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FOOT PRESSURE MEASURMENT AND MAPPING, IN A CASE SERIES ASSESSMENT FOR DIAGNOSING AND TREATING ORTHOPAEDIC FOOT ABNORMALITIES.

Orthopaedics

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ABSTRACT

Introduction: The study that measures the existing fields of pressure between a surface that is used to support, and foot surface that is plantar, is called Pedobarography. It has important applications in the analysis of Gait and other Foot Health problems. The requirement of foot pressure measurement sensors, are that they must have mobility with limited cabling.

Materials And Methods: This was a prospective study done as an outpatient procedure at Chettinad Hospital and Research Institute, Kelambakkam, Chengalpattu district of Tamil Nadu, from January 2019 to December 2019, for foot related ailments of outpatients presenting in the Department of Orthopaedics. The foot mapping was done by standard static mapping and gait analytical mapping systems. The findings were recorded and analyzed by a computer and the patients were prescribed custom made foot-wear.

Results: 945 cases were included in the study of which 575 patients had foot related orthopaedic pain pathology in the age group of 28 to 57years. Only for the 170 patients in the plantar fasciitis group was Hydrocortisone Injection administered. Remaining foot pathologies were treated with wax bath and ultrasound therapy. For the neurological foot pain segment comprising of 114 patients, neurologist consultation was sought, of which 36 cases turned out to be, due to lumbar canal stenosis and were surgically intervened upon. Of the 208 patients with Achilles tendonitis, 165 patients resolved with a heel and sole raise, with physiotherapy and the remaining 43 patient required spur and bursal surgical exploration and excision.

Conclusion: Plantar foot pressure mapping, should be an integral part of the list of investigations, while trying to diagnose and treat the problems related to foot abnormalities and pathologies.

KEYWORDS

Pedobarography, Foot pressure mapping, Non-traumatic foot pain in Orthopaedics.

INTRODUCTION:

The study that measures the existing fields of pressure between a surface that is used to support, and foot surface that is plantar, is called Pedobarography. This occurs continuously when one assumes an erect posture, and is applicable when one is quasi-static (standing), and also when one is locomoting(dynamic walking). It has important applications in the analysis of Gait and other Foot Health problems. In the gait analysis, the parameter of interface pressure between the plantar sole aspect and sole of the foot, becomes increasingly important. These measurements have increasing applications, in screening for high-risk diabetic foot ulceration, design of footwear for those with flat or cavus foot or in feet design of orthotics for diabetes mellitus, peripheral neuropathy etc.

They also find importance in sport and athlete foot injury prevention, as also in gait and posture correction. In order to achieve this, accurate foot pressure mapping is an important prelude. Healthy subjects move during walking hours every 6 minutes in the sagittal plane and every 9 minutes in the frontal plane. Factors that are contributory to the foot pressure formation are moisture, friction, shear and the body weight pressure distribution.

The foot provides for us the primary surface of interaction with the floor, for and during locomotion. Analysis of this is important in many ways. In order to diagnose foot problems, at an early stage for injury prevention. It is important for balance in sports and athletic Biomedical applications. It is also important in soccer balance training and fore-foot loading during running. It is pertinent to analyze and correct these problems in the elderly with gait instability and other balance impaired individuals. The measuring units are broadly classified as platform bases plantar pressure sensor and an insole or in-shoe based plantar pressure sensor system. The types of sensors these employs are the active sensors, resistive sensors, piezo-electric sensors and piezo-resistive sensors. The requirement of foot pressure measurement sensors, are that they must have mobility with limited cabling. They should be both temperature and pressure sensitive.

MATERIALS AND METHODS:

This was a prospective study, done as an outpatient procedure at Chettinad Hospital and Research Institute, Kelambakkam, Chengalpattu district of Tamil Nadu from January 2019 to December 2019, for foot related ailments of outpatients presenting in the Department of Orthopaedics. The recruitment time was for 12 months, and after giving proper treatment in the form of altered and custom-madefootwear, with or without medications, they were followed up for a mean period of 18 months till January 2021. Written consent was obtained from all patients to publish relevant clinico- pictographic data, while maintaining their privacy.

Inclusion Criteria:

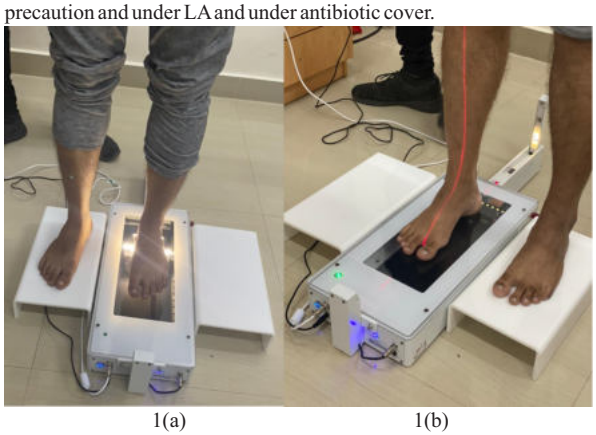
- Adults in the age group 18 to 57 of both the sex, presenting to the Orthopaedic OPD with non-traumatic (COLD ORTHOPAEDIC) foot or feet pain.

Exclusion Criteria:

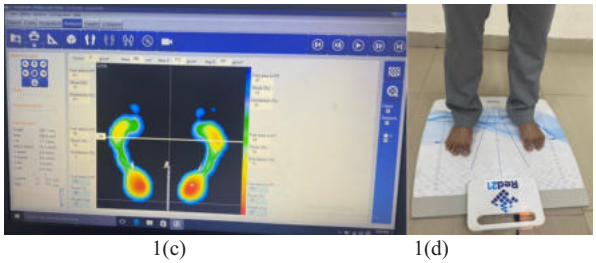
- Foot with earlier rotation flap surgery, skin grafting, burns contracture or trauma in the last 1 year.

- Existing varicose veins or altered Veno-Arterial Doppler study.
- Foot with a large diabetic ulcer.

The foot mapping was done by standard static mapping and gait analytical mapping systems. The findings were recorded and analyzed by computer and the patients were prescribed custom made foot-wear. For relevant cases, Hydrocortisone injections were given under aseptic precaution and under LA and under antibiotic cover.



1(a) 1(b)



1(c) 1(d)

Fig.1 (a – d): Foot Mapping by standard static mapping and gait analytical mapping systems, sequential analysis and computerized results.

RESULTS:

Table 1: Sex And Side Distribution:

Sex	Sidedness of Foot pain		'n'	%age
Parameter	Right Side	Left Side		
Male	142	94	236	25
Female	331	378	709	75
n(%age)	473	472	945	100

Table 2: Age Distribution Pattern.

Age Group	'n'	Percentage
18-27	175	18.52
28-37	205	21.70
38-47	370	39.15
48-57	195	20.63
Total	945	100

Table 3: Foot Pathology Distribution.

Detected Orthopaedic Pathology of Foot	'n' No. of patients
Achilles Tendonitis	208
Bunions	14
Calluses	07
Claw Toes	03
Corns	12
Hammer Toe	01
Plantar fasciitis	346
Mallet Toe	02
Metatarsalgia	12
Mortons Toe	42
Overlapping Toes	02
Overpronation of Foot	93
Seasamoiditis	01
Posterior Tibial Tendonitis	03
Flat Foot	72
High arched cavus foot	02
Arch pain	11
Neurological Foot pain	114
Total	945

In the recruitment period of 12 months, n=945 patients, complying with our inclusion criteria were recruited in all. In all there were n=236, male feet and n=709, female feet. The right sided feet involvement was in n=473 and left sided feet involvement was in n=472. Thus, approximately 25 percent of our patients were males and 75 percent were females. 85% (n=575) patients had foot related orthopaedic pain pathology in the age group of 28 to 57 years. Only for 170 patients in the plantar fasciitis group was Hydrocortisone Injection administered. Remaining foot pathologies were treated with wax bath and ultrasound therapy. For the neurological foot pain segment comprising of n=114 patients, neurologist consultation was sought, of which n=36 cases turned out to be, due to lumbar canal stenosis and were surgically intervened upon. Of the 208 patients with Achilles tendonitis, 165 patients resolved with a heel and sole raise with physiotherapy and the remaining 43 patient required spur and bursal surgical exploration and excision.

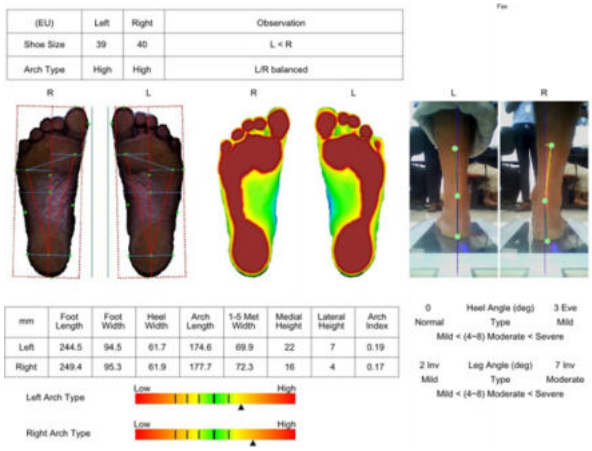


Fig.2: Systematic Foot matrix reproduction and computerized foot plantar pressure distribution analysis.

DISCUSSION:

Abdul Hadi Abdul Razak et al (1), called the plantar pressure, as a field of interaction between the foot plantar surface and the surface that supports the foot, in the everyday locomotive activities, that we undertake. Understanding this pressure map in a computerized manner, helps us to analyze the pressure distribution pattern, for the diagnosis of Sports Biomechanical injuries and their prevention, correction of posture and custom redesigning of footwears to suit various foot pathologies. Here we discuss, the results obtained from the minimally wired pressure distribution Flat platforms. According to Gefen A et al (2), these devices help in the assessment of soft tissue loading, which occurs due to bony prominences, in the plantar aspect of the foot and this technological concept with its spatial resolution accurateness, sensitivity and calibration methodologies, helps create a custom-made footwear to overcome, these unequal and unbalanced feet. For the wellbeing of the patient, Lavery L et al (3), proposed that foot problems are to be accurately diagnosed earlier, in order to prevent further foot injuries. Thus, he propagated the concept of "Foot Health". The available systems with their sensor efficacy, make accurate and reliable foot plantar pressure measurements. Lavery L et al (3) in 1997 studied the therapeutic efficacy of Visco-Elastic insoles in atheletic and therapeutic shoes and used the mean "peak plantar pressure" as an evaluation parameter. Mueller M et al in 1999 (4), made an elaborate study on plantar pressure assessment, in the foot wear of the general public and modified the use of custom made insert designs.

In a similar manner Praet and Louwerens et al (5); studied the influence of shoe design on the plantarly applied pressure in the neuropathic feet. Queen R.M et al (6) in 2010, had published a scholarly article were in, there was a gender comparison and gait posturing with regard to plantar pressure measurements. The above two also commented that, for effectively reducing the pressure on a neuropathic forefoot, a rocker bottom kind of shoe would be helpful as it would decrease the pressure under the first and fifth ray's metatarsal heads. The metatarsal heads are the common sites of ulceration, with feet having a cavo-varus deformity. Queen R.M et al (6); further explains that foot loading pattern are different for men and women, therefore the, footwear design should be custom made for each of the sex, that is they need to be distinguishably different. Diabetes is now considered more as an

epidemic. According to the study Wild S et al (7); (2004) the figures are likely to touch 366 million, by the year 2030. Gioftsidou A et al; (8) (2006) and Queen R.M et al; (6) (2007) have both stressed on the foot pressure balance, both in Sports and other Biomechanical Application. This is especially seen in sports during running and during soccer balance training. Best R et al (9); (2006) did a detail study related to the instability in the gait of the elderly, and highlighted that the foot pressure information can be successfully used to design foot-wears, in order to improve the balance in the elderly. With regard to the above discussion, it becomes critical to device techniques which are capable of efficiently and effectively measuring, the plantar foot pressure so that, the information sought can be used in an effective manner in devising appropriate foot-wears, in those suffering from foot related problems.

The studies done by Mac Williams B A et al (10); (2000) has given a vivid description about the platform system which was used in the present study. The platform systems are flat in their structure and in them have a rigid array of pressure sensing sensors, which are arranged in a contoured matrix configuration. These platform systems are easy to use and have got a minimal wiring system. The patient however needs to walk his or her natural gait. It's mandatory in using these platform systems that the foot contact area is at the center of the sensing area, to get an accurate reading. Limitations include perfection of patient's ability, to make contact with the platform. These measurements are usually carried out indoors and occupy space. The feedback given from the sensors are fed into a computer and the plantar foot pressure map, is generated which helps in target implementation for the assigned defective foot. This analysis relaying on a base foot map, which has areas coded from Zone 1 to 15. Zone 1 being at the bottom of the heel and 10 representing ball of the great toe. The numbers 11-15 are assigned to form the little toe to the great toe. To summarize the sensor system in the platform type according to Bambarg S et al (11) ;(2008) Lee N et al (12) ;(2001) and Urry S et al (13); (1999) have had their performance gauged from linearity, hysteresis, in sensing size pressure range and temperature sensitivity. According to Madau et al; (14) (2001) low creep sensors are one of the key requirements in the foot pressure measurement. Lee N et al (12); (2001), also stressed on the fact that these sensors should have the ability to reproduce and repeat their readings at different timings. Hence, the importance of not only accuracy, but also reproducibility of the result, is stressed upon here.

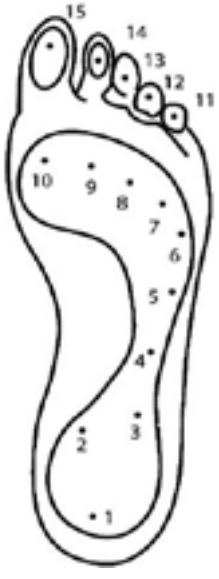


Fig.3: Pictographic representation of Base foot map coded from Zone1 to zone 15 (15).

CONCLUSION:

For assessing various foot pathologies, the platform model of plantar pressure sensory mapping is an efficient way to design custom made insoles and foot-wears. This has served as a panacea for those in the Sporting and the Athletic activity, young and middle-aged people with foot pathology and the elderly with neuropathic foot problems and gait imbalance. This study concludes that plantar foot pressure mapping, should be an integral part of the list of investigations, while trying to diagnose and treat the problems related to foot abnormalities and pathologies.

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