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Methods for the Study of Static Deformities of the Human Foot

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Abstract Valgus deformity of the forefoot remains one of the most common orthopedic conditions requiring surgical intervention. The severity of the deformity is traditionally assessed based on radiographic criteria; however, variability in radiograph interpretation and discrepancies between preoperative PASA measurements and intraoperative findings complicate surgical planning. Despite more than 130 described surgical techniques, unified standards for the correction of static forefoot deformities have yet to be established. In recent years, minimally invasive and percutaneous surgical procedures have gained popularity due to reduced operative trauma, faster postoperative rehabilitation, lower complication rates, and improved cosmetic outcomes. This study emphasizes the importance of comprehensive clinical evaluation, including assessment of gait, foot morphology, and range of motion in the first metatarsophalangeal and interphalangeal joints. Diagnostic methods such as podometry, plantography, pedography, and radiography remain essential in determining the type and severity of deformity. Scarf osteotomy, due to its biomechanical stability and versatility, is currently considered one of the most effective surgical techniques for hallux valgus correction, allowing controlled metatarsal head repositioning according to individualized preoperative planning. Minimally invasive foot surgery has significantly expanded surgical possibilities and patient expectations, enabling correction of deformities previously considered difficult to treat. However, successful outcomes require precise technique, accurate radiographic assessment, and careful evaluation of intraoperative parameters. The integration of advanced imaging tools and software-based planning reduces technical error and contributes to improved functional and aesthetic results.

Keywords Research methods of static deformations of the human foot

1. Introduction

However, the severity of valgus deformity is traditionally classified based on measurements of known radiological criteria, which is complicated by the notorious human factor – the unequal perception of radiographs by specialists, in addition, the difference between the PASA measurements on radiographs and intraoperative has been proven. There are many preoperative planning algorithms described in the literature, based on traditional classifications and recommending specific surgical interventions for each degree of transverse flatfoot. This once again highlights the lack of unified approaches to the surgical treatment of static deformities of the forefoot. Thanks to the Internet, the level of awareness and, consequently, the requirements of patients who come to consult an orthopedist have increased significantly. They know "everything" about their pathology and treatment methods. Even elderly patients do not want to put up with the inability to wear model shoes, pain and cosmetic defects of the foot.

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Currently, more than 130 different surgical procedures are used to correct static deformities of the forefoot, but most of them have only historical significance, and some are used only in some clinics. Forefoot surgery is divided into soft tissue surgery and osteotomy, however, with modern approaches to the treatment of hallux valgus deformity of the first toe, soft tissue surgery is usually an addition to bone surgery, since isolated soft tissue corrections are ineffective. Mann and Coughlin proved that isolated soft tissue surgeries reduce HVA and M1M2, but the frequency of varus curvature of the first finger increases by 11%. Currently, osteotomies are the most popular for correcting deformities of the forefoot, which should be easily feasible and reproducible, and the surgery technique itself is universal in order to simultaneously correct all the necessary angles. Scarf osteotomy allows performing almost any type of displacement of the osteotomated metatarsal head in accordance with preoperative planning, has a high degree of biomechanical stability, being more stable than basal ones, therefore it is a universal procedure for correcting the hallux valgus deformity of the first finger. Over the past few years, foot surgery, and especially minimally invasive surgery, has become one of the most studied specialties in orthopedics.

Understanding biomechanics, growing social needs, and the constant introduction of technological innovations in foot surgery have made it possible to correct almost any pathology. The advantages of minimally invasive foot surgery compared to traditional open methods are: minimal surgical trauma, lower risk of complications, shorter surgery time and rehabilitation process. Minimally invasive methods, which are described in the scientific literature, can be used in the treatment of hallux valgus deformity of the first and lateral toes, and neuroma. To diagnose static deformities of the feet, the following methods are used: clinical method, podometry, plantography, radiography, pedography, computed tomography. It was shown that patients most often complain of shoe restrictions (80%), pain in the "bump" area (70%), cosmetic problems (60%) and pain under the head of the second metatarsal (40%). Pain can also be felt along the dorsal cutaneous nerve due to pressure. An important place in the clinical method is occupied by photographing the foot from its backside in the patient's standing position.

This allows you to capture and evaluate the true functional aspects of the foot and toes. Sometimes, for a more detailed visualization of the feet, a video is shot. In this position, the hammer-like deformity of the fingers can be clearly assessed, unlike radiographs, which are not so easy to imagine. In addition, when photographing, other pathological deformities of the foot can be documented, such as hallux valgus or varus deviation of the posterior part of the foot, supination or pronation of the foot. [2,4,6,8,10,12,14,16,18].

2. Results and Analyzes

The physical examination begins with the patient's standing position, as this increases the hallux valgus deviation of the first finger and other deformities. It is important to assess the position of the posterior and anterior parts of the foot. Squamosal deformity and tension of the gastrocnemius and soleus muscles can often aggravate stress and provoke pain in the forefoot. The clinical examination is carried out in stages. At the first stage, it is necessary to evaluate the shape of the equinus foot, supination and pronation of the foot, as well as the length of the Achilles tendon. Next, they begin to evaluate the first "ray": it is necessary to determine the volume of movements in the first metatarsophalangeal joint, the hallux valgus and the volume of movements in the interphalangeal joint. Upon examination, in addition to the deformities themselves, inflammatory processes, trophic disorders, corns and corns can be detected. In addition, it is necessary pay attention to the elasticity of the forefoot, which was described in detail by A. A. Kardanov. At the third stage of the clinical examination, attention is paid to small "the rays." The presence of corns on the plantar surface of the foot is determined. Palpation of the metatarsal heads reveals metatarsalgia. Thus, pain in the distal regions is an indication for Weil osteotomy, and pain in the proximal regions is an indication for BRT osteotomy. The volume of movements in the metatarsophalangeal joints is assessed. In patients with rather "thin" feet, it is possible to assess the level of location of the metatarsal heads in the sagittal plane by passive plantar flexion of the fingers. In case of hammer-like deformity of the fingers, it is necessary to evaluate the passive correction of the deformation. The relative length of the fingers is estimated. Hypermobility in the first metatarsal joint is also determined. When the foot is brought into a state of plantar flexion, the insufficiency of the long flexor tendons is emphasized. Podometry is a method of diagnosing a person's foot, which is currently performed using a device called a podometer. But if there is no such device, you can calculate the parameters using a regular ruler. The length of the foot and the height of the longitudinal arch are measured, and a podometric index, or Friedland index, is formed from these data. This method is convenient for diagnosing the initial degrees of flat feet. [1,3,5,7,9,11,13,15, 17,19].

Plantography is a method of obtaining foot prints, which makes it possible to judge its spring function. This is one of the most effective and affordable foot examination methods. The patient sits on a chair, a coloring agent is applied to the surface of his feet, then he stands on paper with both feet. A plantogram is obtained, on which points are marked that allow you to determine the calculated, angular and linear indicators. Pedography is a method of assessing the pressure distribution under the foot. This method provides a picture of the pressure distribution under different areas of the foot. Each static deformity of the foot has its own pattern of pressure distribution under the foot, which differs from the norm.

Radiography, along with clinical examination, is the most common method of diagnosing static deformities of the foot and is performed in various projections. Radiography is used to accurately characterize the bony arches of the foot, the position, size and shape of the bones forming it, objective examination and dynamics of changes in the arch during treatment. The most informative projections are: straight, or dorsoplantar, which is performed in a standing position, and medial-oblique (three-quarter projection). The most commonly used projection is a straight line, although it should not be the only method used for operational planning. The impact of workload on the results of standardized measurements is still a matter of debate. According to the results of the study, which assessed the impact of images taken with and without exercise, it was proved that images taken without exercise can be reliably used in preoperative planning and determining surgical treatment tactics, however, most authors recommend performing radiographs under load. During the evaluation of radiographs, the angle of the hallux valgus deviation of the first finger (HVA, norm < 15°) and the interplatelet angle (M1M2, norm < 9°) are measured. The distal angle of the metatarsal joint (PASA, norm < 10°) is the angle between the articular surface of the head and the axis of the first metatarsal bone. In most cases, the PASA angle is normal, and the first metatarsophalangeal joint is in a state of subluxation. This is called a mismatched hallux valgus deformity of the first finger. In a small percentage, usually young patients, the joint is congruent and not in a subluxation. Congruent valgus deformity is less prone to progression than discongruent.

Hallux valgus deformity in the interphalangeal joint of the first finger HVIA (hallux valgus interphalangeus angle) in an isolated form is quite rare and more often it is one of the components of the hallux valgus deformity of the first ray (total valgus deformity of the hallux). Correction of the HVIA angle through medial closed-angle osteotomy is described for the first time. Radiographs can also assess the ratio of the head of the first metatarsal to the sesamoid bones, the magnitude of the medial elevation, and the presence of degenerative changes in the joints of the foot.X-ray angles are used to assess the severity of valgus deformity of the forefoot in preoperative planning, and to evaluate and compare the postoperative results of various interventions. During foot X-ray, the correct placement of the patient for examination and the direction of the X-ray tube are extremely important. It has been proven that the manual method of evaluating foot radiographs is error-prone and time-consuming. The technical errors of measurement using computer programs are lower than those of the manual measurement method. Mathematical models made in appropriate computer programs allow surgeons to go into surgery with a detailed plan for its implementation.

3. Conclusions

Computed tomography (CT) is a method that allows you to obtain a layered image of the foot and make a three-dimensional model of it. The examination reveals not only static deformities, but also injuries, tumors, and inflammatory processes. When using CT with contrast, it is possible to visualize pathological processes in muscles, ligaments, tendons and blood vessels. CT has greater accuracy than conventional foot examination methods, helping surgeons plan surgical treatment for combined foot deformities.

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