Foot & Ankle: Studies

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Impact of Aging on Distal Tibia Metaphysis Diameter

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Received: January 20, 2021; **Accepted:** February 15, 2021; **Published:** February 22, 2021

Abstract

One of the many bone changes that occur with aging is “cortical drift”, the absorption and deposition of bone on the endosteal and periosteal side, respectively, which results in bone enlargement in some but not all metaphyses. The distal tibia is one of the most fractured sites in the body and where anatomically shaped implants are mostly used. The economic viability of these implants depends on the maintenance of bone contour throughout life. MRI sagittal ankle images from 422 patients aged 18 to 100 years were analyzed and total distal tibia diameter measured. No correlation was observed between the parameters age and distal tibia diameter (Pearson-0.099), or when individuals were separated by sex (Pearson-0.021 for men and 0.049 for women). When separated by age, patients younger and older than 60 years old had a similar average height (1.65 and 1.62 m, respectively, student’s t- test = 0). This is the first study to evaluate possible age-related distal tibia enlargement. Bone changes with age do not result in distal tibia enlargement and possibly the majority of anatomically shaped bone implants are suitable irrespective of age.

Keywords: Distal tibia; Aging

Introduction

Age-related bone changes age are well described in animal models [1-3], where total bone mass reduction occurs with bone metaphysis, trabecular struts become less thick [2,3], and the cross-sectional moment of inertia increases (bone distribution around the central axis) [2]. “Cortical drift”, the absorption of cortical bone on the endosteal surface and deposition of bone on the periosteal surface, could compensate for the decline in bone mass since it expands the outer diameter [4-6]. The amount of total bone widening at different body sites [7,8] and whether bone proportionality is maintained remains controversial [9]. Non-proportional bone enlargement with aging may alter the bone surface contour between people of different ages [10].

In orthopedics, fracture reduction is essential for successful bone healing [11]. Bone reduction is achieved by connecting the bone surface and the micro relief, and irregularities are used as contact parameters [11,12]. In comminuted fractures, micro bone relief is lost, resulting in poorly aligned postoperative cases [12,13]. This is even more important for the metaphyseal bone, because articular fractures must not have an uneven surface [13,14]. Perfect reduction in ankle fractures is crucial because of the high load in a small area [13,14].

To solve these cases, many anatomically designed bone implants were created for the distal tibia [15,16]. There are still no data available to show the real effectiveness of these implants [15,16], little information is published about bone surface variance in the population [13,16], and even less is known about these variances between populations of different countries [13,19]. Thus, these implants may not be precise enough to provide the necessary anatomical alignment [16,17].

If bone size changes with aging, the bone surface could differ between young and older patients. As such, implants should be distinguished between these individuals, and it is important to understand if this change differs between sexes [18-20]. To determine distal tibia width and if there is a perceptible age-related size difference, 422 ankle Magnetic Resonance Imaging (MRI) scans were evaluated and the distal tibia diameter measured.

Materials and Methods

After institutional ethical committee approval, 422 ankle MRIs (one ankle per patient) from the archives of the radiology department, taken between 2017 and 2019, were retrospectively analyzed. Inclusion criteria were sagittal ankle MRIs, age between 18 and 100 years old and no ankle bone abnormalities after careful analysis by the radiologist and orthopedic surgeon. Measurements were taken using Carestream’s Vue Motion Viewer®.

The decision to use MRI images was based on the fact that there were more MRIs available at the department than ankle CT scans, which could be another option. MRI correlation between images and *in vivo* findings are well described [21,22]. Ankle x-rays were not used because of the less reliable correlation resulting from the variations in the distance between the ankle and x-ray ampoule [23]. Distal tibia diameter was determined in the sagittal MRI view, where the largest measurement was obtained using the oblique view of former cartilage growth scar tissue (Figure 1).

Intra and interobserver reliability were assessed by applying the Intraclass Correlation Coefficient (ICC). Thirty-seven ankles were used in this analysis. Correlations of 0.81 to 0.99 were considered near perfect; 0.61 to 0.80, substantial; 0.41 to 0.60, moderate, 0.21 to 0.40, fair; and slight if less than or equal to 0.20 [21]. Age-related distal tibia enlargement was determined using Pearson’s coefficient between age and distal tibia width and by comparing patients under and over 60 years old (Figure 1).

Results

Average distal tibia diameter of the population was 38.5

Citation: Astolfi RS, Batista AV, Santos ALM and Leite JAD. Impact of Aging on Distal Tibia Metaphysis Diameter. Foot Ankle Stud. 2021; 3(1): 1020.

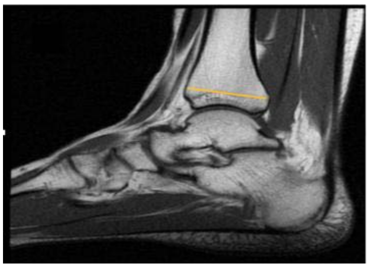

Figure 1: Distal tibia width assessment at sagittal cut T1; the largest measure obtained in a straight line at the former cartilage growth.

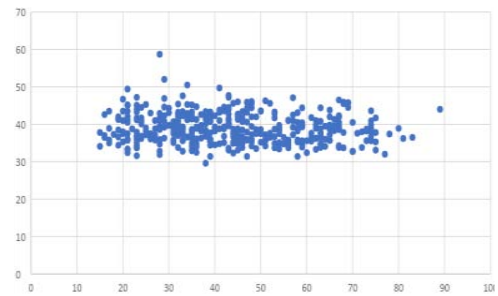

Figure 2: Graphic distribution correlation between distal tibia size (y) and patient age (x).

Table 1: Population characteristics.

Average Age	43 years	SD (41.46-44.53)
Sex distribution	56.45% female	
Average Height	1.65 m	SD (1.63-1.66)
Distal Tibia Diameter	38.5 mm	SD (38.12-38.87)
Distal Tibia Women	36.5mm	SD (36.19-36.80)
Height Women	1.61 m	SD (1.59-1.62)
Distal Tibia Men	42 mm	SD (41.51-42.48)
Height Men	1.72 m	SD (1.69-1.74)

mm (SD 38.12-38.87) and no correlation with age was observed (Pearson-0.099) (Figure 2). Distal tibia diameter did not change with age when the analyses were separated by sex (Pearson-0.021 for men and 0.049 for women) (Table 1) (Figure 2). When divided by age, patients under and over 60 years old had similar average height (1.65 and 1.62 respectively, student's t-test=0.012) and distal tibia diameter (38.4 and 37.7 mm respectively, -student's t-test=0.42).

Discussion

Bone enlargement is thought to be an important compensation for bone mass loss in age-related osteopenia [24]. Few and conflicting literature studies have addressed if, where or how much enlargement actually occurs. Since trabecular bone microstructural properties are heterogeneous throughout the skeleton, evolution, and changes in bone shape with age vary between skeletal sites [6,8,25-29]. Significant differences between men and women are observed at some, but not all sites [29]. Age-dependent rib enlargement was observed [25] in the distal radius [25] and femoral neck [6,8], but not in the vertebral body [2,10,26,27] or ilium [28]. Although understanding the external distal tibia contour behavior with aging is essential since there are many anatomically designed ankle implants used to restore the anatomy contour of this region [15,16], one of the most fractured bones in the body [30], this is the first study to address age-related distal tibia enlargement.

No correlation was observed between distal tibia metaphysis diameter values and age, but some bias could have occurred. The average age (43 years) characterizes a relatively young group, which could affect the results, since fewer patients over 60 years old were included (only 64 of the 422 patients). However, given that Pearson`s coefficient was consistent, and the total number of patients analyzed significant, this fact does not seem relevant.

Another possible bias could be a decrease in distal tibia size in older patients in Brazil, as a different nutritional environment in childhood could result in smaller older adults, with smaller bones. The average height of patients under and over 60 years old was very similar (1.65 and 1.62 m respectively), as was distal tibia diameter (38.4 and 37.7 cm respectively). The absence of distal tibia enlargement cannot be due to consistent intergroup height differences since none were observed. The use of MRI to analyze detailed bone structure could affect the precision of these measures, but the literature has shown good correlation between MRI and anatomical measurements [22].

Anatomically shaped implants designed for the distal tibia can probably be used with no modifications in adults or older patients as effective distal tibia enlargement with aging do not occur. To confirm this hypothesis, studies should address the micro contour details in both groups [16]. Little is known about micro bone contour variations between people in general, and knowing these patterns could result in more precise implants and reduce the high failure rate in restoring anatomical alignment in particular comminuted fractures [31].

Conclusion

Age-related bone metaphysis enlargement is uneven and differs between bone sites. The distal tibia does not widen with age. This finding may help calculate the economic viability of new anatomically shaped implants.

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