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SIGNIFICANCE OF RADIOLOGICAL MEASUREMENTS OF CALCANEUM IN POSTERIOR HEEL PAIN IN NORTH BENGAL POPULATION

Anatomy

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ABSTRACT

Introduction: Pain originating from heel has various causes- due to structural abnormality or pathological causes. Fowler Philip angle, Calcaneal inclination angle and Ruch's total angle are some radiological parameters which are playing very vital role in posterior heel pain.
Objective: Analytical study was conducted to find the significance of these radiological parameters in patients of posterior heel pain.
Materials and methods: After obtaining permission from Institutional Ethics Committee the case and control groups underwent lateral view X-ray of foot. Three angles were calculated from the radiograph and compared in respect to their sensitivity, % of false positive and negative.
Results: There was a significant relationship between case and control group for all the three parameters. Though significant but sensitivity of Fowler & Philip angle was found to be only 46.66%. The sensitivity of Calcaneal Inclination angle was highest (68%) and that of Ruch's total angle was 38.2%.
Conclusion: Calcaneal Inclination angle was found to be most reliable indicator of posterior heel pain among the three parameters.

KEYWORDS

Fowler Philip angle, Calcaneal inclination angle, Ruch's total angle.

INTRODUCTION

The heel has played a significant part in man's life from several stand points- physical, historical and rhetorical. The 'Achilles Heel' has long been a synonym for vulnerability, but the heel has also been the fulcrum of terrestrial action in man's evolution and achievement in civilization.

The Indian fore bearer had a lower heel with a small talus and calcaneum. This configuration favoured the lower long arch, which was not really the flat foot so often depicted. The heel has been made to function and expected to work efficiently regardless of the altered stresses inflicted by footwear. No other portion of human anatomy has been so exposed to civilization's needs or fashion's fads. Man's heel has continued to perform its vital role with relatively little objection [1].

Pain in the heel area varies from annoyance to a significantly disabling problem. Heel pain has multiple origins and it is imperative that a careful history and physical examination should be carried out to pin point the cause as precisely as possible. Heel pain may result from disorders of Achilles tendon, soft tissue disorder near heel, hind foot bone injury, bony prominence irritation, neurological disorders, biomechanical causes and systemic cause [2]. Pain emanates from four areas in the heel complex. Plantar and medial heel pain are much common than lateral and posterior heel pain.

Posterior heel pain is a common complaint in both the athlete and the non-athlete and a variety of pathological processes have been implicated as its cause [3].

Posterior heel pain i.e. pain when the Tendo-Achilles attaches to the calcaneum are mediated by Posterior Tibial nerve which ramifies in the area. Pain is experienced both on action and contaction as well as at rest. Direct pressure triggers a posterior calcaneal discomfort from the subcutaneous and the Tendo–Achilles attachment zones. The principal cause of posterior heel pain is almost always an action produced sensation; stretch irritation resulting from disrupted cord mechanics.
The causes of Posterior heel pain are broadly divided into local and systemic causes.

Fowler Philip angle, Calcaneal inclination angle and Ruch's total angle are some radiological parameters which are playing very important role in posterior heel pain.

The angle of Fowler and Philip described by Fowler A and Philip JE in 1945 was used to measure the angle formed by the intersection of a line tangential to the postero-superior surface of the greater tuberosity [4]. Ruch's JA described the influence of addition of Calcaneal Inclination angle on Fowler Philip angle on heel pain [5].

MATERIALS AND METHODS

Hospital based, Case control type of analytical (observational) study was carried out in North Bengal Medical College & Hospital among the subjects concerned. It was carried out to delineate three parameters for measuring the anatomical variation of calcaneus in case and control group concerned. The study was conducted during the period of May 2015- May 2016.

The study has been conducted in the department of Anatomy in collaboration with the department of Radiodiagnosis in this institute after obtaining permission from concerned departments, institutional authorities and the Institutional Ethical Committee.

Study was conducted among

- Subjects aged >18 years having heel pain due to local causes as case group and a control group matching with the case group in all basic parameters (age, sex, occupation) attending radiological OPD for X ray of lower limb other than foot.

Exclusion criteria

- Those patients unwilling to give consent.
- Patients of posterior heel pain due to pathological causes.
- Patients of posterior heel pain due to systemic causes like gouty arthritis, Rheumatoid arthritis.
- Patients with previous history of surgery in posterior heel
- Pregnant ladies with foot pain.

Patients referred to Radiology OPD having posterior heel pain were approached as cases and patients referred for X-ray of lower limb other than foot were taken as control. After getting the informed consent from the patient, demographical information and history of present illness surgical history and Medical history were noted in the format (Annexure No.1) by direct interview. After excluding those patients having exclusion criteria the remaining subjects were provisionally selected. The subjects thus provisionally selected underwent X-Ray (Lateral view) of affected foot [Figure 1]. The radiological measurements of various angles of foot were done. By the method of complete enumeration of the patients who fulfilled the inclusion criteria, a total of 50 patients (10 having bilateral heel pain, n=60) were examined as case group and 50 patients (examined bilaterally, n=100) were selected as control group. The following angles were measured in the X-ray plate.

Figure 1

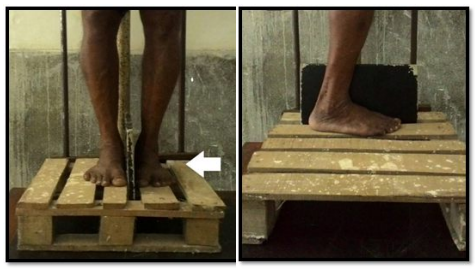

Figure 1: (A) Photograph demonstrating the technique standing weight bearing x ray of right foot from lateral view.

(B) standing weight bearing x ray of left foot from front where arrow is representing the x ray beam.

Fowler – Philip angle

The angles formed by a line tangential to the postero – superior surface of the greater tuberosity and another line tangential to inferior border of calcaneus [Figure 2].

Figure2: Measurement of Fowler- Philip angle.

In this figure Fowler Philip angle (a) is measured by an angle formed by line A tangent to postero-superior surface and a line B tangent to inferior border of calcaneus.

Calcaneal inclination angle

Intersection of the baseline tangent to the anterior tubercle and medial tuberosity with horizontal surface [Figure 3].

Figure 3: Measurement of Calcaneal inclination angle.

In the above figure Calcaneal Inclination angle (b) is measured by angle formed due to intersection of line B and line C.

Ruch's total angle

Summation of Fowler – Philip angle and Calcaneal Inclination angle [Figure 4].

Figure 4: Measurement of Ruch's total angle.

Summation of Fowler – Philip angle (a) and Calcaneal Inclination angle (b).

Groups	Symptomatic cases (n=50)	Asymptomatic Control (n=50)	Student's t test value P value
Mean	39.5	39	8.64 Not significant
Standard Deviation	16.2	12.9	

RESULTS

The range of age in case group was 18-80 years and in control was 22-67 years. In cases mean was calculated to be 39.52 ± 16.2 as against 39 ± 12.9 in control. The p value was calculated to be 0.864, hence statistically insignificant. [Table 1].

Table1: Relationship of Posterior heel pain with age

Table 2: Gender distribution of case and control groups

Gender	Case (n=50 Heels=60)	Control (n=50 Heels=100)
Male	21	26
Female	39	74

The mean Fowler & Philip angle in the case group was 69.05 ± 6.7 (62.35-75.75) and in control was 61.10 ± 4.3 (56.8-65.4). There was a significant difference of mean value between the two groups (p=0.000). 28 heels out of 60 heels in case group are abnormal (more than 75°) with sensitivity of the test being 46.6%. No heels were found positive in control group hence percentage of false positive is 0%. The percentage of false negative is 54% i.e. in 54% of cases the Fowler Philip angle was found to be normal. [Table 3].

Table 3: Relationship of Fowler & Philip angle and Posterior heel pain in case and control group

The Calcaneal Inclination angle in the case group was 18.65 ± 3.15 (15.5-21.8) and in control group was 13.4 ± 3.7 (9.7-17.4). There was a significant difference between case and control group as depicted by the p value =0.000. 41 heels out of 60 in cases were abnormal (more than 17°) with sensitivity of the test being 63.3%. 82 heels were positive in control hence percentage of false positive is 82%. The percentage of false negative is 31.6% i.e. 31.6% of cases calcaneal inclination angle was found to be normal. [Table 4].

Table 4: Relationship of Calcaneal Inclination angle and Posterior heel pain in case and control group

Fowler & Philip angle	Case (n=60)	Control (n=100)	t- test value	P value
Mean	69.05	61.10	7.24	0.000 (<0.000) Highly Significant
Standard Deviation	6.7	4.3		
Sensitivity	46.66%			
Percentage false positive	0%			
Percentage false negative	54%			

Calcaneal Inclination angle	Case (n=60)	Control (n=100)	T- test value	P value
Mean	18.65	13.4	8.04	0.000 (<0.000) Highly Significant
Standard Deviation	3.15	3.7		
Sensitivity	68.33%			
Percentage false positive	82%			
Percentage false negative	31.6%			

The Ruch's Total angle in the cases was 87.77 ± 7.6 (80.1 – 97.37) and in Control group was 74.5 ± 7.5 (67 - 82). There was a significant relationship between case and control group (p value =0.000). 23 heels out of 60 in cases group are abnormal (more than 89°) with sensitivity of the test being38.8%. 8 heels were positive in control hence % of false positive is 8%. The percentage of false negative is 61.6% i.e.

61.6% of the cases the angle was found to be normal. [Table 5].

Table 5: Relationship of Ruch's total angle and Posterior heel pain in case and control group

Ruch's total angle	Case (n=60)	Control (n=100)	T- test value	P value
Mean	87.77	74.5	9.17	0.000 (<0.000) Highly Significant
Standard Deviation	7.6	7.5		
Sensitivity	38.3%			
Percentage false positive	8%			
Percentage false negative	61.6%			

The mean, sensitivity, percentage of false positive and false negative of these three angles have been compared. [Table 6, Figure 5].

Figure 5: Diagrammatic representation of mean of various angles in both case and control group

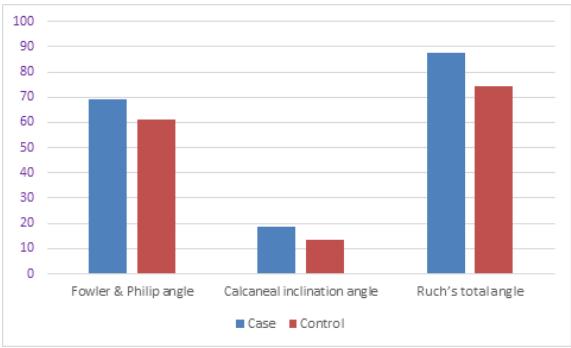

Table 6: Comparison of three angles in respect to their sensitivity, percentage false positive and percentage false negative

Angles	Sensitivity	Percentage false positive	Percentage false negative
Fowler & Philip angle	46.66	0	54
Calcaneal inclination angle	68.33	82	31
Ruch's total angle	38.3	8	61.6

DISCUSSION

Posterior heel pain is a common problem in all age groups out of which abnormal anatomy of calcaneus and cavus foot are important anatomical causes. Many methods have been studied to find the correlation between these anatomical causes and posterior heel pain namely Fowler Philip angle, Calcaneal Inclination angle, Ruch's total angle [4,5].

With the development of the recent concept in 1970 considerable progress has been made in understanding the developmental changes in morphological evolution [6,7]. In 1928 Haglund first attributed the deformity of postero-superior portion of calcaneus as a cause of posterior heel pain [8,9]. Fowler and Philip described an angle to measure the backward projection of calcaneus [4,10]. This angle was more than 75° in lateral radiography of a symptomatic heel. The Calcaneal Inclination angle was found to be an important cause of heel pain [11,12]. Ruch observed that the degree of calcaneal inclination will directly influence postero-superior heel prominence so he described a total angle for more accuracy which comprised of a sum of Fowler Philip angle and Calcaneal Inclination angle [5].

FOWLER AND PHILIP ANGLE

In radiological evaluation of the calcaneus for Fowler & Philip angle by Sharma SC et al there was 1 patient (2.5) with Fowler Philip angle more than 75°. There was thus no significant difference for this angle in case and control [4].Heneghan and Pavlov observed 100% false negative testing for Fowler Philip angle, Ruch and Fuglsang Troup observed 86%-88% false negative [4,5,13].

According to Cheng- Chang Lu et al, Fowler Philip angle in symptomatic group was 62.31± 7.79 and in control group was 60.14± 7.01 degree [14]. There was no significant difference between the two groups (p=0.49). 35 out of 37 heels did not meet the criteria for Fowler pathological criteria in the symptomatic group and the false negative rate was 94.6%.

Fiamengo SA et al observed 100% false negative and 62% false positive [15]. Similarly, Schneider et al also did not find the angle to be of importance [16].

In the present study Fowler Philip angle in symptomatic group was found to be 69.06± 6.7 degree and in control was 61± 43 degree. There was significant difference (p=0.000) between the two groups. 28 out of 60 subjects had Fowler Philip more than 75° and no angle was positive in control group. Thus though significant but its sensitivity was found to be only 46.66% with 54% false negative i..e 54% of cases were found to be normal though clinically they had posterior heel pain.

CALCANEAL INCLINATION ANGLE

In cavus deformity, the calcaneus is more vertical directly affecting the prominence of postero-superior aspect of the calcaneus predisposing to bursitis because of cavus foot [8]. Fuglsang and Troup found 57% of their study having cavus foot [13]. Moynou et al repeated a constant association of more than 12° of calcaneal angle with Haglund's disease [17].

Sharma SC found only 3 heels of 2 patients to be highly arched. The control group had slightly greater angle (23.20) than the symptomatic patients (20.82). This comprised 5% of high arched foot among the total subjects [18].

R Singh found calcaneal inclination angle to be 29.6% sensitive and 30% false positive and 70.4% false negative not agreeing with its contribution in diagnosis of posterior heel pain [19].

In the present study, Calcaneal Inclination angle in case group was 18.75± 3.16(15.5-21.8) and in control group was 13.4± 3.7(9.7- 17.4). There was a significant difference (p=0.000) between the two groups.41 out of 60 heels had more than 17° Calcaneal inclination angle and 82 out of 100 had Calcaneal Inclination angle more than 17°. The sensitivity was 68% and 31.6% was false negative among case group% i.e. 31.6% of cases calcaneal inclination angle was found to be normal (less than 17) though they had heel pain. Since this proportion is quite less of the total hence this angle seems to be a reliable indicator of posterior heel pain.

RUCH'S TOTAL ANGLE

According to Ruch'swhen Fowler Philip angle was added to Calcaneal Inclination angle there would be more accuracy, but according to R Singh Ruch's total angle had a sensitivity of 7.04% and 93% false negative [5,19].

Sharma SC found Ruch's total angle to be less significant (p= 0.27) with only 5 heels (12.5%) had an angle more than 90°[18].

In the present study Ruch's total angle calculated by summation of Calcaneal Inclination angle and Fowler Philip angle does not correlate much with the findings of Ruch and Vega et al according to whom symptoms increased with the correlation of heel pain with value more than 90degree. In the present study Ruch's total angle in case group was 87.77± 7.6 (80.1- 97.37) and in control group was 74.4± 7.5 (67-82) .23 out of 60 heels in case and 8 out of 100 in control group was found positive. Sensitivity being 38.2%, 8% false positive and 61.6% false negative.Hence this angle does not correlate much with the findings of previous studies.

SUMMARY

In our clinical practice, it has been seen that a large number of patients suffer from pain in the posterior part of heel associated with tenderness, erythema and odema. They have obvious prominence at the posterior part of their heel. In 1928 Haglund first drew attention towards this painful heel condition also known as Pump bump, winter heel, Albert's disease and Retrocalcaneal bursitis. This was followed by the development of new radiological angles by Fowler and Philip (1945), Ruch JA (1974).

A study was thus conducted at North Bengal Medical College where 50 cases were examined out of which 10 had bilateral heel pain and 50

bilateral control heels were examined to determine the relationship between posterior heel pain with the variation in shape and anatomical structures of calcaneus based on the above mentioned radiological angles and lines.

Considering the age group and sex it was found that in the present study, age of the patient was not influencing variation in calcaneal anatomy to cause posterior heel pain. Females were no doubt affected more than males in our study.

Considering the various angles:

1) **Fowler and Philip angle:-**
It was 46.6% sensitive and in 54% it was found to be normal though they had pain clinically, hence not very reliable.

2) **Calcaneal inclination angle:-**
Sensitivity 63.3% with 31.6% false negative thus making it appear as a reliable indicator.

3) **Ruch's total angle:-**
Sensitivity was 38.8% and 61.6% false negative, thus making it less reliable.

The present study result has been compared with the previous ones in table 7.

Table 7: Comparison of sensitivity of three radiological parameters of previous studies with the present one:

Name of the Author	Sensitivity Calcaneal Inclination angle	Sensitivity Fowler Philip angle	Sensitivity Ruch's Total angle
Fuglsang F,Torup D (1961) [13]	57%	86%	-
Sharma SC et al (2005) [18]	5%	-	12.5%
R Singh et al (2008) [19]	29.6%	-	7.04%
Pavlov H.et al (1982)[20]	-	100%	-
Ruch (1974) [5]	-	86%-88%	-
Lu CC et al (2007)[14]	-	94.6%	-
Fiamengo SA et al (1982)[15]	-	100%	-
Present study	68%	54%	38.2%

Hence to sum up Calcaneal inclination angle could be of importance while evaluating posterior heel pain radiologically but it has to be kept in mind that no single parameter gives 100% accuracy so these parameters should be treated as adjuncts to the case history and clinical examination of the patient for proper and effective treatment.

CONCLUSION

An attempt has been made to find out if there is any significance of these three angles in posterior heel pain and one parameter was found to be reliable, objective diagnostic indicator of bony deformity of calcaneus namely Calcaneal inclination angle. Increased Ruch's total angle is taking the least position of importance among the diagnostic parameters though their presence was found clinically and statistically significant. Hence, we can conclude that no single radiological parameter alone gives 100% accuracy; it is the combination of these bony parameters which enhance the diagnostic significance.

The angles were not much reliable in making decisions for surgery and it is important that the clinician diagnosis and treatment of posterior heel pain should be done according to clinical symptom and use these parameters as only auxiliary tools.

Hence the combination of changes in shape, inclination around calcaneus which can to some extent be calculated by the studied angles might be responsible for the posterior heel pain which is initially managed symptomatically by non operative care requiring surgical intervention only when there is lack of desired response.

LIMITATIONS OF THE STUDY

1.The sample size for Case (sample 1) was 50 with n=60 (40 unilateral and 10 bilateral posterior heel pain). For Control (sample 2) sample size was 50 with n=100 (50 bilateral). Thus, maintaining the ratio of Case: Control of 1:1. Hence the statistical significance of the result was comparable with similar studies only.

2.Exact documentation of distribution of body weight equally on two limbs during taking standing X ray could not be done due to lack of such instruments.

3.There might be age subjective variation during study because the observer had to depend fully on the statements of the subject.

4.During this study only bony parameters which are commonly measured in day to day practice were considered, further study taking other soft tissue parameter and bony calcification cam be done namely: Planter spur, Posterior calcaneal step, Calcaneal length, Test of Denis& Huber- Levernieux, Achilles tendon calcification. Soft tissue parameters are Retrocalcaneal recess, Achilles tendon anterior-posterior diameter, Superficial tendo Achilles bursa.

5.Further accuracy in diagnosis can be achieved by taking additional views beneficial for specific presentation.

i. Calcaneal axial view for frontal plane curvature within body of calcaneus.
ii. Modified Calcaneal axial view for location of the calcification and exostoses on posterior surface of heel. This view can be taken by ankle dorsiflexed and heel on the ground with the tube 90° to the plate and angled parallel with posterior calcaneus.

This view provides excellent visualization of the middle and superior third of the calcaneus for the evaluation of Retrocalcaneal and Intra tendinous calcification.

6.This study leaves a window for study of these angles by advanced radiological techniques and imaging modalities like CT scan and MRI which will be beneficial for additional visualization of calcaneal and Achilles tendon pathology. These advanced modalities are adjuncts to clinical and Radiological evaluation.

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