

A CROSS-SECTIONAL STUDY OF TRABECULAR PATTERN OF CALCANEUS THROUGH HIGH RESOLUTION RADIOGRAPHS IN NORMAL & MENOPAUSAL WOMEN

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Abstract

Background: Human skeletal bones are having different distribution of cortical & trabecular bone. Arrangement of bony elements of trabecular bone mainly influenced by line of stress on that particular bone during weight bearing. Many investigators were interested to reveal this wealth of architectural variety. Trabecular pattern of the calcaneus is comprised of 5 trabecular lamellae and Ward's neutral triangle enclosed within trabeculae. This trabecular pattern is influenced by various factors like age, sex, hormones & disturbances in calcium metabolism. Present study is aimed to find out the influence of hormones on trabecular pattern of calcaneus with the help of high-resolution radiographs as fracture of this bone accounts to 2% of all the fractures & 60% of tarsal fractures. **Materials and Methods:** With consideration of inclusion & exclusion criteria total 50 high resolution radiographs of lateral view of ankle joint of patients between 25-35 years & 50-60 years each, had been collected. Images were procured from PAX database & information about patients retrieved from medical records. Comparison of 5 types of trabecular pattern & Ward's triangle of calcaneus in normal & menopausal women was done. Qualitative analysis of trabecular pattern & Ward's triangle was done with the help of graphs & pie chart. Quantitative analysis of modified calcaneal index was done by applying Chi square test & p-value was calculated. **Result:** In reproductive age group, trabeculae like tendotuberosity trabeculae, primary compressive & tensile trabeculae were seen in all images. Secondary compressive trabeculae were absent in 9(18%) and secondary tensile trabeculae in 3(6%) radiographs. In menopausal age group secondary compressive trabeculae was absent in 32(64%), secondary tensile trabeculae in 28(56%), primary tensile trabeculae in 22(44%), primary compressive trabeculae in 18(36%) and tendotuberosity trabeculae in 7(14%) radiographs. In menopausal age group large size Ward's triangle was observed in 44% radiographs, medium size in 32% of the sample and in the remaining 24% it was of small size. In reproductive age group only in 8% Ward's triangle was medium size and the remaining 92% were having small size triangle. Grading of calcaneal index done for both the groups. For statistical analysis we combined grade I & II and IV & V. Chi square test applied and p-value was calculated. p-value was significant for the calcaneal index. **Conclusion:** The present study would help us to understand the biomechanics & its relation with disappearance of compressive & tensile trabeculae with age in female. It is hoped that the present study will enlighten in designing & development of prosthesis for the ankle in managing the conditions associated with calcaneum.

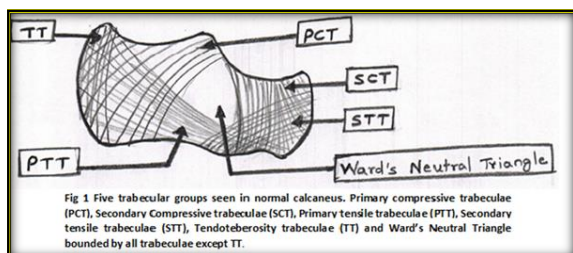
INTRODUCTION

Human skeletal bones are having different anatomical structure. This is due to difference in the

distribution of cortical & trabecular bone. Among mammals, man has got peculiar arched structure of foot. Till now many investigators got interested to know the complexity of cancellous bones of foot.

Study of surface features of each tarsal bone with its internal architecture is essential to know its role in dynamics of the foot pertaining to weight transmission while locomotion.^[1] Stress experienced by each tarsal bone during weight transmission will be reflected in arrangement of trabeculae within the bone.^[2] Study of trabecular pattern is helpful to understand the pattern of weight transmission & probable site of fracture in case of extra stress experienced by each bone.^[3] This trabecular pattern is influenced by various factors like age, sex, hormones & disturbances in calcium metabolism.^[4] Present study is aimed to find out the influence of hormones on trabecular pattern of calcaneus with the help of high-resolution radiographs as fracture of this bone accounts to 2% of all the fractures & 60% of tarsal fractures.

Trabecular pattern of each bone is influenced by two force- compression & tensile force. These two forces act at right angle to each other & meant to sustain the impact experienced by each bone during locomotion.^[5] Trabecular pattern of the calcaneus is comprised of 5 trabecular lamellae as shown in figure no. 1. The primary compressive trabeculae (PCT) extend from subtalar surface to posterior and plantar surface. Secondary compressive trabeculae (SCT) extend from subtalar surface to anterior part of plantar surface. The primary & secondary tensile trabeculae (PTT & STT) extend from calcaneal tuberosity & anterior surface of calcaneus to anterior plantar surface respectively. The tendotuberosity trabeculae (TT) run parallel to posterior surface of calcaneus.^[2,5] Ward's Neutral triangle is a region in the calcaneus with sparse mineralization & relative hypodensity of trabecular bone.^[4]



Osteoporosis means decreased bone mineral density, is one of the chronic disease commonly seen in post-menopausal women.^[3] Metabolic changes are more obvious in trabecular bone because of its larger surface area compared to cortical bone. Age, race, menopause, genetic- factors, calcium & medication use are some of the risk factors affecting composition of bone tissue.^[6] Mineralization of trabecular bone is strongly related to continuous mechanical stress. Bone mineral density (BMD) will be more in bones involved in body weight transmission in locomotion. Calcaneus can be taken as good indicator of demineralization.^[7] Uneven bone resorption happens because of age related risk factors. For females bone resorption in calcaneus

starts from 35 years of age at the rate of 1.2% in a year. This becomes intense at the 60 years of age.^[8] The attenuation of trabecular bone volume differs with ageing & sex. Evidence suggests that women tend to lose trabecular number & men tend to lose trabecular thickness with advancement of age.^[9] Human calcaneal trabecular structure is complex & varies in anatomical region. It is found to have highest trabecular thickness & bone volume ratio inferior to talocalcaneal joint with highest trabecular number in its posterior region.^[10]

MATERIALS AND METHODS

Present cross-sectional study was conducted by collecting retrospective data from radiodiagnosis department of SDM medical college & hospital Dharwad. Total 50 high resolution radiographs of lateral view of ankle joint of patients between 25-35 years & 50-60 years each, had been collected. Images were procured from PAX database & information about patients retrieved from medical records.

Selection of patients done by applying inclusion & exclusion criteria. Institutional ethical committee approval was taken to conduct the study.

The study population

Inclusion criteria

1. Women patient between 25-35 years & between 50-60 years.
2. Women patient with history of natural menopause.

Exclusion Criteria

1. Women patient with previous history of fracture of foot bones.
2. Women patient on medication which can affect calcium metabolism in the body.
3. Women patient with hormonal supplement.

Statistical Analysis

Chi square test was applied for the calculation of modified calcaneal index.

Method

All radiographs were evaluated for trabecular pattern of calcaneus and presence or absence of Ward's triangle. Modified calcaneal index was used for p-value calculation.

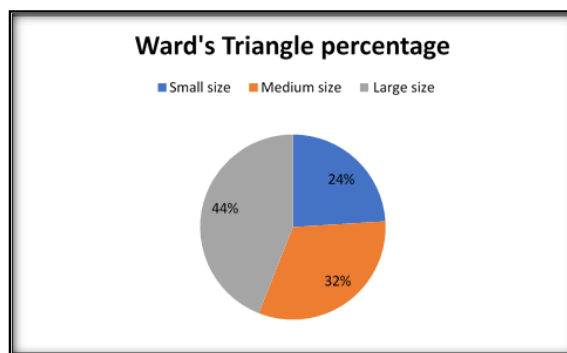
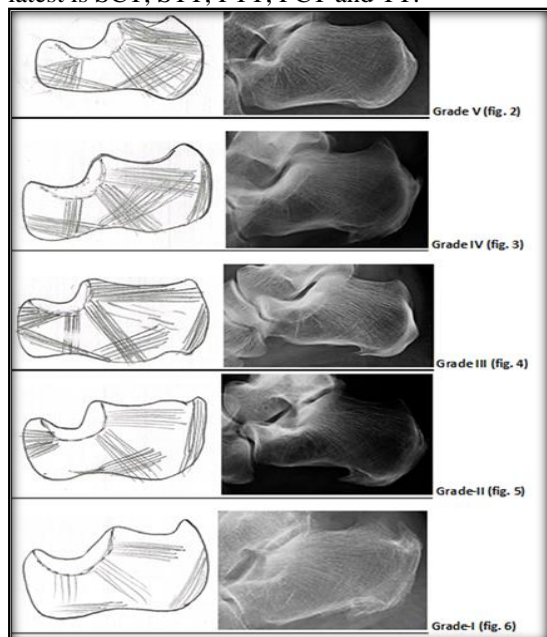
Calcaneal index was graded into five grades as described by Jhamaria et. al. ^[6] For statistical analysis modified calcaneal index was used as per Pande et. al.^[11] [Table 1] They have combined group I & II under one category. Similarly group IV & V under one category.

RESULTS

In reproductive age group, trabeculae like TT, PCT & PTT were seen in all images. SCT were absent in 9(18%) and STT in 3(6%) radiographs. In menopausal age group SCT was absent in 32(64%),

STT in 28(56%), PTT in 22(44%), PCT in 18(36%) and TT in 7(14%) radiographs. [Table 2]

From the graphical representation shown in [Figure No. 7], order of disappearing trabeculae earliest to latest is SCT, STT, PTT, PCT and TT.



As Ward's triangle bounded by all trabeculae, disappearing of these trabeculae will result in increase in the size of Ward's triangle. In menopausal age group large size Ward's triangle was observed in 44% radiographs, medium size in 32% of the sample and in the remaining (24%) it was of small size. In reproductive age group only in 8% Ward's triangle was medium size and the remaining 92% were having small size triangle.

Grading of Calcaneal index done for both the groups. For statistical analysis we combined grade I & II and IV & V. Chi square test applied and p-value was calculated. p-value was significant for the calcaneal index. [Table 3]

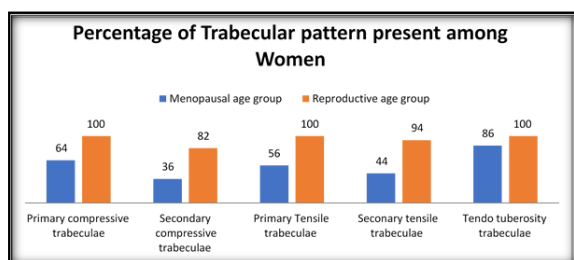


Table 1: Grading of trabecular pattern of Calcaneus

Sr. No.	Grade	Criterion for Grading
1.	V	Normal. All 5 types of trabeculae are well demarcated.
2.	IV	Normal. All 5 types of trabeculae are well demarcated except radiolucent area in the middle part of the PCT making it appear as two pillars.
3.	III	Borderline. In addition to Grade IV findings, there is reduction in the extent of PTT crossing anterior pillar of PCT.
4.	II	Osteoporotic. In addition to Grade III findings, thinning of PTT & absence of STT.
5.	I	Severely osteoporotic. Reduction in the number & thickness of compressive trabeculae. Total absence of tensile trabeculae.

Table 2: Trabeculae & their percentage in two groups

	Menopausal age group		Reproductive age group	
	Yes N (%)	No N (%)	Yes N (%)	No N (%)
Primary Compressive Trabeculae	32 (64%)	18 (36%)	50 (100%)	0 (0%)
Secondary Compressive Trabeculae	18 (36%)	32 (64%)	41 (82%)	9 (18%)
Primary Tensile Trabeculae	28 (56%)	22 (44%)	50 (100%)	0 (0%)
Secondary Tensile Trabeculae	22 (44%)	28 (56%)	47 (94%)	3 (6%)
Tendo Tuberosity	43 (86%)	7 (14%)	50 (100%)	0 (0%)

Table 3: Calcaneal Index

Status		Grades				Chi square Test	P value
		I & II	III	IV & V	Total		
Menopausal Age group		28	16	6	50	68.612	0.0001
		56.0%	32.0%	12.0%	100.0%		
Reproductive Age group		0	3	47	50		
		0.0%	6.0%	94.0%	100.0%		
Total		28	19	53	100		
		28.0%	19.0%	53.0%	100.0%		

DISCUSSION

DN Sinha studied trabecular pattern of all tarsal bones with the help of surface photographs of their cut sections. According to their observation calcaneus had a very thin outer layer of compact bone with presence of compression trabeculae & tension trabeculae at right angles to each other. In this study they found that at place of intersection of trabeculae the cancellous architecture was fine & delicate but below the posterior articular facet coarse & irregular trabeculae was present. In man trabecular disposition in the bones of the lower limb will start when child starts weight bearing as mechanical requirement of the bone plays major role in it.^[1] Pressure and tension lamellae present in any cancellous bones is seen in calcaneus, cuboid, navicular and intermediate cuneiform while in other tarsal bones these lamellae were not organised.^[12] According to Mergim Bajraliu et. al. Ward's neutral triangle was developed because of evolution of foot according to the functional needs of human beings.^[2] Best et.al. studied on trabecular pattern in runners and found observed thicker calcaneal trabeculae. They also found inverse correlation between trabecular thickness & age at which they begin. They concluded that trabecular number is determined in early life & does not form as result of bone functional adaptation in later life.^[13] Inderbir Singh (1978) studied architecture of cancellous bone in macerated human bones. Accordingly, they made types and subtypes of cancellous structure of bone depending on their architecture. Calcaneus fall into subtype IIb.^[12]

The architecture of all bones of body are subjected to reduction in bone mineral density due to various factors are happening at different stages of life at different rates. Decrease in BMD will increase fracture risk in individual. E. Jagelaviciene et. al. observed statistically significant relation between calcaneal BMD and patient's age but they couldn't get same relation between calcaneal BMD & mental index.^[3] Results of a study by Jhamaria et. al. shows that with increasing age there is decrease in calcaneal index, it also states that changes in trabecular pattern can be utmost important index for diagnosing as well as grading of osteoporosis.^[6] In our study p value was statistically significant for calcaneal index indicating same relation. Calcaneal index was determined by the trabecular pattern in calcaneus. In our study we also observed changes in the pattern of trabeculae as age advances. Age-related risk factors lead to uneven bone resorption. In females from the age of 35 years onwards calcaneal BMD begins to reduce & to be continued to entire post-menopausal period. By the age of 60-70 years resorption occurs in cortical bone slowly to involve the entire calcaneal bone.^[16]

In a study done on trabecular pattern on femur by Veena Vidya Shankar et.al. observed SCT was first to disappear around menopausal age group & PCT

last to disappear.^[17-25] Our observation was also similar to their observation.

Kullenberg and Falch used tripartite model (bone, muscle, adipose tissue) to determine sensitivity and specificity of portable dual energy X-ray and laser (DXL) Calscan in prognosticating OP. They come to conclusion that DXL Calscan device is reliable in the diagnosis of post-menopausal OP and for choosing preventive measures.^[14] Early diagnosis of OP in post-menopausal women and timely intervention will definitely help to improve the quality of life.

Limitations

This study failed to find a sex-specific difference in trabecular pattern of calcaneum as the present study was done only in females.

CONCLUSION

The present study would be of at most help in better understanding of the changes in the trabecular pattern of calcaneum in menopausal age group as calcaneal fractures accounts to 60% of all tarsal fractures. It also helps to understand the biomechanics & its relation with disappearance of compressive & tensile trabeculae with age in females. It is hoped that the present study will enlighten in designing & development of prosthesis for the ankle in managing the conditions associated with calcaneum.

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