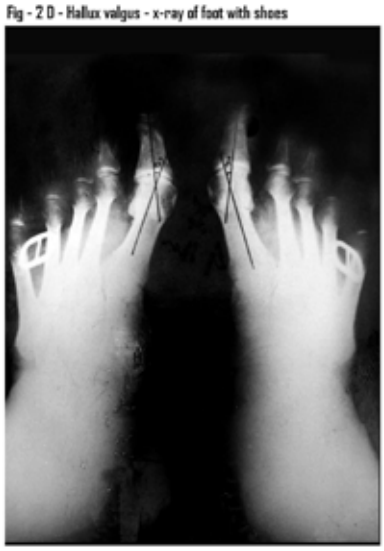


Fig - 3 A - Intermetatarsal angle - diagrammatic representation

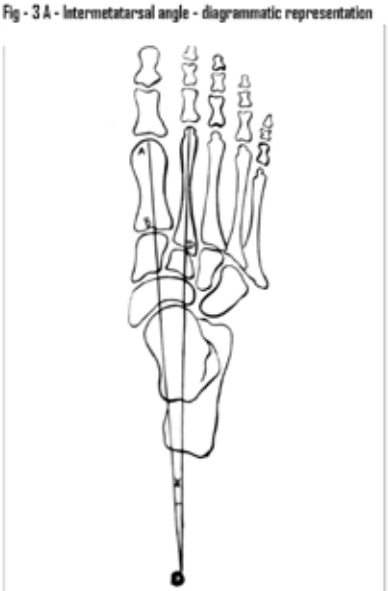
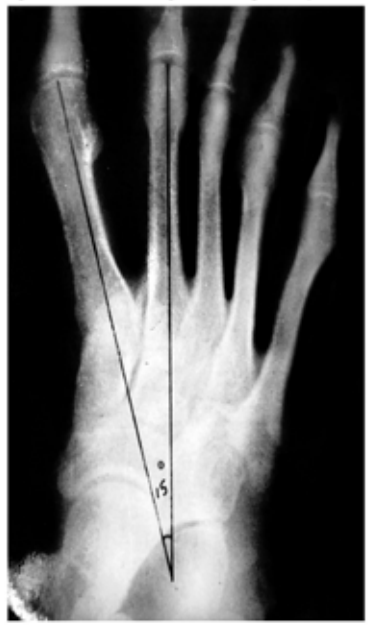


Fig - 3 B - Intermetatarsal angle - Normal angle in x-ray



SUMMARY AND CONCLUSIONS

There is no significant difference between the right and left foot.

A significant positive correlation is found between the angle of hallux valgus and the.

The 1st intermetatarsal angle.

A small 1st intermetatarsal angle seems to be better as it contributes to making a stable foot.

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