

## Footprint an insight for medial longitudinal arch

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### Abstract

**Introduction:** Medial Longitudinal Arch (MLA) is important for the foot, since it provides necessary shock absorption during movement. Its estimation can be done by various techniques, viz navicular height method, footprint, radiography. On the footprint various indexes have been suggested by researchers.

The study aims to correlate the values of medial longitudinal arch by using standing navicular height method, Clark's angle and chosen morphological characteristics (mid-footprint planter angle; MFPA) in medical and health science students of Sumandeep Vidyapeeth University.

**Materials and Methods:** Non-randomized study was conducted in the department of Anatomy in SBKSMI&RC on 50 students of medical & health science at Sumandeep Vidyapeeth after prior approval. Three different methods were used for measuring MLA, navicular height method, Clark's angle (using footprint) and MFPA (using footprint an angle formed by joining the medial most point anteriorly with the point of maximum concavity on the medial side of the foot while posteriorly due to calcaneus bone forming a triangle with this angle).

**Results:** Middle level negative correlation (-0.531 & -0.500) between MFPA and Clark's angle for right & left foot with statistical significance of <0.001. Negative lower level correlation (-0.297 & -0.104) between Clark's angle and Navicular method of MLA assessment with statistical significance of <0.05 for right and no significance for left foot were found. Navicular height and MFPA showed positive lower level of correlation (0.435 and 0.461) for right and left foot with statistical significance of <0.005. Inverse regression analysis for MLA value measurement using Clark's angle and MFPA in left and right foot with regression significance value of  $r^2 = 0.25$  and  $r^2 = 0.282$  respectively.

**Conclusion:** The new technique (MFPA) of estimating MLA using footprint is significant and strongly correlated with other methods, thus can be considered efficient method for estimation of arch in OPD on day to day basis.

**Keywords:** Medial longitudinal arch, Navicular height method, Footprint, Clark's angle.

### Introduction

Humans are unique by virtue of having bipedal gait and the evolution of thought process. Just like the uniqueness in the face of a person and his/her hand print; so we can say about foot print too. Human footprints not only provide evidence of presence, but also information about the individuals who made the prints including stature, foot anatomy, gait, and locomotor style.<sup>1</sup>

Medial longitudinal arch is the most important arch of the foot out of other two since it provides necessary shock absorption for the foot during activity.<sup>2-5</sup>

There are many techniques that have been used to assess the medial longitudinal arch (MLA) which can divide them into two groups: indirect and direct methods. Indirect methods include ink or digital footprints which can be static (standing) or dynamic (walking) and photographic techniques. Multiple methods exist for measuring the height of the medial longitudinal arch; therefore, it is important to develop a standard set of measurements to be used when foot type is used as a variable in research studies or when making a clinical diagnosis. Footprint indices are found to be highly correlated with navicular height, indicating that both navicular height measurements and footprint measurements are valid measures of medial longitudinal arch height.<sup>6,7</sup> On the basis of footprint technique, we can measure the medial longitudinal arch by using different sorts of indexes like Clark's angle (footprint angle),

Chippaux - Simirak index (CSI), arch index, and Sztriter-Godunow index (Ky) Rose GK (1990),<sup>8</sup> Stavlas P (2005)<sup>9</sup> and Chen CH (2006).<sup>10</sup>

In this research authors have chosen morphological characteristics, mid-footprint planter angle (MFPA), as a new angle on footprint to assess the medial longitudinal arch of the foot during weight transmission and then comparing it with anthropometric measurement of MLA as well as that of the standard footprint Clark's angle. The purpose of this study is to investigate if MFPA can be used for measuring MLA in near future.

### Aim

To correlate the values of medial longitudinal arch by using standing navicular height method, Clark's angle and chosen morphological characteristics (MFPA) in medical and health science students of Sumandeep Vidyapeeth University.

### Objectives

1. To compare and correlate the findings from the footprint data of MFPA with that of Clark's angle.
2. To compare and correlate the findings from the footprint data of Clark's angle with that of standing navicular height.
3. To compare and correlate the findings from the footprint data of MFPA with that of standing navicular height.

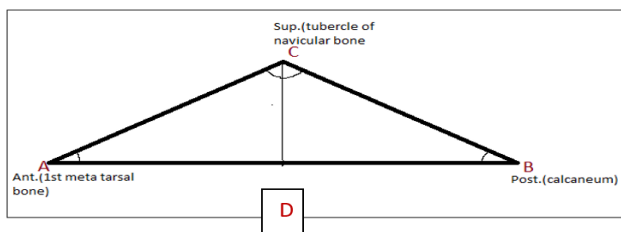
**Materials and Methods**

A non-randomized and purposive, observational and analytical study was conducted in the department of anatomy in Smt. B. K. Shah Medical Institute and Research Center, Sumandeep Vidyapeeth University, Piparia on 50 students from medical and health science students. Students excluded from the study were those having any gross foot deformity, lower extremity injury within the past six months or history of foot or ankle surgery or footprints showing high or low arch footprint. Study was started after taking prior approval from the ethical committee of Sumandeep Vidyapeeth. First year students of medical, dental, physiotherapy and nursing were enrolled in the study. A foot length measurement scale, ink roller, inepad, A-3 size white chart sheet, scale, protractor, height measuring scale and weighing balance.

Three points were marked on foot (Soren Spornly-Nees et al 2011)<sup>11</sup> and measured using metallic scale.

- A. The tubercle of navicular bone (C)
- B. Most prominent posterior portion of calcaneum (B)
- C. Most prominent medial end of 1<sup>st</sup> metatarsal (A)

The following lengths were measured viz. AB, AC and CB Height of the medial longitudinal arch was taken by dropping a perpendicular from the point ‘C’ to ground. With the help of these four measurements triangle was constructed and following angles and lengths were measured and recorded.



Lengths: AB, AC, CB and CD  
Angles: CAD, CBD, ACB, ACD and BCD

**Measurement of Loaded Footprint Data**

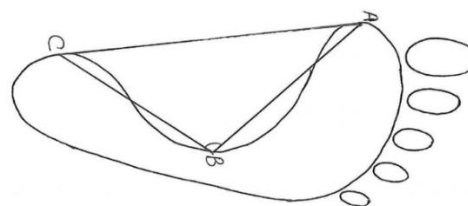
Foot print was impregnated using inepad with a non-reactive, non-indelible black ink, on A-3 size white sheet for both the feet after weight bearing on the feet. After cleaning the foot, the participants were requested to step their soles on the inepad with minimal pressure, and then transfer the inked foot onto a plain A-3 white paper kept aside on a flat surface. Left and right footprints were recorded one by one

for each participant. Three major foot imprint components were considered:

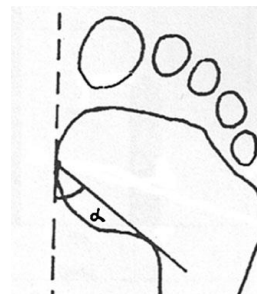
During weight transmission the area of the foot in contact with the ground determined the integrity of the arches of foot.

1. Anteriorly 1/3 is formed due to the metatarsal head which remains constant mostly.
2. Posteriorly 1/3 of the foot print also remains constant which is formed due to the calcaneus bone.
3. Middle 1/3 concavity part is variable reflecting the height of the arch formed by the 5<sup>th</sup> metatarsal bone.

Measuring the angle formed by joining the medial most point anteriorly due to metatarsal head with the point of maximum concavity on the medial side of the foot while posteriorly due to calcaneus bone forming a triangle with this angle for the study i.e., angle ABC



Lastly Clark’s angle ( $\alpha$ : tangent to the medial edge of the foot, the prints and a line connecting the deeper part of the footprint with the most medial point of the forefoot) was calculated from the footprint sheet of students.



The data collected was subjected to statistical analysis using excel & SPSS-20 software for descriptive analysis, correlation and regression analysis using excel and SPSS-20 software.

**Results**

**Table 1:** Descriptive Analysis for calculating MLA using MFPA, Navicular height method and Clark’s angle in right and left foot

	Minimum	Maximum	Mean	Std. Deviation
BMI	16.2	40.3	22.984	5.5890
Right foot MLA by MFPA	88.2	139.0	117.852	9.9881
Right foot MLA by Navicular height method	82.4	130.1	108.533	10.5140
Right foot MAL by Clark’s Angle	35.0	62.0	49.260	6.2948
Left foot-- MLA by MFPA	80.6	137.0	117.408	11.0625
Left foot MLA by Navicular method	80.4	126.1	105.870	9.9171
Left foot MLA by Clark’s Angle	30.0	62.0	47.820	6.1568

Table 1 shows descriptive statistical values for MLA measured by navicular method, MFPA and Clark’s angle for right and left foot as 108.53±10.51, 117.85±9.99, 49.26±6.29, 105.87±9.92, 117.41±11.06, and 47.82±6.16 respectively.

**Table 2:** Paired correlation analysis for six pair samples

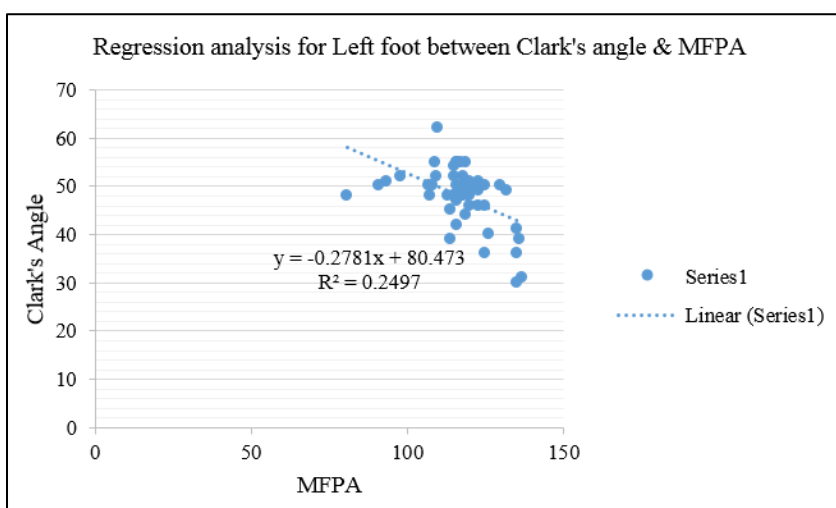
		Correlation	Sig.
Pair 1	Right foot--MLA by MFPA & Clark’s angle	-.531	.000
Pair 2	Right foot -MLA by Navicular height method & Clark’s angle	-.297	.036
Pair 3	Left foot--MLA by MFPA & Clark’s Angle	-.500	.000
Pair 4	Left foot--MLA by Navicular height method & Clark’s Angle	-.104	.472
Pair 5	Right foot--MLA by MFPA & Navicular height method	.435	.002
Pair 6	Left foot--MLA by MFPA & Navicular height method	.461	.001

Table 2 shows middle level negative correlation (-0.531 & -0.500) between MFPA and Clark’s angle for right & left foot with statistical significance of <0.001 while negative lower level correlation (-0.297 & -0.104) between Clark’s angle and Navicular method of MLA assessment with statistical significance of <0.05 for right and no significance for left foot. Navicular height and MFPA shows positive lower level of correlation (0.435 and 0.461) for right and left foot with statistical significance of <0.005.

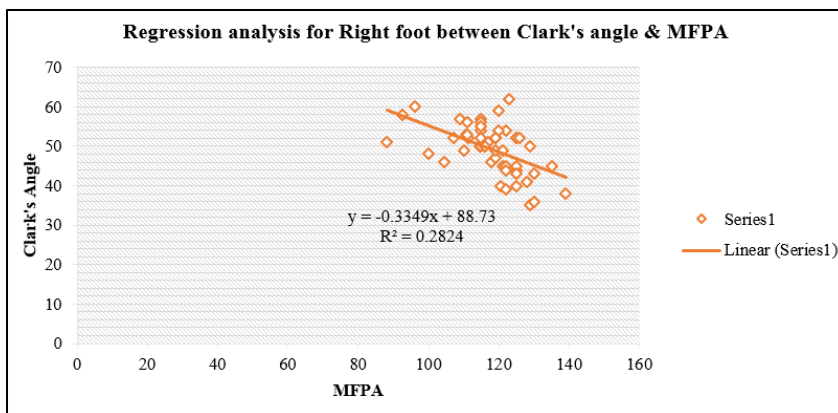
**Table 3:** Paired difference test

		Mean	Std. Deviation	Std. Error Mean	95% CI of the Difference		t	Sig. (2-tailed)
					Lower	Upper		
Pair 1	Right foot--MLA by MFPA - Right foot—Clark’s angle	68.592	14.360	2.031	64.5109	72.6731	33.776	.000
Pair 2	Right-LMA by Navicular method - Right foot-- Clark’s angle	59.273	13.765	1.947	55.3610	63.1847	30.450	.000
Pair 3	Left foot--MLA by MFPA - Left foot-- Clark’s angle	69.588	15.111	2.137	65.2934	73.8826	32.562	.000
Pair 4	Left-LMA by Navicular method - Left foot-- Clark’s angle	58.050	12.205	1.726	54.5812	61.5186	33.631	.000
Pair 5	Right foot--MLA by MFPA - Right-LMA by Navicular method	9.319	10.906	1.542	6.2196	12.419	6.042	.000
Pair 6	Left foot--MLA by MFPA - Left-LMA by Navicular method	11.538	10.936	1.547	8.4302	14.646	7.461	.000

Table-3 shows paired difference test for both foot found statistical significance value at two tailed scale (<0.001) within each pair of the MLA measurement method.

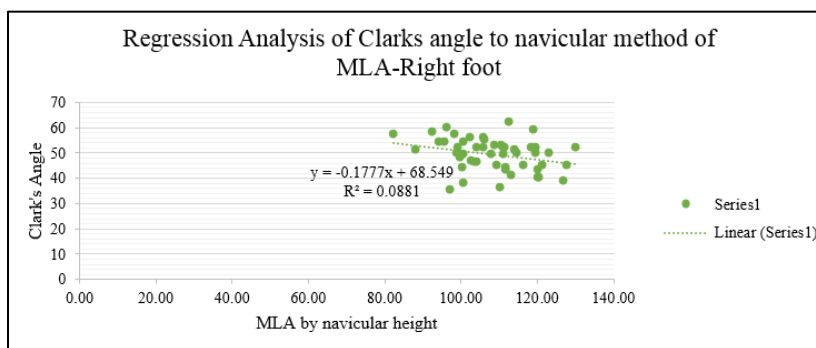


**Fig. 1:** Regression analysis for MLA measurement by Clark’s angle and MFPA in left foot



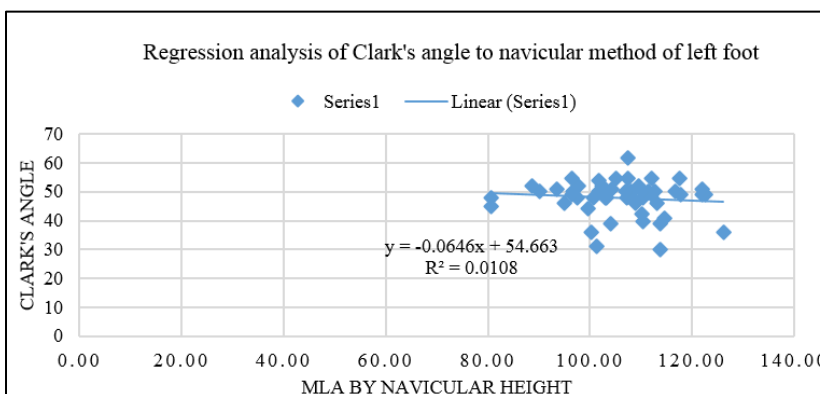
**Fig. 2:** Regression analysis for MLA measurement by Clark’s angle and MFPA in right foot

Fig. 2 shows inverse regression analysis for MLA value measurement using Clark’s angle and MFPA in right foot with regression significance value of  $r^2 = 0.282$   
 $Y = -0.33x + 88.73$



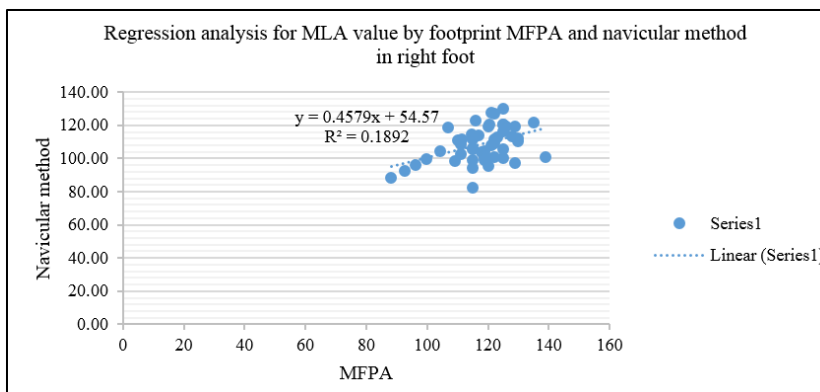
**Fig. 3:** Regression analysis for MLA measurement by Clark’s angle and Navicular method for right foot

Fig. 3 shows inverse regression analysis for MLA value measurement using Clark’s angle and navicular method in right foot with regression significance value of  $r^2 = 0.081$   
 $Y = -0.178x + 68.55$



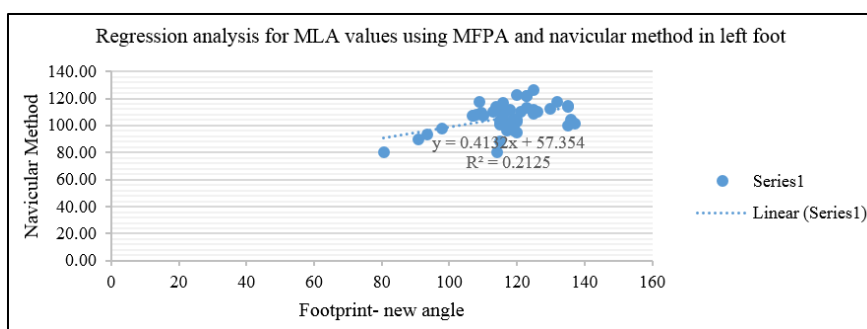
**Fig. 4:** Regression analysis for MLA measurement by Clark’s angle and Navicular method for left foot

Fig. 4 shows inverse regression analysis for MLA value measurement using Clark’s angle and navicular method in left foot with regression significance value of  $r^2 = 0.011$   
 $Y = -0.0646x + 54.66$



**Fig. 5:** Regression analysis for MLA measurement by MFPA and Navicular method for right foot

Fig. 5 shows regression analysis for MLA value measurement using MFPA and navicular method in right foot with regression significance value of  $r^2 = 0.189$   
 $Y = 0.458x + 54.57$



**Fig. 6:** Regression analysis for MLA measurement by MFPA and Navicular method for left foot

Fig. 6 shows regression analysis for MLA value measurement using MFPA and navicular method in left foot with regression significance value of  $r^2 = 0.2125$   
 $Y = 0.4132x + 57.35$

**Discussion**

Essence of this study is to use innovative technique for measuring medical longitudinal arch (MLA) to be used in day to day clinical practice. This has been successfully achieved by the correlation equations enlisted above as well as Clark’s angle.

Although footprints have been widely used by several authors for analysis and description of the MLA, there is not a universally accepted method till date.<sup>9,10</sup>

The purpose of this study was to investigate the MLA by linear navicular height measurement and by MFPA and with that of Clark’s angle.

Descriptive statistics of the averaged values of the measurement shows descriptive statistical values for MLA measured by navicular method, MFPA and Clark’s angle for right and left foot as  $108.53 \pm 10.51$ ,  $117.85 \pm 9.99$ ,  $49.26 \pm 6.29$ ,  $105.87 \pm 9.92$ ,  $117.41 \pm 11.06$ , and  $47.82 \pm 6.16$  respectively.

This study showed middle level of negative correlation between MFPA and Clark’s angle  $-0.531$  &  $-0.500$  for right & left foot with statistical significance of  $<0.001$  while negative lower level correlation between Clark’s angle and

Navicular method of MLA assessment  $-0.297$  &  $-0.104$  with statistical significance of  $<0.05$  for right and no significance for left foot. Although a positive lower level of correlation between Navicular height and MFPA  $0.435$  and  $0.461$  for right and left foot was identified with statistical significance of  $<0.005$ .

Roy (2012)<sup>12</sup> showed significant negative correlations and simple linear regressions with standing navicular height, standing talar height as well as standing normalized navicular and talar heights in the arch-index analyzed in both sexes separately with supporting mathematical equations. Shiang T (1998)<sup>2</sup> showed a better correlation between the footprint value measurements and the normalized navicular height. Even Gilmour J and Burns Y (2001)<sup>13</sup> showed plantar arch index and navicular vertical height correlated although latter was accepted to be better, considering it to be measured directly, other than being key to the medial arch, and easy to achieve. While the result in Queen RM (2007)<sup>6</sup> study showed no correlation of footprint measurement with that of navicular height. Present study exhibits slight variations in footprint dimensions were the left footprint has greater dimension than the right footprint

which are similar to the result shown by Abledu JK (2015).<sup>14</sup>

Fernández SP (2015)<sup>15</sup> considered Clarke's angle, to be highly accurate for flat foot diagnosis in the population with higher specificity (90.7%), than other footprint indexes like the Chippaux-Smirak index (56.1%) and Staheli index (58.7%).

### Conclusion

This study has highlighted the innovative, non-invasive, cost effective and accurate technique for estimating medial longitudinal arch (MLA) using footprint. Its values are significantly correlated to the values estimated via navicular height method, which is considered to be efficient method of its estimation.

This procedure can be used in OPD on day to day basis other than, can provide a basis for the surgical reconstruction of injured foot and help in designing better external devices for non-surgical correction.

### Limitations

Less sample size for the study is one of the major limitation. Other than, the association of MFPA with that of gender, age difference and body mass index might be able to provide much clearer opinion for considering it as an alternative for estimating MLA on OPD basis.

**Conflict of Interest:** None.

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