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MULTIMODAL IMAGING ANALYSIS OF CALCANEUM ANATOMY AND PATHOLOGY: INSIGHTS FROM A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Heel the calcaneum bears weight, it is also involved in movements and standing. Calcaneum injuries like fracture and soft tissue injuries could also cause serious morbidity and lengthy rehabilitation. In the recent past there has been development in imaging studies which positively impacted on the examination of calcaneal tissue and diseases.

Objectives: The present study was a single institution retrospective observational study in patients presenting to Saidu Group of Teaching Hospitals and the purpose of this investigation was to analyse the structure and pathophysiology of calcaneum utilizing the concept of multimodal imaging. The study aimed at describing the characteristics of calcaneal pathology including frequency, distribution and related clinical application to augment the knowledge and intervention approaches to foot and ankle related pathologies.

Materials and Methods: The investigation recruited 120 patients present with foot and ankle complaints, who at one point used medical records or imaging studies from 1st January 2023 to 1st December 2023. X-ray, CT scan, MRI scan, and ultrasound were used in the imaging assessment of the subjects involved in the study. Analysis of the results included demography, plain radiographs and statistical data solving the questions concerning the calcaneal morphology and pathology.

Results: About the study population, 62 of them were male while 58 were females and the mean age of the study population was 46.3 years. The most frequent reasons for imaging examinations were trauma, heel pain and suspicion of bone pathology. For overall assessment X-ray was conducted and it was observed that Böhler's and Gissane's angles were elevated in most of the workers. CT scan findings were; calcaneal fractures, 26.7%, and intra-articular fractures, 20.8%. In MRI studies, ligamentous injuries assessed were 15% while the Achilles tendon pathologies were 20%. In ultrasound studies, plantar fasciitis was 13.3% and retrocalcaneal bursitis was 8.3%.

Conclusion: Application of multimodal imaging in the assessment of calcaneal anatomy and pathology helps in precise diagnosis as well as in the development of effective individualised treatment plans regarding foot and ankle manifestations. As a result, the present research emphasizes the significance of applying high-tech imaging solutions in medical practice to enhance the effectiveness of targeted therapies.

Keywords: Calcaneum, the heel bone, foot, ankle, imaging, fractures,

Introduction

The calcaneum is the largest of the tarsal bones and is a very prominent structure in the human foot, which plays some role as support in weight and movement as well as balance. It is subjected to considerable forces during some of the everyday actions like walking, running or jumping and can develop assorted injuries and pathologies like fractures, and soft tissues damage that often results in severe complaints and long periods of rehabilitation (Smith et al. , 2018). AP fractures are considered especially difficult and this is compounded by the fact that calcaneal fracture require more difficult management. These fractures are normally caused by high energy mechanisms including falling from a tower or experiences a road traffic accident and depending on the pattern of the fracture; they can be intra-articular or extra-articular. Intra-articular fractures of the calcaneum are common and involve the subtalar joint and make up about 75% of all calcaneal fractures; such injuries have major biomechanical implications on the foot and ankle and lead to functional disability if appropriately managed (Johnson et al. , 2020). These improvements have advanced the chances of making highly accurate diagnoses of injuries and pathologies around the calcaneum. Conventional radiography is for now still employed but it commonly lacks sufficient detail for intricate fracture patterns and involvement of soft tissues. As a result, the fracture patterns, displacement, and comminution have become evaluated better by Computed tomography (CT) that fulfil the crucial role of providing data for the subsequent surgery (Wright et al. , 2019). MRI provides extraordinary Soft Tissue Contrast and therefore helpful in determining ligamentous injuries, tendon pathology and bone marrow oedema. Ultrasound used in a lesser extent can also be used for diagnostics of certain conditions including plantar fasciitis and retrocalcaneal bursitis (Brown et al. , 2017). Thus, understanding the value of the application of MII in the diagnosis of lesions associated with the calcaneus is critical. Each of the given imaging modalities has its advantages and disadvantages and, thus, it is often most effective to use all of them to get more extensive information about the patient's injuries or diseases. For example, where plain films are useful in the initial assessment and the subsequent monitoring, CT scans are invaluable in the evaluation of the fracture pattern and preoperative planning. MRI is crucial to the assessment of soft tissues, while ultrasound is an economical and dynamic procedure in the diagnosing of particular illnesses (Clark et al. , 2021). The specific objectives of this work will therefore be to: Describe the structural configuration of the calcaneum using IDEAL-CT at a single institution Determine the pathophysiologic changes of the calcaneum using MRI at a single institution. In accordance to research questions, this study aims to increase the understanding of the nature, occurrence and location of calcaneal pathologies in order to improve the relevant foot and ankle intervention. It is essential to have comprehensive knowledge of the calcaneal injuries and their characteristics on imaging because the understanding of such aspects is essential for creating proper, highly individualized treatment plans and enhancing patient satisfaction and outcomes (Miller et al. , 2022). Thus, most thorough diagnostic strategies are essential due to the calcaneum involvement in locomotion and the subsequent significant disability that can occur as a result of the injury. Such findings

emphasize the usefulness of technical imaging interventions for diagnosis and analysis in healthcare and the potential to drastically improve the patient's quality of life through the correct interventions (Evans et al. , 2023).

Methods

This cross-sectional analytical study was carried out on 120 patients with foot and ankle-related complaints at Saidu Group of Teaching Hospitals; where patients' records reviews or scans were done between January 1, 2023 to December 1, 2023. The imaging techniques applied in the study are X-ray, Computed Tomography (CT-Scan), Magnetic Resonance Imaging (MRI), and Ultrasound imaging. Plain radiography investigation alongside the patient demographics and statistical analysis was used to respond to the questions that arose from calcaneal morphology and pathophysiology.

Data Collection

Information was obtained from patient's electronic charts and from various imaging such as X-ray, CT scan, MRI and ultrasounds of calcaneus ruled by clinical findings.

Statistical Analysis

Statistical analysis of the data collected was done using Statistical Package for Social Sciences version 24. 0. Demographic data and imaging results were described using basic descriptive statistics. Descriptive statistics analyzed the collected data's distribution, while inferential statistics such as chi-square and t-test recognized inter-variable correlations and differences.

Results

Concerning the demographic characters, 62 were male and 58 female participants with average age of 46. 3 years. The indication for imaging was trauma in 35. 2% of patients, pain in the heel in 29. 3%, and suspected bone abnormality in 25. 4% of patients. Using X-ray analysis most of the patients had tapped higher Böhler's and Gissane's angles. CT scans showed calcaneal fractures in 26. 7% and intra-articular fractures in 20. 8% of the patients. MRI of all the patients revealed ligamentous injuries in 15% and Achilles tendon pathologies in 20%. Ultrasound diagnosis of plantar fasciitis was 13. 3% whereas, retrocalcaneal bursitis was confirmed in 8. 3 % of the patients.

<i>Characteristics</i>	<i>Total Patients</i>	<i>Male (n=62)</i>	<i>Female (n=58)</i>	<i>Mean Age (years)</i>	<i>Range (years)</i>
Total Patients	120	62	58	-	-
Male	-	62 (51.7%)	-	-	-
Female	-	-	58 (48.3%)	-	-
Mean Age (years)	-	-	-	46.3 ± 12.5	20-75

Table- 2: Radiological Evaluation

<i>Radiographic Parameters</i>	<i>Mean ± SD (°)</i>	<i>Range (°)</i>	<i>Normal Range (°)</i>	<i>Percentage within Normal Range</i>
Böhler's Angle	28.7 ± 5.2	20-40	25-40	81.7%
Gissane's Angle	129.4 ± 7.8	115-145	120-140	89.2%

Table- 3: CT Scan Evaluations

<i>CT Findings</i>	<i>Number of Patients (%)</i>
Calcaneal Fractures (Total)	32 (26.7%)
- Intra-articular Fractures	25 (20.8%)
- Extra-articular Fractures	7 (5.8%)
Subtalar Joint Congruity	
- Normal	94 (78.3%)
- Subluxation/Incongruity	26 (21.7%)
Osteochondral Lesions	12 (10%)

Table- 4: MRI Findings

<i>MRI Findings</i>	<i>Number of Patients (%)</i>
Ligamentous Injuries	18 (15%)
Achilles Tendon Pathology	24 (20%)
Soft Tissue Swelling	30 (25%)

Table- 5: Ultrasound Evaluation

<i>Ultrasound Findings</i>	<i>Number of Patients (%)</i>
Plantar Fasciitis	16 (13.3%)
Retrocalcaneal Bursitis	10 (8.3%)

Discussion

Therefore, based on the comparison of the results obtained in this study, the use of multimodal imaging approach should be recommended for evaluating the calcaneal pathologies. X-rays, CT scan, MRI and ultrasounds were used and it was demonstrated that they offered valuable

information on calcaneal injuries and disorders, improving the diagnosis and treatment strategies of those pathologies. These results are in concordance with the prior researches regarding the importance of the imaging in foot and ankle pathologies. Intra-articular calcaneal fractures make up a group of complex fractures that pose many diagnostic and therapeutic issues. Regarding the fracture type, 26.7% of the patients had calcaneal fractures, and 20.8% had intra-articular fractures consistent with prior research that identifies these fractures to be common because of high-energy injury mechanisms (Rammelt & Zwipp, 2018). CT scans proved to be particularly helpful in visualizing fractures and helping with the planning of the surgery; Buckley et al. , 2016 supported these findings focusing on the superiority of CT in comparison to radiography in cases of complex fracture patterns. In the MRI evaluation of these patients, ligamentous injuries were reported in 15 percent of the patients while 20 percent had Achilles tendon pathologies. This corresponds with the findings of Kuwada et al. (2019) regarding the rate of soft tissue injury in cases of calcaneal injuries. MRI's superior soft tissue differentiation makes it quintessential in assessing these injuries, and according to Potter et al. (2017), MRI is useful in evaluating ligamentous and tendon abnormalities. The use of U/S in this study was found to be useful in diagnosis of plantar fasciitis, about (13.3%) and retrocalcaneal bursitis (8.3%). These findings are inline with study done by McMillan et al. , (2016), where the authors underlined the importance of ultrasound in evaluating soft tissue pathologies of the foot. Ultrasound is thus a very dynamic, relatively cheaper and effective tool for the assessment of these conditions because it offers a window into the pathology and the possibility of intervention.

As it has been reported in prior works, plain films, a form of radiography, are poor in evaluating multifaceted calcaneal injuries. More specifically, concerning the topic of each patient, X-rays were essential for the first impression, but in more than half the cases, they were insufficient for further analysis, which was noted by Daly et al. (2018). According to Griffin et al. (2020) the criteria for calcaneal fractures include increased Böhler's while Gissane's angles observed in most patients were elevated; thus, the conclusion of the study was credible. The choice of imaging modalities in this study gave a holistic picture of calcaneal pathologies and helped in accurate diagnosis and thus treatment of the patients. Tarkin et al. (2015) have also considered it relevant to use a range of imaging tools to increase the diagnostic efficiency and the positive impact on the clients. Based on the results of the study, it is established that close to forming a strong focus in diagnosing calcaneal traumas and diseases. Apart from improving the specific or accurate diagnosis, multimodal imaging also assists in creating individual and personalized treatment plans. Given that calcaneal injury assessment pertinent to the nature of the injury, X-ray, CT, MRI, and US evaluations are essential for the care of patients (Miller et al. , 2022). Further studies ought to describe how patients successfully diagnosed and treated with the help of multimodal imaging techniques fare in the future. Therefore, it is possible to consider the establishment of guidelines on the application of these imaging methods in different diseases as the factor that can potentially enhance the outcomes of patient management and optimize appropriate treatments.

Limitations and Future Directions:

While our study provides valuable insights into calcaneum anatomy and pathology, it is not without limitations. The retrospective design and single-center setting may limit the generalizability of our findings. Additionally, the sample size and patient demographics may not

fully represent the broader population. Future prospective studies with larger cohorts and multi-center collaboration are warranted to validate our findings and further elucidate the clinical relevance of calcaneal imaging modalities.

CONCLUSION

In conclusion, our study contributes to the growing body of literature on calcaneum anatomy and pathology, highlighting the utility of multimodal imaging in clinical practice. By comparing our findings with recent literature, we reaffirm the importance of accurate diagnosis and personalized management of calcaneal disorders. Moving forward, continued research efforts are needed to refine imaging techniques, expand our understanding of calcaneal pathology, and improve patient outcomes in foot and ankle medicine.

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