Study of Variations in Pattern of Calcaneal Articular Facets in Human Tali in the Population of Rajasthan (India).
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Abstract:
Talus (astragalus) is the second largest tarsal bone. It has no muscular or tendinous attachment. It takes part in the formation of various articulations in the form of talocrural, talocalcaneonavicular or subtalar joints. The prior knowledge of the anatomical set of talus and its various articulations holds significance in operating procedures. Knowing anatomy of talus not only helps in delineating underlying pathology but also helps in treatment. Three hundred dry adult tali (150-right and 150-left) were studied. Each talus was examined for the presence of various patterns of articular facets. They were classified into five groups. Type I was found in 39% cases. Type II in 43.7% cases, Type III in 6% cases, Type IV in 5.3% cases and Type V has two subtypes. Subtype ‘A’ was found in 5% cases & subtype ‘B’ was found in 1% cases. In the present study, highest incidence of type II tali was 43.7 % and type IV had lowest incidence of 5.3%. These variations and their incidences can be used as an anthropological marker for racial and regional differences in unidentified bones. Further, studies on various other population is indicated using larger sample size to make comparative studies more meaningful.

Key Words: Talus, Calcaneal articular facets, Calcaneum, Subtalar joint.

Introduction:
Talus is the second largest of the tarsals and is situated between the tibia and fibula superiorly and calcaneum inferiorly. One peculiar feature of talus is that it has no muscular attachments and no tendinous attachments (White et al, 2011). Talus is considered as the cornerstone of medial longitudinal arch of the foot (Kulkarni, 2012). It receives the body weight and transmits it to the plantar arch below (Versfeld, 1986). The prior knowledge of anatomy of talus is significant to the anatomists as well as to the orthopaedic surgeons as fracture of talus is quite common. Even those patients with displaced fractures of the neck who avoid necrosis of the body, run a considerable risk of developing osteoarthrosis especially in subtalar joint (Lorentzen et al, 1977). Unstable joints are more likely to suffer trauma, accidents, or other biomechanical stress as a result of uneven weight distribution and excessive incremental motion which results in development of arthritic changes in subtalar joint (Verhagen, 1993). The subtalar joint is a complex articulation in both its structure and function. The orthopaedicians and sports physical therapists must be familiar with these areas to better understand the rationale for examination and treatment procedures. (Rocker, 1995)

The subtalar (or calcaneal) facets on the inferior aspect of the talus are usually three in number and variable in shape. The anterior subtalar (or calcaneal) facet is the most anterior facet on the plantar (inferior) surface of the talus, often somewhat continuous with the articular surface of the talar head. The medial subtalar (or calcaneal) facet is highly variable, sometimes separated from but often merging to a greater or lesser extent with the anterior subtalar facet. The posterior subtalar (or calcaneal) facet is the largest facet on the plantar surface of the talus. White et al (2011) stated that it is concave and obliquely oriented (posteromedial to anterolateral).

Arora et al (1979), Bilodi & Agrawal (2003) and Kaur et al (2011) studied different patterns of articular facets of calcaneum in human tali. These authors divided talar articular facets into different types and stated that differences in incidence of different types of articular facets could be due to differences in gait, built, structure of population or racial differences. Therefore, prior knowledge of articulation and various anatomical variations in articulation holds significance not only in delineating underlying pathologies but also in its treatment. Thus, present study was carried out to determine incidence of various types of calcaneal articulating facets in human tali, variations in both feet and correlate these findings to existing literature.

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Material and Methods:
The present study was carried out on 300 dry (150 right and 150 left) adult tali of unknown age and sex from bone bank of Department of Anatomy, S.M.S. Medical College, Jaipur, Rajasthan. As far as it could be ascertained, samples were free of physical or pathological damage or any anomalies. Each talus was carefully examined for various patterns of articular facets for calcaneum on plantar surface of talus. Articular margin of facets was marked with black sketch pen and each talus was numbered and photographed. Incidence of various patterns was observed and compared with available literature.

Results:
Various researchers have classified these facets into different types. In the present study incidence of various types of calcaneal articular facets were classified according to classification given by Arora et al (1979) and Kaur et al (2011).

Type I: single calcaneal facet on plantar surface of head of talus was found in 39% cases (Fig. I).

Type II: single calcaneal facet on plantar surface of head of talus divided by a ridge into two parts. It was found in 43.7% cases (Fig. II).

Type III: two calcaneal facets on plantar surface of head of talus separated partly by a ridge and partly by a groove and was found in 6% cases (Fig. III).

Type IV: two calcaneal facets on plantar surface of head of talus separated by a non-articular groove, it was found in 5.3% cases (Fig. IV).

Type V: has two subtypes:-
VA- single calcaneal facet continuous with posterior calcaneal facet. It was found in 5% cases. (Fig. Va).
VB- Two calcaneal facets; one of them continuing with
posterior calcaneal facet. It was found in 1% cases. (Fig. Vb).

In the present study type II tali had the highest incidence i.e. 43.7% and type IV had lowest incidence i.e. 5.3%. Results were compared with earlier studies (Table I).

Discussion:
The present study was carried out to verify the incidence and variations in types of calcaneal facets on tali, their alliance with racial similarities and differences if any. The variations on plantar surface of the talus enable the tali to be classified according to the number and disposition of the articular facets. In the present study, Type II showed the highest incidence of 43.7%. It was more on the left side (48.7%) as compared to the right side (38.7%). This observation was comparable with study of Bilodi (2006) who observed incidence of Type II to be 50%. Lee et al (2012) reported incidence of this type of facet to be 31.6% in Koreans. Though, much higher incidence of 78% was reported by Arora et al (1979) and much lower by Kaur et al (2011) as 45% and Lee et al (2012) as 30.3%. The incidence of type I tali was 39% in the present series which is in agreement with the observations of Kaur et al (2011) as 45% and Lee et al (2012) as 30.3%. The incidence of type I tali was almost equal on the right side (39.3%) and on the left side (38.7%). Other researchers have reported a lower incidence of this type of tali (Table II). Incidence of Type III tali was found to be 6% in the present study which is at par to the work of Barbaix et al (2000). The least common type of talus found in the present study was of type IV (5.3%). Kaur et al (2011), Bilodi (2006) & Arora et al (1979) also reported incidence of this type of tali to be least common in their studies. In contrast, Barbaix et al (2000) & Lee et al (2012) found it to be very high i.e. 39% & 28.9% respectively. Bilodi & Agarwal (2003) did not observe this type of tali in their study. In the present study incidence of Type V tali was 6%, where as Arora et al (1979) found it to be 2%. In contrast much higher incidence was reported by Bilodi & Agarwal (2003) as 56%. Bilodi (2006) as 18.44% and Kaur et al (2011) as 17% (Table II).

Barbaix et al (2000) and Lee et al (2012) did not find type V in their studies. In addition, Barbaix et al (2000) found missing anterior facet configuration in 11% of tali. Results of the present study showed wide range of variations in incidence of various patterns of articular facets of tali as compared to earlier workers. Kaur et al (2011) concluded that these variations may be due to different type of population, type of gait and built of an individual or the place of living which could be plain or hilly area. Some of these variants probably have an impact on the position of the axis of movements between talus and calcaneum resulting in different positions relative to load and ground reaction forces, and hence, in more or less inversion momentum. Bruckner (1987) opined that a significant difference in joint mobility is expected between joints with different numbers of articular facets. In the three-facet arrangement, the talus sits on an architecturally stable articular tripod and contacts the calcaneum at three distinct points. Both, joint motion and facet surface areas are restricted. A two facet configuration would be more mobile. The two anterior facets combine to form one larger facet and enable more gliding of joint surfaces. The one facet configuration should be the most mobile since all the facets have blended into one. Verhagen (1993) supported Bruckner’s hypothesis and found that arthritic limping was significantly less common in 3 separate facets configuration than in others and stated that people with long continuous facet or only medial facet may be at a greater risk for subtalar joint instability than individuals with the 3 facet configuration.

Barbaix et al (2000) concluded that these variations might well be an overlooked intrinsic risk

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Table I: Incidences of various types of calcaneal articular facets in human tali in the present study.

<table>
<thead>
<tr>
<th>Type</th>
<th>Subtypes</th>
<th>Total (300)</th>
<th>Right (150)</th>
<th>Left (150)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Type I</td>
<td></td>
<td>117</td>
<td>39%</td>
<td>58</td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td>131</td>
<td>43.7%</td>
<td>73</td>
</tr>
<tr>
<td>Type III</td>
<td></td>
<td>18</td>
<td>6%</td>
<td>6</td>
</tr>
<tr>
<td>Type IV</td>
<td></td>
<td>16</td>
<td>5.3%</td>
<td>7</td>
</tr>
<tr>
<td>Type V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(b)</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

Barbaix et al (2000) and Lee et al (2012) did not find type V in their studies. In addition, Barbaix et al (2000) found missing anterior facet configuration in 11% of tali. Results of the present study showed wide range of variations in incidence of various patterns of articular facets of tali as compared to earlier workers. Kaur et al (2011) concluded that these variations may be due to different type of population, type of gait and built of an individual or the place of living which could be plain or hilly area. Some of these variants probably have an impact on the position of the axis of movements between talus and calcaneum resulting in different positions relative to load and ground reaction forces, and hence, in more or less inversion momentum. Bruckner (1987) opined that a significant difference in joint mobility is expected between joints with different numbers of articular facets. In the three-facet arrangement, the talus sits on an architecturally stable articular tripod and contacts the calcaneum at three distinct points. Both, joint motion and facet surface areas are restricted. A two facet configuration would be more mobile. The two anterior facets combine to form one larger facet and enable more gliding of joint surfaces. The one facet configuration should be the most mobile since all the facets have blended into one. Verhagen (1993) supported Bruckner’s hypothesis and found that arthritic limping was significantly less common in 3 separate facets configuration than in others and stated that people with long continuous facet or only medial facet may be at a greater risk for subtalar joint instability than individuals with the 3 facet configuration.

Barbaix et al (2000) concluded that these variations might well be an overlooked intrinsic risk
factors for a chronic post traumatic lateral instability of the ankle and of the subtalar joint in particular. These variations exist from the earliest days of life without causing any trouble. So, at the start of complaints like pain or instability, a detailed analysis is needed to explain why the pre-existing variants have been traumatized. In many diseases of the foot, such as talocalcaneal arthritis and coalition, intra-articular fractures and congenital dysmorphological flat foot, valgus deformities, the size and shape of the bones, the relationship of talus and calcaneum with each other and other bones of the foot must be considered for treatment procedures like internal and external fixation, osteotomy or anatomic reduction.

In the ‘triple arthrodesis’ procedure to correct the deformities of flat foot, the articular facet configuration should be clearly kept in mind in order to safely denude the surfaces of the subtalar joints of all the articular cartilages (Richardson, 1998).

A classification system is a first requirement to distinguish different configuration types. In the present study, classification given by Arora et al. (1979) and Kaur et al. (2011) was used to classify different fusion types. This classification was not used by all the other authors, which could give a biased distribution of the different configurations especially for fused types. This can create difficulties to compare the results. It is important to use a standard classification in future studies. Nevertheless, when new configurations are found, such as observed by Barbaix et al. (2000), the classification must easily be adaptable.

The present study shows racial similarities as well as differences. A reliable estimation of race from skeleton using various criteria is important while dealing with undocumented skeletal material. These variations and their incidences can be used as an anthropological marker for racial and regional differentiation of unidentified bones.

Today with the aid of improvement of the technology there has been a great development of ankle prosthesis, implants, etc for the foot. Detailed anatomic information will act as a baseline for advanced treatment procedure.

Talar articular surface characteristics and sex difference was not taken in account during the present study. Future studies taking care of these factors on other population groups using larger sample size and by using imaging modalities is being suggested to make comparative studies more meaningful.

References:


Table II: Comparison of incidences of various types of calcaneaean articular facets in human tali.

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Indians</td>
<td>Belgium</td>
<td>Nepal</td>
<td>South Indians</td>
<td>North Indians</td>
<td>Koreans</td>
<td>Rajasthan-India</td>
</tr>
<tr>
<td>n</td>
<td>500</td>
<td>122</td>
<td>50</td>
<td>240</td>
<td>100</td>
<td>76</td>
<td>300</td>
</tr>
<tr>
<td>Type I</td>
<td>16%</td>
<td>21%</td>
<td>10%</td>
<td>10%</td>
<td>45%</td>
<td>30.3%</td>
<td>39%</td>
</tr>
<tr>
<td>Type II</td>
<td>78%</td>
<td>22%</td>
<td>14%</td>
<td>50%</td>
<td>24%</td>
<td>31.6%</td>
<td>43.7%</td>
</tr>
<tr>
<td>Type III</td>
<td>1%</td>
<td>6%</td>
<td>20%</td>
<td>16.6%</td>
<td>9%</td>
<td>28.9%</td>
<td>6%</td>
</tr>
<tr>
<td>Type IV</td>
<td>3%</td>
<td>39%</td>
<td>----</td>
<td>5%</td>
<td>5%</td>
<td>9.2%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Type V</td>
<td>2%</td>
<td>----</td>
<td>56%</td>
<td>18.4%</td>
<td>17%</td>
<td>----</td>
<td>6%</td>
</tr>
<tr>
<td>Subtype V(a)</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>8%</td>
<td>----</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Subtype V(b)</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>9%</td>
<td>----</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

n=total tali examined.


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**Conflict of Interest**: None declared.