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STUDY of ROLE of IST & IIND METATARSAL in HALLUX VALGUS DEFORMITY

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ABSTRACT

The foot is a specialized structure. It possesses a record of man's prehistory which in completeness and legibility surpasses that of any other structure of the body. Indeed, the foot is a specialized structure adapted to the pattern of bipedal locomotion and to the additional stresses imposed upon the hind limb. During the transition of the foot from an arboreal ape's foot to the terrestrial change has predominantly affected the 1st metatarsal with medial cuneiform (1stray)and the 2nd metatarsal with intermediate cuneiform (2ndray) In most primates the distal end of the 1st metatarsal is not tied by ligaments to the 2nd thus allowing the hallux marked freedom of movements (opposability). In the human foot, the plantar ligaments of the 1st metatarsophalangeal joint are connected to the 2nd by deep transverse metatarsal ligaments. These are four bands and connect plantar ligaments of adjoining metatarsophalangeal joints to one another.1 Thus, the most important change which distinguishes man even from other primates is that, the opposability of the hallux in the apes has given way to the stability of the hallux in the apes has given way to the stability of the hallux and the 1st ray in the human foot. The 1st and the 2nd rays play a crucial role in foot function of weight bearing, body support and locomotion. Their deformities and affections, therefore, are disabling. Forefoot deformities constitute 90 % of all foot deformities1and those affecting the 1st ray are the commonest. Among these hallux valgus is the most disabling .Hence, it is important to understand the normal relationship between some of the parameters that constitute the most important part of the forefoot i.e. the 1st and the 2nd rays. Some of the parameters were studied earlier by based on anatomical observation and some statistical correlation2 of the 1st ray and its effect on the second ray. However, while examining the various abnormalities of the 1st ray, it was observed that not all the measurements were quantified or statistically correlated with each other. The two rays were linked to each other some a study of parameters and of their statistical correlations with each other. It would be possible to corroborate the previous opinions as to the anatomical causes of hallus valgus. Thus, the aim of this study is to –1 Establish and compare the values for bony configurations of the first and the second rays in the Indian feet 2 Show statistical correlation between parameters which will suggest the anatomical factors predisposing to hallux valgus.

KEYWORDS 1st ray, 2nd ray, metatarsal length, hallux valgus,angle of hallux valgus

INTRODUCTION

The two main function of the foot is the support of body weight and other being locomotion, the foot help to bear body weight the person is standing as well as when he is walking. According to Morton3 the weight distribution in the foot is in the following proportion on metatarsal heads 2:1:1:1:1,thus in standing the first metatarsal takes a major i.e. 1/3 share of weight on the forefoot. The more 1st metatarsal protrudes the more is its share in weight bearing 3"heel strike", most of the weight is borne by the heel as the foot proceeds from " heel strike" to"step off" phase, the weight shifts from the heel to the lateral border of the foot , then medially along the line of metatarsal heads, to a point between the 1st and the 2nd metatarsal heads, the lateral arch remains the major weight bearing area from ' foot flat' to 'mid stance' in 'forefoot phase' of walking hallux predominates in sharing the body weight and in 'step off ' phase pressure is entirely on toes especially hallux 4 The hallux presses on the ground and makes contact with it over most of its plantar surface and give the final thrust for ' push off' the big toe is the last point to leave the ground. In walking , the entire body weight is supported on only one foot in " stance phase". The 1st metatarsal now carries half the body weight which is distributed in the 4:1:1:1:1 proportion5. In the foot, as a unit , mainly the 1st ray has undergone important changes in evolution forms an important support of medial longitudinal arch and is important in static and dynamic weight bearing; gives in the 'toe off' phase and helps the foot to act as the second class lever in locomotion. Morton2 introduced the term "short 1st metatarsal" he used a specific method and criteria to measure and grade the shortness of the 1st metatarsal. Morton postulated that such metatarsal was the cause of many foot problems and suggested that in the ideal foot the 1st and 2nd the metatarsal are equidistant from the heel. Harris and Beath6 used a specific method to measure relative lengths of the first two metatarsals and found that in the majority of cases these two are equal. Only in some cases the difference between their relative lengths was 1 mm or less. Hardy and clapham7 found no correlation between the length of the 1st metatarsal and foot deformities.

Later used another definite method to find the difference in forward projections of the first two metatarsals and found that the head of first projected distally than 2nd, contradicting all observations on this subject so far. They reported that in hallux valgus, the 1st metatarsal projected much more distally and called this as the long 1st metatarsal and it is a cause of hallux valgus. In the normal human foot, the 1st metatar-

sal is not parallel to the 2nd metatarsal but is lightly deviated 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 [8] Deformities of the1st metatarsal especially hallux valgus, are most disabling. Hallux valgus, as a clinical entity, is defined as the lateral deviation of the great toe with a medial prominence of head of the 1stmetatarsal and is found to be the commonest of all forefoot deformities. It is responsible for bringing maximum patients to orthopaedic wards in foreign countrie[9] because of cosmetic disfigurement of foot, difficulty in finding proper footwear8 and nagging pain due to improper weight bearing. The 1st metatarsal may or may not be short, suggested by Morton as the cause of many forefoot problems, a short 1st metatarsal according to current opinion does not give rise to foot problems. Harris and Beath [6] However , Hardy et al [7]proved that the 1st metatarsal is longer in hallux valgus than the 2nd .

MATERIALS AND METHODS

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

METHOD:

1. Roentgenograms of both right and the left feet of a volunteer were taken on the same x-ray plate.
2. Both feet without shoes were kept on the film holder, slightly separated from each other with lateral bordeds of feet parallel to lateral margins of film cassette. Thus, the distance between the film and the object is reduced to a minimum to avoid distortion
3. Volunteers sat on the x-ray table with their knees held together and their feet on the x-ray film holder as shown in the diagram these x-rays are not taken under weight bearing conditions.
4. Central beam was directed at an angle of 150 to the perpendicular from an anteroposterior direction over the point midway between 1st metatarsal heads for bilaterally symmetrical shadows.

MEASURMENT:-

Dried x-ray films were collected and marking were made.

The following parameters were recorded to measure foot

(1) Measurement of absolute length of the 1st metatarsal:-
The long axis of the 1st metatarsal is marked by joining the midpoint of the centers of articular surfaces of the head and base of the 1st metatarsal. The distance between these two points along the long axis of the 1st metatarsal is measured in mms with the help of a pair of dividers and a ruler. This gives the absolute length of the 1st metatarsal.
(2) Measurement of absolute length of the 2nd metatarsalthe same as above is used for the 1st metatarsal.
(3) 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 valgus12
(4) Measurement of the metatarsal of the difference of radial lengths of the 1st and 2nd metatarsal as suggested by Hardy and Clapham. 7 This is done by measuring the difference between the forward projections of the 1st and 2nd metatarsal heads from a fixed posterior point and not by actually measuring the radial length.

OBSERVATION

Total no. of volunteers are 58 (15 females, 43 males).

Total no. of feet studied is 116.

Table No 1 : Differences in male and female metatarsal

	Male	Female	Diff.in Mean
1.Absolute length of 1st metatarsal	55.5mm	51.2mm	4.3
2 Absolute length of 2nd metatarsal	68.08mm	61.97mm	6.11
3.Ratio of lengths	0.815	0.827	0.012

Table No 2:

	Absolute length (in mm) of the 1st metatarsal			Absolute length (in mm) of the 2nd metatarsal		
	Total	Male	Female	Total	Male	Female
Mean	54.24	55.5	51.2	66.38	68.08	61.97
SE	4.659	4.258	3.763	5.47	4.66	4.895
Mode	53.23	53.36	53.40	69.6	69.66	58.50
Range	43-64	43-64	44-58	54-78	54-78	54-72
Mean ± 2SE	44.92-63.56	46.98-64.02	43.67-58.73	55.44-77.32	58.75-77.41	52.18 - 71.76
Percentage of feet in the range of mean±2SE	98.2%	96.5%	100%	77.32	95.3%	100%
Ratio Male : female		100:92		100:91		

Table No 3 :

Ratio of absolute lengths of1st metatarsal : absolute length of the 2nd metatarsal.			
	Total	male	female
Mean	0.818	0.815	0.827
SE	0.042	0.041	0.043
Mean ± 2SE	0.73-0.90	0.73 - 0.90	0.74 - 0.91
Precentage of feet	98.2%	98.8%	96.6%
coefficient of correlation (r) between the absolute lengths of the 1st and 2nd metatarsal:			
	Total	Male	Female
'r'	0.813	0.766	0.78
't'	14.90	10.92	6.60

t - test values are significant, concluded that there is positive correlation between absolute lengths of 1st metatarsal : absolute length of the 2nd metatarsal

Table 4:- 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%

DISCUSSION

Hallux valgus is a common and disabling disorder of 1st ray, where there is a lateral deviation of the big toe with consequent effect on dynamic weight bearing, Bones of females are generally lighter, shorter and more. It is found that the incidence of hallux valgus is more in females. therefore, the sexual difference is calculated to find out if there is any structural factor which predisposes the female feet.

Absolute lengths of the 1st and 2nd metatarsals.

The absolute lengths of the 1st metatarsal in males, has a mean of 55.5+_ 8.517 mm. And in females 51.2+_ 7.526 mm. The absolute lengths of the 2nd metatarsal in males, has a mean of 68.08 +_9.326 mm and in females 61.966± 9.790 mm. A difference in ratios of absolute lengths of the 1st and 2nd metatarsal in males (0.815) and females (0.827)is found in this study (Table No. 1-3) and though it is statistically significant, it does not appear to have a ignificant effect on either the angle of hallux valgus or on the difference in forward projections of the 1st and 2nd metatarsal heads, both of which do not show any sexual difference. So, it can be said that this difference in ratios is not clinically important. It also suggests that the 1st metatarsal is slightly longer than the 2nd in females.

Correlation between the lengths of the first two metatarsals.

There is a significant positive correlation between the lengths of the 1st and the 2nd metatarsals in both sexes, It can also be said from the present study that in absolute length the 1st metatarsal is always shorter than the 2nd .The results obtained by Hardy and Clapham's method showed that a majority of feet have the 1st metatarsal head distal to that of the 2nd by a mean measure of +1.034 + 6.09 mm This range compises 97% readings. A Long 1st metatarsal was suggested as a cause of hallux valgus by 7,10,11 Hardy et al 7 said that the 1st metatarsal projected distally by 4mm or more, than the 2nd in patients with hallux valgus.

The difference in forward projections of the 1st two metatarsals.

This measurement shows the levels of the first two metatarso-phalangeal joints in relation to each other. The 1st joint is especially important as it play a major role during both static and dynamic weight bearing. In the present study ,The results obtained by Hardy and Clapham's method showed that a majority of feet have the 1st metatarsal head distal to that of the 2nd by a mean measure of +1.034 + 6.09 mm(+7.934 to -5.87mm). This range comprises 97% readings8.The difference in forward projections shows its interdependence on the angle of hallux valgus. So, if this difference increases, both these angles will also increase.

Table No.5 : Difference between forward projections of 1st two metatarsal (in mm) – A Comparison.

	Present study(Hardy et al method)	Hardy et al	Morton's
Mean	+1.034mm	+2mm	-2mm-40%
Mode	+3.39mm	+2-+4mm	-5mm –Frequent -1cm - Unusual

Referring to the table No.5, the present findings correspond with Hardy and Clapham.

A Long 1st metatarsal was suggested as a cause of hallux valgus by, Haines10.Hardy et al found et al found that the 1st metatarsal projected distally by 4mm or more than the 2nd in patients with hallux valgus and hence his above suggestion. In the present study it is seen that more the difference between the forward projections, more will be the angle of hallux valgus(Fig.1,A,B) If the 1st metatarsal projections, the more will be the angle of hallux valgus. If the 1st metatarsal projects distally beyond + 7mm. It will tend to increase the angle of hallux valgus. Therefore, the findings of present study corroborate the above view and show that, the longer the 1st metatarsal protrudes, the greater will be the angle of hallux valgus. In this study there is only one case where the 1st metatarsal Head protrudes +8 mm. This is a predisposed foot with a normal angle of hallux valgus which may remain unaltered if it is not forced into tight toed shoes. When the 1st metatarsal is longer, the 1st digit will be longer which if pushed into tight shoes will shift laterally, allowing the " bow string" mechanism of the extensor of the big toe to start operating causing its gradual lateral deviation and hallux valgus. It, therefore, appears that extrinsic factors play an important role in precipitating hallux valgus in such feet A short 1st metatarsal – was suggested as a cause of hallux valgus by D. J.Morton. His opinion was proved incorrect by Harris and Beath 7, who said that a short 1st metatarsal is not the cause of hallux valgus. The present study, however, indicates that if the 1st metatarsal head is behind that of the 2nd by more than 6 mm, it will increase the angle of hallux valgus. In this study there is only one case where the 1st metatarsal head is behind by -7 mm than the 2nd. This is a predisposed foot with a normal angle of hallux valgus and needs follow up as it may develop hallux valgus even in the absence of extrinsic factors. It is, therefore, inferred that if the 1st metatarsal is excessively short, even when measured by Hardy's method, it can cause hallux valgus. A possible mechanism is suggested by which a short 1st metatarsal can cause hallux valgus. Such a metatarsal does not reach the ground to take its share of weight in locomotion. In its effort to do so, the 1st cuneometatarsal joint becomes hypermobile and allows the 'short'1st metatarsal to go into varus position. The hallux shifts laterally and extensor hallucis longus tendon starts having its "bow string" effect, causing hallux valgus. It appears that in feet with short 1st metatarsal it is mainly the intrinsic factors which precipitate the hallux valgus.It would be worthwhile here to note that though Morton's opinion on short 1st metatarsal has been shown to be wrong by many workers, a controversy still goes on. Carr and boyd[12] in 1968 attributed excessive shortening (3-4mm) of the 1st metatarsal as a cause of failures in their series of operations. The present study indicates that if the 1st metatarsal is excessively long or short (by Hardy and Clapham's method), it predisposes the foot to hallux valgus. It would be proper to state here, that since the study is on normal feet between the ages of 18 and 23 years and as no case of hallux valgus has been studied, it is difficult to decide the critical angle beyond which it can be diagnosed as being pathological.

The 2nd ray [13] is the longest of the metatarsal bones. The proximal surface of its base is triangular and articulates with the intermediate cuneiform and also with the medial cuneiform medially and lateral cuneiform as well as the 3rd metatarsal laterally . It does not normally articulate with the 1st metatarsal. The 1st ray is marked as so vital a unit to the mechanics of foot function, that any defect or deficiency in it would impair the foot's entire mechanism. When this ray is abnormal, its weight bearing function is mainly taken over by the 2nd metatarsal and the 2nd cuneometatarsal joint. In such cases, lines of stress converge on the base of the 2nd, subjecting it to heavy stresses minor movements of medial plantar nerves and cause metatarsalgia

SUMMARY AND CONCLUSIONS

The 1st ray, is the cause of hallux valgus. Therefore, the 1st metatarsal is studied in relation to the 2nd.

There is a significant difference between the feet of males and females with respect to lengths of the first two metatarsals

It is observed that closed and pointed toed shoes do have a deleterious effect on the hallux and do form a precipitating cause of hallux valgus. So, such shoes should be avoided. Broad toed footwear is more healthy for the feet and is recommended.

Finally, it is believed that the statistical interdependence between various parameters shown in this study, throw some light on the complex problem of finding the cause of hallux valgus.

Fig 1 A - Angle of hallux valgus - Diagrammatic representation

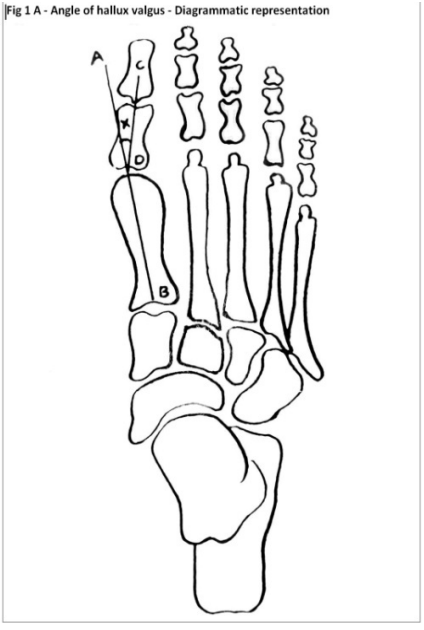

Fig 1 B - X-ray showing normal angle of hallux valgus.



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