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Original Article

Calcaneum talar facets, its diagnostic and clinical relevance to fracture

Fazal ur Rehman

Department of Anatomy, Jawahar Lal Nehru Medical College, Aligarh Muslim University, Aligarh, 202002, India

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ABSTRACT

Introduction: Calcanei are classified into three to five patterns according to the number of superior articular facets present. As reported earlier the relative distribution of facets pattern varies with race and sex. Study of the calcaneal talar facets variation is important because it influence subtalar joint stability and knowledge of facets is essential while correcting foot deformities and for placing the screw in fracture fixation by orthopaedic surgeons.

Material & method: For this study sixty calcanei of human cadaver were procured from various sources. The calcanei were observed for patterns of the talar articular facets and the separation between the facets.

Result: In this study, only three patterns were described. Pattern I calcanei bear three facets for the talus, Pattern II calcanei bear two and Pattern III calcanei a single facet only. This study is important with the view that fracture involved facet and lead to decrease in calcaneal axial length.

Discussion: An understanding of the complex surgical calcaneal anatomy begins with a 3-D appreciation of the multiple articulations and bony processes. Calcaneal reconstruction is predicted on the restoration of the articular surfaces especially the posterior facet, appropriate reconstruction of the 3 dimentional spatial relationship between three articular facets is of paramount importance. Nature of calcaneal bone (spongy or dense) is important for orthopaedic surgeon in fracture fixation, calcaneum is harder beneath the posterior facet. Distance between anterior and middle facet is important for calcaneal lengthening osteotomy without violating the subtalar joint.

1. Introduction

Calcaneum is the largest of the tarsal bones, with its long axis inclined upwards and laterally.In anterior one third of the calcaneum, there are anterior and middle facets for articulation with the head of the talus.[1] In middle one third of the superior surface of the calcaneum, there is an oval shaped posterior facet for articulation with the body of the talus. Between the posterior and middle facets, the tarsal tunnel and sinus tarsi are placed. Calcanei are classified into three patterns according to the number of superior articular facets present. Pattern I calcanei bear three facets for the talus, Pattern II calcanei bear two and Pattern III calcanei a single facet only. As reported earlier the relative distribution of pattern I and pattern II bones in any given sample varies with race and sex.[2–5] The inside of the calcaneus consists of spongious bone except beneath the posterior facet; this part of the calcaneusis harder and called the thalamic portion. The thicker cortical bone is over the sustentaculum tali (4 mm) and under the angle of Gissane. The bonewhich is lateral and inferior to the calcaneal thalamic partlacks trabecula and radiologically resembles a cyst iscalled the neutral triangle.The movements of the calcaneum are integrated in the subtalar and transverse tarsal joint. Study of the calcaneal talar facets variation is important because it influence subtalar joint stability and isalso essential for orthopaedic surgeons while correcting foot deformities (pes planus)[6] and for placing the screw at the time of fracture fixation.The purpose of this study was to identify the dominance of pattern of facets in individual'sbased on distinction between anterior and middle calcaneal facets and the distance between the two facets, from orthopaedics surgical procedure point of view. Calcaneal lengthening osteotomyby Mosca, is extra-articular, with its site being the interval between the anterior and middle calcaneal facets. For individuals without a distinct anterior and middle facet, the subtalar joint must be violated to perform this operation. In those with discrete facets, an osteotomy begun between 11.5 mm and 15 mm from the calcaneocuboid joint should pass between the anterior and middle facets and avoid damaging these articular surfaces. This information may aid the foot and ankle surgeon in patient selection and in attaining optimal surgical outcome for the Evans lateral column lengthening procedure.The calcaneum is the most frequently injured tarsal bone. Even though

E-mail address: fazalorth12@gmail.com (F.u. Rehman).

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calcaneal fractures occurred in 2% of patientsthey represent 60% of all tarsal fractures, and of an increasing number of fractures due to traffic accidents with unpredictable outcome approximately 75% of these injuries are intra-articular with sub talar joint involvement.[7,8] Although a talocalcaneal coalition may occur at any of the three facets, the majority of the osseous fusions involve the middle facet. It was seen that there was 100% involvement of posterior talocalcaneal facet in intra-articular calcaneal fractures.[9] Almost all fracture occurs due to an axial load such as a fall from a height or a motor vehicle accident, about 10% of patients will have a spine fracture as well due to the axial load and almost 10% of injuries are bilateral and less than 5% are open. Many calcaneal fractures are work-related, as they result from a fall from height, especially in male's age 35–45 years. These fractures frequently result in long-term disability with potentially severe economic impact on the patient. The medial wall of calcanei is thicker with sustentaculum tali, and fracture line is always passes behind it. During a fall, the axial load is applied; the oblique fracture line is caused, dividing two main fragments: sustentacular - constant fragment and tuberosity fragment (Fig. 1). Due to its strong talocalcaneal interosseousligament, the sustentaculum fragments are not significantlydisplaced and its position is stable, whereas the tuberosityfragment is displaced laterally. Further,continuous injury force develops the secondary fractureline creating the "thalamic fragment" with depressedposition of the posterior subtalar facet. If the fractureline ends superiorly into the posterior facet, this is "centraldepression type fracture", whereas if the fracture line exits posteriorly, involving the entire posterior process, it iscalled the "tongue type fracture". This central fragment displaces the spongious bone widening the lateral calcanealwall with further calcaneofibular impingement andpossible peroneal tendon entrapment. The lateral wall is thin and this fracture is of comminute type. The tuberosity fragment tilts into varus position, while the Achilles tendon pulls it proximally. But now aday's with proper classification, new imaging and fixation devices and indication for certain surgical procedures have led to the improved outcome. Besides x-rays, Computed tomography (CT) scan has become a routine tool for evaluating the three-dimensional anatomy of the injury. Reconstructed images are obtained in coronal, transverse, and sagittal planes. CT can be helpful for (1) preoperative planning, including deciding whether to proceed with surgical fixation or primary fusion; (2) intraoperative decision-making with regard to fracture reduction and orientation ofhardware;Studies have suggested that the anatomic reduction of calcaneal fractures is important for feet and ankles functional outcomes, and the purpose of treatment for calcaneal fractures is to restore the height, length, width and axis of the calcaneus and articular facet congruency.[10–14] The integrity of calcaneal anatomic morphology is of clinical importance, to maintain normal function of the hindfoot, supporting modality of the arch, and to ensure stress conduction for weight bearing.[12–16] Gissane's and Böhler's angles were the commonly assessed angles in calcaneal fractures. They could give information on the severity of the injury especially; the restoration of Böhler's angle is an important prognostic factor that is correlated with outcomes.[12,16] The Bohler's angle (20-40°) is formed by the two lines -1st drawn from superior margin of posterior facet to superior margin on anterior process and 2nd line is drawn from superior margin of posterior facet to superior margin of tuberosity.[17] The angle of Gissane (100°) is formed by the two lines that are drawn on the lateral cortex of the posterior facet and anteriorly to the anterior process of the calcaneus.

Gissane's angle was formed by the posterior facet and anterior facet and the normal value was between 120° and 145°.[7] Restoring the relationship of the articular surfaces required the reconstruction of Gissane's angle. Reduction of the anterior process followed by the posterior facet allows fracture fragments to be easily manipulated into an anatomic position via the extensile lateral approach.[18] Reduction of the anterior process distal to Gissane's angle is important in restoring lateral column length. The calcaneal axial length sometimes shortens in the intra-articular calcaneal fractures or the compression type of anterior process fractures. For simple injury patterns such as Sanders type IIA and IIB fractures, percutaneous reduction and screw fixation is an optional method.[13] Therefore, the calcaneal axial length is not only helpful for diagnosis, but also for deciding the size of axial screws during surgical procedures (Fig. 2).

2. Material and method

We have studied 60 calcanei procured from the department of anatomy, forensic medicine, orthopaedic and personal bone sets of human cadaver. Adult bones, irrespective of the sex were included for this study. Calcaneal bones with pathological changes were excluded. The patterns of the talar articular facets of calcanei were observed with the naked eye and by using a hand lens. A sliding vernier calliper was used to measure the separation between the facets. For measuring the Boehler's angles, calcaneum was fixed on transverse axis like calcaneum of a standing man; angle was measured with a universal goniometer at frontal axis -between two lines, 1stdrawn from superior margin of posterior facet to superior margin on anterior process and 2nd line is drawn from superior margin of posterior facet to superior margin of tuberosity (Fig. 3). Literature analysis revealed that four to five patterns of talar facets were found in the calcanei.

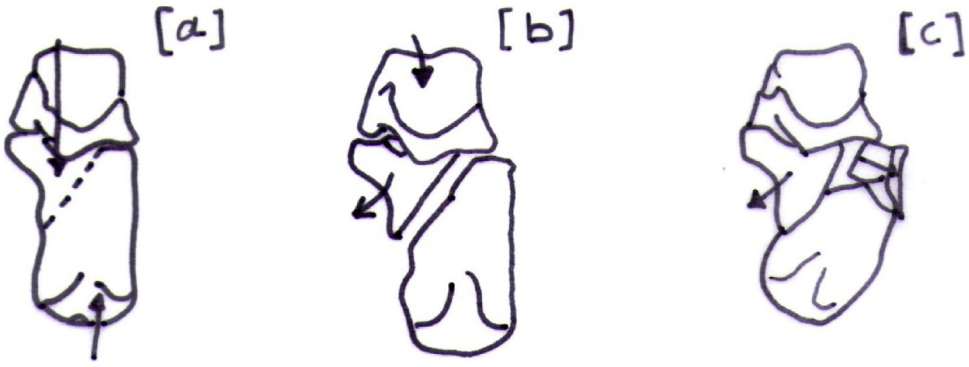

Fig. 1. (a)The oblique fracture line, (b) Dividing calcaneum in two main fragments, (c) Sustentacular (constant fragment) and tuberosity fragment.

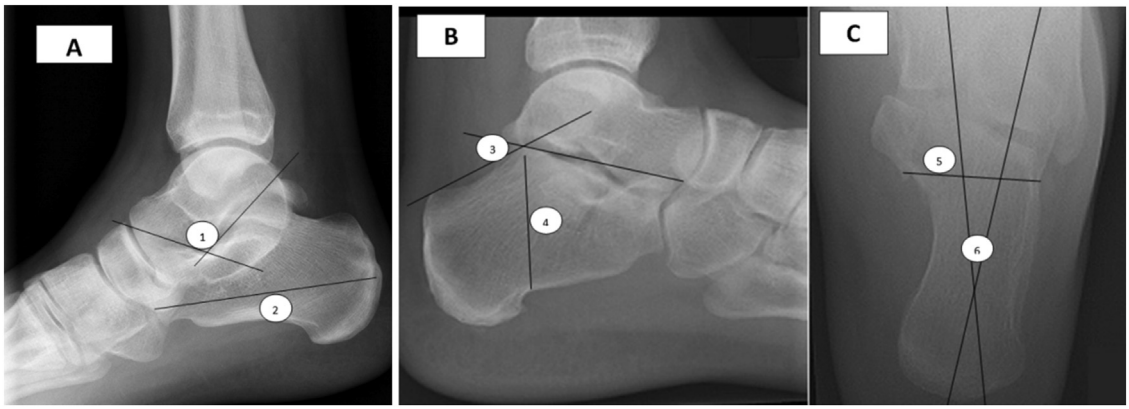

Fig. 2. (a) Gissane angle 1 and calcaneal length 2, (b) Bohler angle 3 and calcaneal height 4 and (c) Calcaneal width 5 and heel varus angle 6.

3. Results

Calcanei were categorized using the Bunning and Barnett classification of subtalar facet configuration. In this study, only three patterns were described as follows: Pattern I calcanei bear three facets for the talus 22/60 (36.66%), Pattern II calcanei bear two 28/60 (46.66%) and Pattern III calcanei a single facet only 10/60 (16.66%) (Fig. 4) Table1.

Depending on the constriction of facets pattern 2 is sub typed into (a) if the facet was constricted and (b) if the facet was not constricted. Depending on the degree of separation between the anterior and the middle facets, pattern 1 was sub typed into three varieties as (a) 3 mm, (b) 3–5 mm and (c) 5 mm.For classification and operative planning, CT (coronal plane) is useful.[19]

In this study there is a dominance of pattern 2 calcanei ascompared to the Europeans whose pattern I is common. This fact necessitates the orthopaedic surgeons in India to modify the surgical techniques when they perform calcaneal osteotomy. Indians maybe at a lesser risk of developing subtalar arthritis due to the dominance of pattern II calcanei according to different studies performed. In this study we also measured the surface area of facets which shows more available surface area for articulation in pattern 2 provides better stability. So chances of subtalar arthritis are less. Therefore, pattern 2 is better as far as management and results are concerned. Cortical bone is being the thickest (4 mm) beneath sustentaculum tali. This is important for the fixation, i.e., this fragment is the most stable and it must be fixed well.This study of the calcaneal talar facets is important clinically too because calcaneal fracture are grouped according to the anterior extension of the primary fracture line (primary fracture line may extend into the articular surface or b/w two articular surfaces or into periarticular location or into a medial & lateral location or may involved the calcaneocuboid or talocalcaneal joint).Usually the primary fracture line extends anterior to angle of Gissane, creating a relatively consistant anterolateral fragment. In calcaneal fracture, the plain radiographic evaluation of calcaneal articular surfaces highlights the posterior facet, but now a day with the help of CT clinician pay attention to the anatomy of anterior portion of calcaneus also. Anterior to posterior facet there are three articular surfaces: the surfaces of the anterior and middle facets of the talocalcaneal joint and the surface of the calcaneocuboid joint. It has been reported that alteration in the alignment of the joints may contribute to degenerative osteoarthritis changes and pain in the subtalar joint.

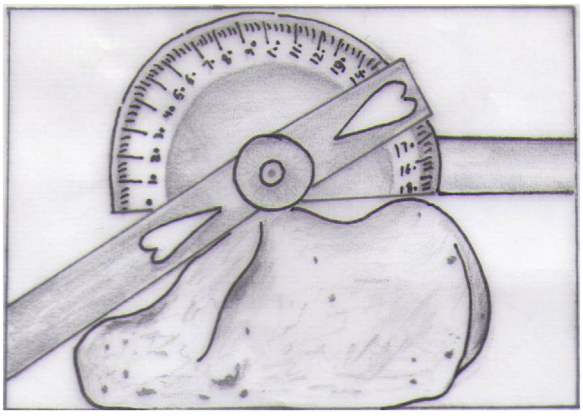

Fig. 3. Measuring the Boehler's angles.

4. Discussion

An understanding of the complex surgical calcaneal anatomy begins with a 3-D appreciation of the multiple articulations and bony processes. Radiological evaluation of the fracture consists of the standard x rays and computed tomography scans.On the plain radiography, four trabecularsystems of the calcaneus are described: thalamic anterior,anterior apophyseal, anterior plantar and posterior plantar.The thalamic trabecular system is in direct contact withweight-bearing systems of the tibia and the talus and isthe mostdense beneath the posterior facets. By measuringthe thickness of the cortical bone, it has been found that itis thinner on the lateral and plantar sides, being the thickest(4 mm) beneath sustentaculum tali. This is of importancefor the fixation, i.e., this fragment is the most stableand it must be fixed well.Onthe plain lateral view, Bohler's & Gissane's angles are ofimportance for determining the fracture.[20–22] In case of compressive fracture of the posteriorfacet, on the lateral view the Bohler's angle is decreased(described as tuber joint sign), while the Gissane'sangle is increased. The posterior facet length is alsodecreased. In case of one side facet fracture, double density sign is seen.On lateral view difference between jointdepression from tongue type fracture are made easily.[21,23] More precise diagnosis is obtained by computed tomography. Therefore; CT scan imaging is indicated in all calcanealfractures, especially the intra-articular ones in thecoronal plane (perpendicularly to the posterior facet) andin the axial

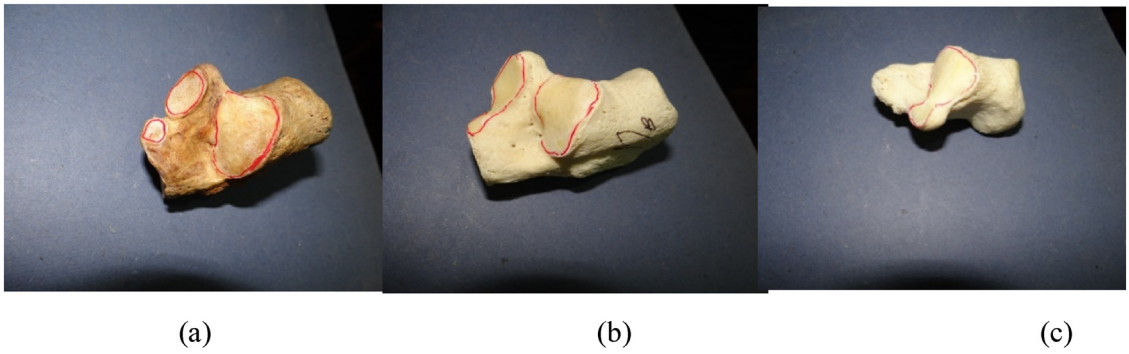

Fig. 4. (a) Pattern 1: Three facets for the talus. (b) Pattern 2: Two facets for the talus (c) Pattern 3: Single facets for the talus.

Table 1
Incidence of individual types of calcaneum with their percentage.

Type	No of Calcanei/total	Percentage
I	22/60	36.66
II	28/60	46.66
III	10/60	16.66

plane. Some authors also suggest semi-coronalslices at the angle of 30°.[23–26] In the sagittal plane, the dislocated tuberosity fractures can be revealed involving the anterior process, rotational deformities and a difference between tongue typeand the joint depression fractures can be determined. In the axial plane, on the CT scans one can trace thelength of the fracture up to the processus anterior and

calcaneocuboidjoint, as well as to the sustentaculum tali andthe posterior facet.The semi-coronal plane enables the best visualisation ofthe fragment position in the posterior facet, the sustentaculumtali and the peroneal tendon localisation.Both on X- raysand CT scans, the talar declination is seen, which leads tothe Achilles tendon shortening.Considering the above placement of the screw were shown in (Fig. 5). In any study of calcaneal fracture fixation the result can be evaluated considering the radiographic parameters like the Bohler and Gissane angles along with calcaneal width, were corrected to near normal at follow up indicating restoration of the normal calcaneal anatomy.

Lateral and axial view showing anatomical reduction and fixation using percutaneously applied screws with restoration of the Bohler and Gissane angles and talocalcaneal joint alignment.

Keeping in mind the facets pattern and fracture type, calcanium percutaneous fixation was advised as described by Westhues and Essex-Lopresti. The first stepin the technique is to force the heel into varus to free up thefragments. The wire(s) is/ are inserted through the heel tothe talus, which is then immediately pass toward plantarwhile the forefoot is in equinus. After the reduction is confirmed on x-ray, the wires are advanced with thefoot in valgus and fixed to the talus (Westhues) or to theanterior tuberosity of the calcaneus (Essex-Lopresti). It isimmobilized for 4 weeks with a plaster cast; the wires areremoved in 6 or 8 weeks; and weight-bearing is permittedat 10 weeks.

5. Conclusion

Usually the three subtalar facets (anterior, middle, and posterior) function as a unit and any fracture that interrupts their alignment is, an intra-articular fracture. Classically, calcaneal reconstruction is predicted on the restoration of the articular surfaces especially the posterior facet. Therefore, appropriate reconstruction of the 3 dimentional spatial relationship between three articular facets is of paramount importance. Bohler in 1931 outlined the goal of ORIF, namely 1) accurate anatomic reduction of the subtalar joint 2)restoration of calcaneal anatomy 3) stable fixation & 4)early range of motion.

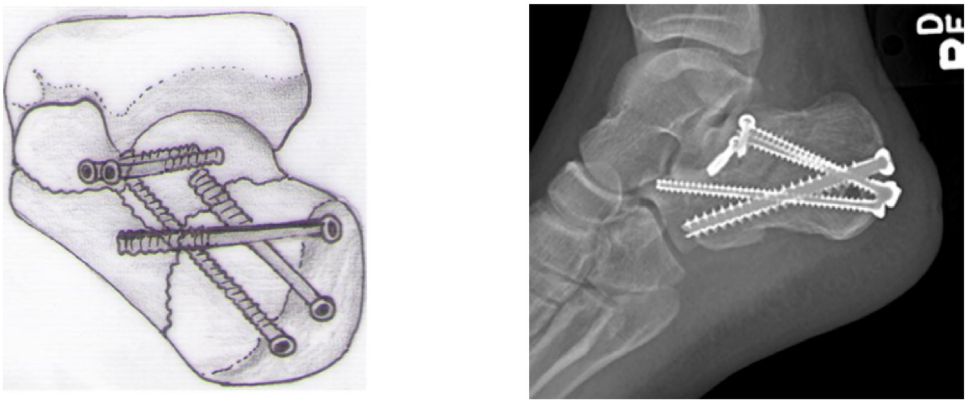

Fig. 5. (a) Placement of the screw (b) post op x-ray.

Conflict of interest

The author has none to declare.

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