LUPINE PUBLISHERS

Research and Reviews on Healthcare: Open Access Journal

DOI: 10.32474/RRHOAJ.2023.08.000286

ISSN: 2637-6679

Review Article

Orthopaedic Footwear and Foot Deformities: A Review

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Received: June 16, 2023 **Published:** June 23, 2023

Abstract

Many people experience problems with their feet and/or ankles. Foot deformities can either present at birth or develop over some time. The definition of foot deformities is not predicted generally. The proposed solutions are surgical or non-surgical methods to cure foot deformities. Custom made shoes are costly which are not affordable to the masses. A comprehensive study of the medical, functional, and technical requirements for this type of footwear is still lacking to date. Hence in this paper, an attempt is made to review different foot deformities and low-cost customized orthopedic shoes for it. The paper is divided into four main parts. The first part deals with the introduction and literature review. The second part is related to the foot anatomy, different deformities, and their causes. The third part deals with the low-cost custom-made shoes for these deformities. Lastly, it discusses the conclusion and future scope.

Keywords: Foot deformities; customized shoes; foot problems; custom shoe last

Introduction

The foot is the bottom most part of the body, which comes in the contact of ground may or may not through footwear. It has two fundamental functions, namely stability of body and dynamics of motion to move forward or backward. The foot has a complex structure to support while standing or moving on even or uneven surfaces [1]. Foot arch indicates that the portion of foot meets the ground and helps in distributing pressure and provides cushioning effect to absorb shocks. Thus, in a healthy foot, the medial longitudinal arch is elevated 15 to 18 mm from the surface, while the lateral arch is elevated 3 to 5 mm [2]. Deformities occur if the above-mentioned ratio of foot arches is disrupted and affects the joints' performance of the ankle, knee, and hip, which may cause backache. The problem is aggravated due to excessive body weight, weakness of tissue, excessive physical effort, prolonged and improper way of standing and unsuitable footwear [3]. The foot deformities begin with minor foot trauma due to lack of knowledge of foot care [4]. It is further contributed by poverty and illiteracy. Sociocultural practices like walking with barefoot as religious practices, not wearing socks contribute to foot injury and the development of hyperkeratosis, nail problems and heel fissures in the Indian population [5]. The percentage of athletes having foot problems in different parts of the country varies from 25% to 55% and maximum in the athletes of the middle age group. Also, the foot problem to female athletes has more prevalence than men [5]. Foot problems are generally seen in many people independent of age and gender. It may be developed at an early stage or over some time due to various factors like ill-fitting shoe, genetically problem, pointed shoe, lack of education, arthritis etc. Care must be given to feet because approximately 25% of total bones are present in human feet [6]. In general, two methods are likely to be suggested to cure foot deformities i.e., surgical method and non-surgical method. Here low-cost customized method is used for making EVA custom-made orthopaedic shoe for various foot deformities [7-11] (Figures 1 & 2).

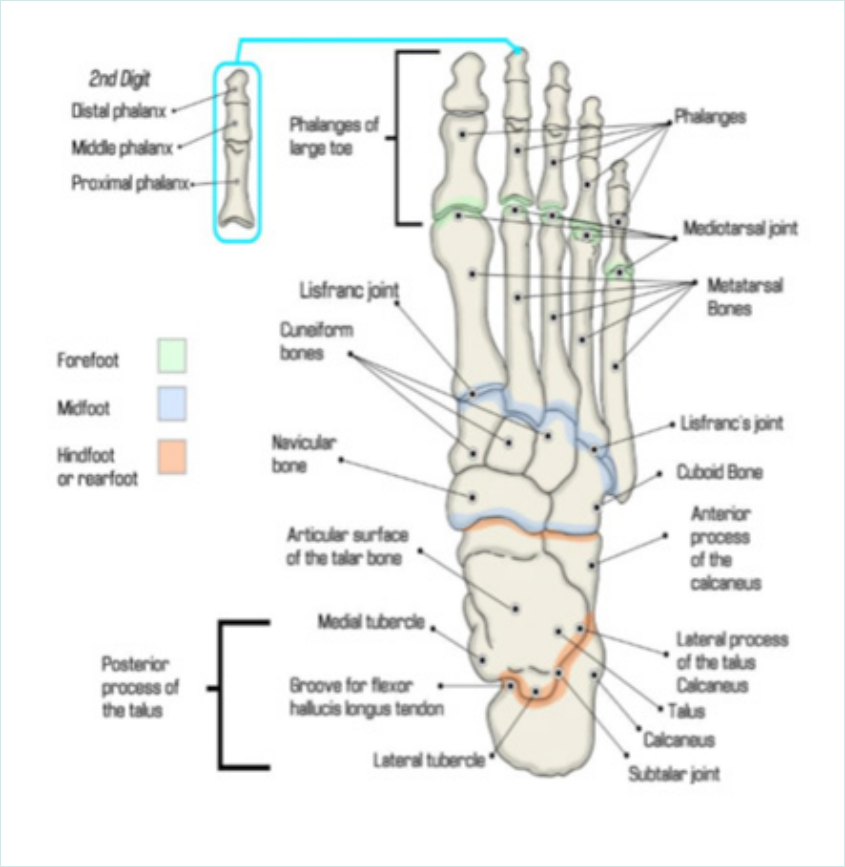

Figure 1: Structure of foot[a].

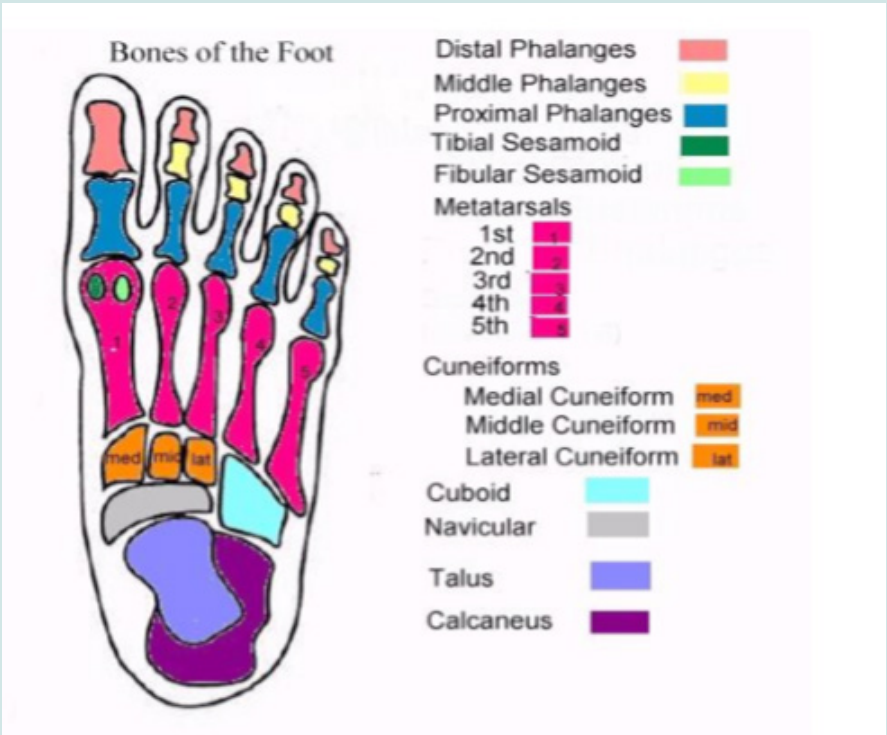

Figure 2: Distribution of Bones [b].

Literature review

Ellen Sobel [10] mentioned the weight-bearing foot pressures which were found to be lower when walking with shoes as compared to barefoot. Adding a soft cushioned in the shoe which further decreases the weight-bearing pressure. Asad Ayub [11] said that the initial treatment is primarily conservative and must first address the patient's footwear. Foot padding, taping, night splints, foot exercises, orthotic devices, nonsteroidal anti-inflammatory medications, or a combination of these treatment modalities may be prescribed. Allowance should be made for adequate space in the shoe to prevent further injury. Orthotic devices may provide short-term symptomatic pain relief for mild to moderate Bunion deformity. J Leng [12], Shuping Xiong [13], and Nibedita Rout [14] proposed different systems for foot scanning to obtain data to fit customer foot shape for custom made shoe last. Then CAD file is prepared according to measurement and prepared the final last using CNC machine and ready for shoe production. Salvatore Moscadini fabricated a soft leather shoe with a wide toe box and preferably a soft sole for relief of symptoms of flat foot and Bunion. Different orthotic devices like bunion pads, night splints, bunion posts etc. may also help in relieving symptoms. No assurance that orthotic devices prevent progression of the deformity, and it is uncomfortable for a patient because it occupies space within the toe box. According to Kilmartin et al (1991) found that the Bunion angle increased more in patients who used orthotics and concluded that orthoses did not prevent progression of a Bunion deformity [15]. A Luximon [16] applied a non-medicated hammertoe pad for hammertoe deformity. Hylton B Menz [17] discussed about all the orthoses were of full length and modified by adding a cut-out section beneath the first metatarsal and trimming the distal edge to level the second to fifth phalanges. Chakma Shimul [18] deals to make custom made shoe last for a deformed person using CAD file and last preparation using CNC machine. On the other hand, J Peixoto [19] used 3D scanning to scan foot and the information utilized by 3D printing machine for making custom made insole. Mike Freckling ton [20] applied an extra-depth in the forefoot region to accommodate forefoot deformity. Soft leather upper and smooth lining offered protection, laces, padded heel counter to improve the fit at the heel side and a long inside counter was given to improve rear foot stability and for supporting arches. Paulus Wisnu Anggoro [21], Nor Rofizah Johari [22], Liliia Chernenko [23,24] prepared a custom-made orthotic insole using CAD file and CNC machine for patients suffering from diabetes. Chul Hyun Park [25] applied treatment for patients who favour footwear with a lower heel and a wider toe box section. An MT bar on the sole of footwear reduces pressure loading on the space between MT heads and transfers it more proximally. Ermakova EO [26] proposed a concept of automated measuring the inner dimensions of a deformed person's foot and to develop an algorithm using the data. This integrated approach helped to make the custom-made orthopaedic footwear better way. Haddaya Umar [27] conducted a survey on people who were suffering from plantar fasciitis and planned to investigate the impact of daily wear footwear on foot health by mentioning the various features of the shoes worn daily by the sufferer.

Human Foot Anatomy

Foot anatomy is the science of knowing the structure of the feet and interrelation of its parts. The human foot consists of bones, muscles, Ligaments, & Tendons which are covered by the skin. The whole system can support the body while it is standing, walking, and running [28].

Function of Feet

Feet have the following two functions:

a) Supporting the weight of the body to balance in an erect position i.e., stability

b) Propelling the body forward (movement) i.e., flexibility

Introduction of Bones

The skeleton of the body gives strength, supports its weight, and protects the more vulnerable organs. It is formed by long and short bones. Long bones are responsible for its movement and the short bones are associated with the weight bearing of the foot. There are a total of 26 bones present in human foot [17].

Distribution of Bones

It is divided into three parts-

A. Tarsus: Back portion of the skeleton of the human foot is termed as tarsus. It has seven irregular shaped bones. The body weight is transferred through heel bone to the ground.

B. Metatarsus: Consists of five metatarsi (long bones). The first three joins with three cuneiforms and next two with the cuboids.

C. Phalanges: Phalanges are the fourteen long bones forming the toes. It is divided into three subgroups as

a) Tarsus: 7 short bones

b) Metatarsus: 5 – long bones

c) Phalanges: 14 – long bones.

Phalanges is further classified as: +

a. Proximal phalanges (5- bones)

b. Middle phalanges (4-bones)

c. Distal phalanges (5-bones)

Foot Deformities

Deformities can be painful and affect the way you walk. It may cause hard and thick skin, and lead to calluses and pressure sores. Sometimes misalignments (wrong bone positions) can cause toes and other parts of the foot to become deformed too. This applies abnormal strain on tendons and muscles, which may even tear as a result [29]. Abnormal strain on joints can lead to wear-and-tear, and eventually to osteoarthritis. Further risk factors include injuries, inflammations and being overweight, as well as diseases such as osteoarthritis, rheumatoid arthritis, or brain diseases. Genes usually play an important role. For instance, some people have weak con-

nective tissue, so the supporting structures in the foot can't always hold everything in place properly [30].

Various foot Deformities

Hammer toe

A hammer toe is a kind of deformity in which the human toe tends to bend or curl downwards instead of pointing forward as shown in Figure 3. It generally affects the second, third, and fourth toe. Although, it may be present at birth and develop over some time due to arthritis or wearing some ill-fitting shoes, such as tight, pointed heels. In most cases, a hammer toe condition is treatable [31].

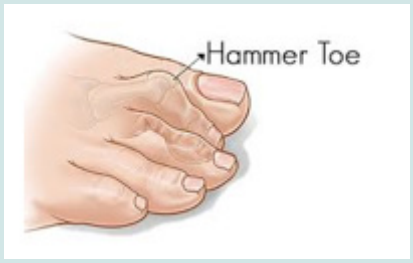

Figure 3: Hammer toe deformity [c].

Bunion

A bunion also called hallux valgusis a type of foot deformity occurs at first metatarsal phalangeal joint as shown in Figure 4. In this, the big toe generally bends towards the other toes and the joint also becomes red and sometimes painful. The exact cause is still unclear. Some proposed factors include wearing overly tight shoes, high-heeled shoes, family history, and rheumatoid arthritis [32-34].

Figure 4: Bunion foot deformity [d].

Splayfoot

In splayfoot deformity, the metatarsal bones are spread out as shown in Figure 5 and the front end of the foot becomes wider. As a result, more pressure is put on the middle bones in the forefoot. It is generally painful, and can make the skin hard and thick, leading to calluses. People with splayfeet are also more likely to develop hallux valgus. In this, the first metatarsal bone moves sideways (towards the other foot) and the big toe moving towards the neighbouring toes [16,29].

Figure 5: Splayfoot deformity [e].

Fallen arch/ Flat foot.

Flat foot is a common deformity in which the medial longitudinal arch is reduced or eliminated as shown in Figure 6, when standing and walking, the foot touches the floor. Fallen arches become painful after several years, mainly when you put more weight on them. Some extreme cases of fallen arches or flat foot are referred to as flat feet. The possible causes of fallen arches include weak foot muscles, abnormal strain on the foot, unsuitable footwear, and some joint inflammations [16,29].

Figure 6: Flat foot deformity [f].

Claw toe

It affects the four smaller toes at a same time. It is bend at the joint as shown in Figure 7. where the foot and the toes meet. It is bend down at the middle joints and at the joints which is nearest to the tip of the toes. As a result, it causes the toes to curl down towards the floor [16,29,31].

Figure 7: Claw toe deformity [g].

Mallet toe

Figure 8: Mallet toe deformity [h]].

This toe is bent down at the joint as shown in Figure 8. which is closest to the tip of the toe. It affects the second toe, but there is a chance of occurring in the other toes too [16,29].

Cavus Foot

It is a condition in which the child has an excessively high arch as shown in Figure 9. Most of the time, the heel of the foot is turned inwards (called Cavo varus foot deformity). The condition frequently affects both the feet and often progressive [16,29-30].

Orthopaedic Shoes

Many people experience problems with their feet and/or ankles. Orthopaedic footwear can help in preventing or reducing these problems. For a successful outcome, it is essential that customized orthopaedic shoes are used. We investigated the relationship between a person's decision to use the shoes and aspects of the usability, such as effectiveness, comfort, and cosmetics. It is found that all aspects of usability are important. Therefore, clinicians and shoe technicians should focus not only on the effect alone but also on the comfort and cosmetics of the shoes to make the best pair of shoes for the people who have deformed foot [32]. The main problem of custom-made shoes is the high cost. The major cost of custom-made shoes lies in its custom made last. The cost of these last can be reduced if they are made in one stroke and with reusable material (Figure 10).

Figure 9: Cavus foot deformity [j]

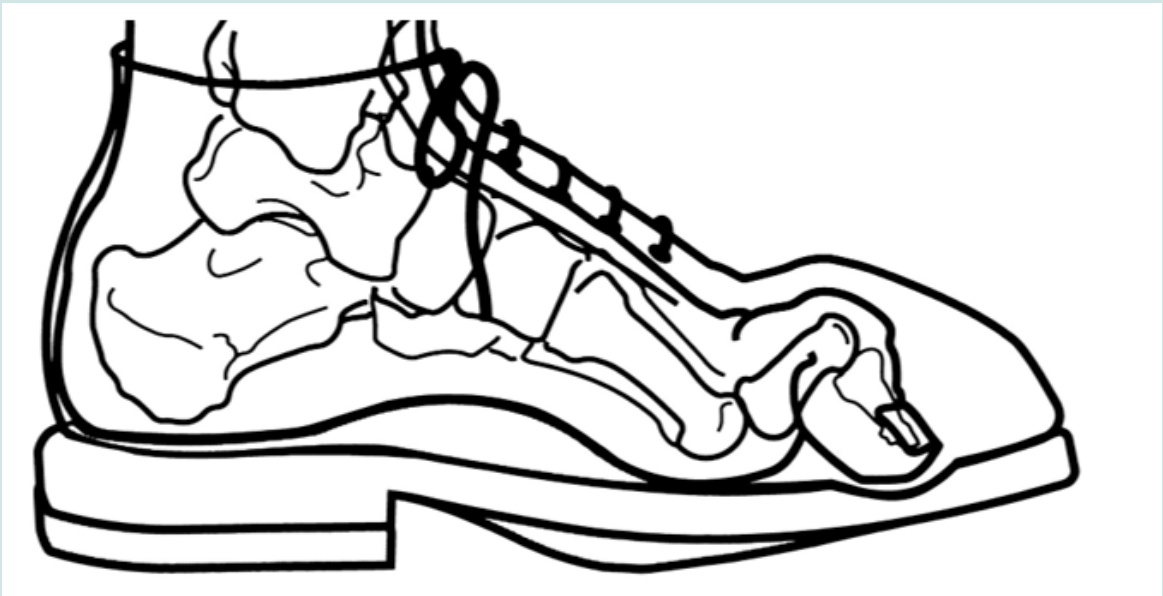

Figure 10: Orthopaedic Footwear.

Conclusion

The paper deals with the review of different foot deformities and its orthopaedic shoes. Most of the researchers tried to increase the distal limit area of toe box for the person who were suffering from different types of foot deformities. As a result, the shape of footwear affects the aesthetics appeal. Custom made shoes are very costly and its cost depends upon the type of foot deformity. Individual shoe last is required for a deformed foot, which cannot be reused. Preparation time for making custom made footwear according to the type of deformity is more. The custom-made footwear is heavy. Hence, there is a need to Design and Develop customized orthopaedic shoes which are cheap, light in weight, washable, good looking and cater with different foot deformities.

Acknowledgment

The authors are extremely thankful to Prof. P.S. Satsangi, Chairman, Advisory Committee of Education, Dayal Bagh, Agra for his guiding and inspiring us in our research work. We express our gratitude towards Prof. P.K. Kalra, Director, D.E.I. and the Lab Staff Mr. Aman Kushwah, Anoop Saran for their kind support and help provided during experimentations.

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DOI: 10.32474/RRHOAJ.2023.08.000286