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Original Article

Foot Pressure Comparison Between Hallux Rigidus Patients and Normal Asymptomatic Matched Individuals Using Pedobarograph

應用動態足底測壓圖來比較患有大腳指基部退化性關節炎的病人與正常配對者足底壓力之差異

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ABSTRACT

Background/Purpose: We present a study comparing the plantar pressures of hallux rigidus patients with that of asymptomatic feet. The aim was to find new means that could be used in further assessment and management of this condition.
Methods: We assessed foot pressure distributions in eight patients with hallux rigidus using the foot pressure pedobarograph system. This was compared with eight asymptomatic matched individuals. The foot pressures were assessed in the five key areas.
Results: The differences between the affected foot pressures and the normal foot pressures were statistically significant with a p value less than 0.05. The pressure under the hallux in the hallux rigidus patients was significantly less and associated with a significantly increased pressures in the hind foot and under the third, fourth, and the fifth metatarsal heads when compared with the asymptomatic matched individuals suggesting weight transfer onto the lateral and hind foot regions.
Conclusion: This study has demonstrated an increased pressure transmitted through the outer aspect of the sole of the foot in the patients suffering from hallux rigidus. This is helpful in choosing treatment options and managing hallux rigidus patients particularly when using conservative and foot wear considerations.

中 文 摘 要

引言：本文敘述一個比較患有大腳指基部退化性關節炎的病人與正常配對者足底壓力差異之研究，希望能 找出新的方法應用在評估和治療這個臨床病症。
方法： 我們採用動態足底測壓系統來評估八個患有大腳指基部退化性關節炎的病人之足底壓力分佈，並與八個正常配對者之足底壓力分佈比較，主要在五方面去評估其足底壓力。
結果：患者與正常配對者之足底壓力在統計學上有顯著的差異($p<0.05$) 。對比正常配對者，患有大腳指基部退化性關節炎的病人的大腳指底部壓力較小，但後足和第三、四及五跖骨頭底部壓力則較大。這顯示負重轉移到足部的外側和後端位置。
結論： 這研究顯示患有大腳指基部退化性關節炎的病人的負重會轉移到足底的外側，可以幫助我們選擇不同的治療方法，尤其是保守性治療和足履選擇方面。

Introduction

Hallux rigidus, also known as hallux limitus, is a condition affecting the first metatarsophalangeal joint. It is the second most common deformity of the metatarsophalangeal joint after hallux valgus, with greater symptoms and disability. Dorsiflexion at the metatarsophalangeal joint is severely restricted and painful.[1] The diagnosis of hallux rigidus is based on the presence of pain in the first metatarsophalangeal joint and physical findings of restricted dorsiflexion (<30°), increased joint bulk mainly dorsally, and often an associated synovitis.[2]

Plantar pressure patterns have been described as a mean to identify the effects of surgery (cheilectomy) on the metatarsophalangeal joint motion in comparison with the same patient's normal foot previously.[3] Our study was to compare the

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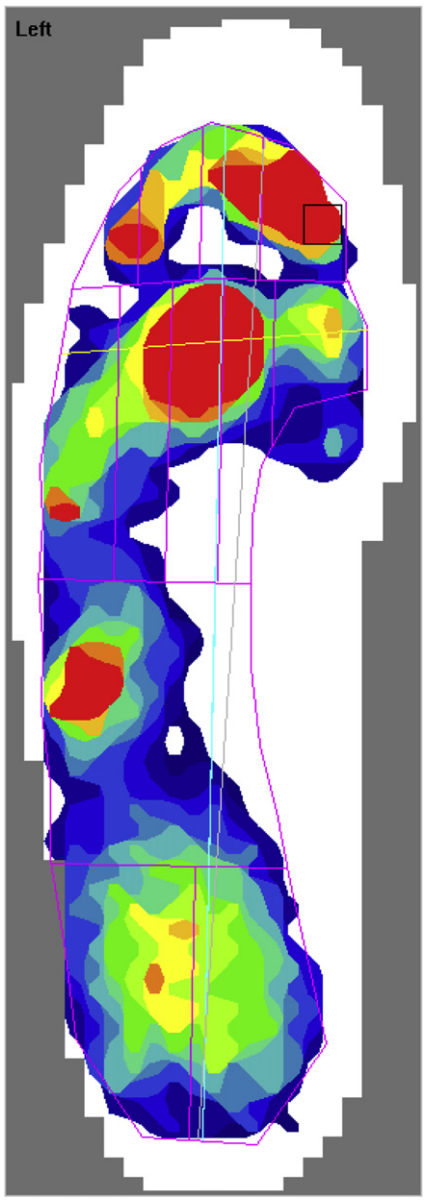

Figure 1. Picture showing a foot map divided into different areas measured using F-scan Pedobarograph. Normal Left foot (full gait cycle).

Figure 2. Picture showing the F-scan Pedobarograph system set up using insoles.

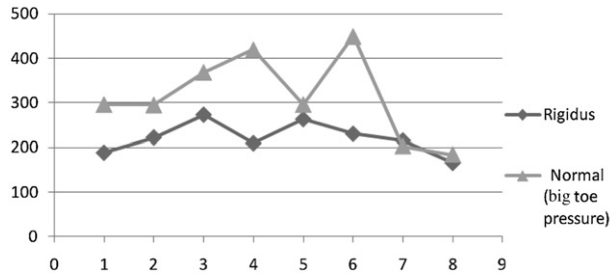

Chart 1. Peak pressures under the hallux.

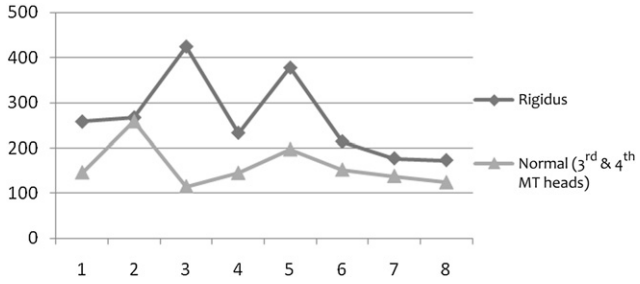

Chart 2. Peak pressures under the third and fourth MT heads. MT = metatarsal.

plantar pressure footprints of hallux rigidus patients to that of matched asymptomatic individual's feet. The aim was to find new means that could be used in further assessment and management of this condition.

Methods

We assessed the foot pressure distributions in otherwise eight healthy patients with unilateral Grade III hallux rigidus[4] using the foot pressure pedobarograph (Figure 1) system and F-Scan computer software (Tekscan Ltd, Boston, Massachusetts, USA). The calibration of the F-Scan insoles was done before measuring the pressure for each individual by inputting the weight of the patient in kilograms into the computer software; the F-Scan software then calibrates all the sensors in the insoles (Figure 2) for that particular weight by using the software pressure constant. The foot area was divided into hallux, first metatarsal head, second metatarsal head, third and fourth metatarsal heads, fifth metatarsal head, midfoot, and hindfoot. Five steps were collected for each foot and the peak pressure of the five steps was then documented. We have opted to allow the patients to walk at a self-selected normal speed. The pressures in the affected foot were compared with eight asymptomatic individuals matched for age and sex. The foot pressures in the five key areas are demonstrated in the graphs below (Charts 1–5). We compared the results using paired *t* test for statistical significance using SPSS statistical software (SPSS, Inc., Chicago, IL, USA). The pressures are demonstrated in Pascal.

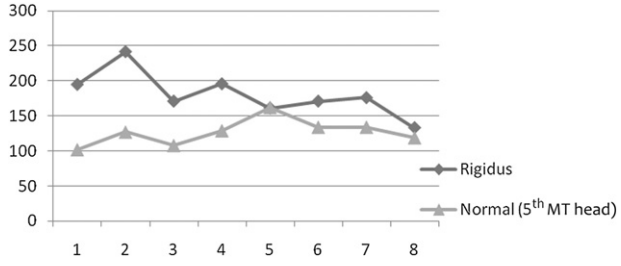

Chart 3. Peak pressure under the fifth MT head. MT = metatarsal.

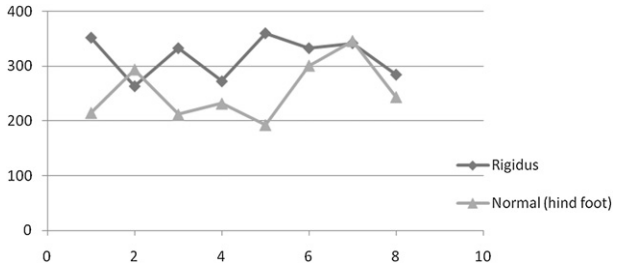

Chart 4. Peak pressure under the hindfoot.

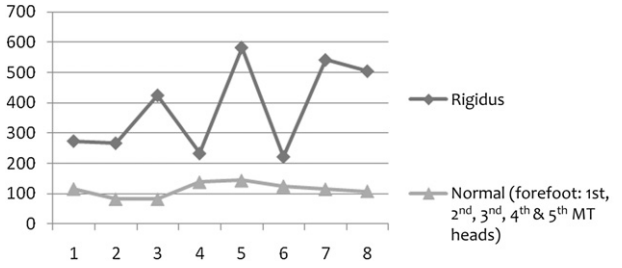

Chart 5. Peak pressure under the forefoot (first, second, third, fourth, and the fifth MT heads). MT = metatarsal.

Results

The results are shown in the Table 1. The foot pressures were measured in Pascal.

Discussion

Hallux rigidus is recognised as a common form of osteoarthrosis[5] and is most commonly seen in middle-aged patients but can develop during adolescence. Although most of the causative factors described in the literature appear to be poor evidence, historic, and anecdotal, there appears to be sufficient clinical evidence available to suggest that trauma, flat, square- or chevron-shaped metatarsal head, short first metatarsal, and family history could be associated with the development of hallux rigidus.[6]

The symptoms of hallux rigidus can produce an altered gait and a plantar loading pattern when patients attempt to avoid pain and compensate for motion restriction at the first metatarsophalangeal joint.[7] Grade III hallux rigidus patients have moderate to severe pain that may be constant.[4] This pain combined with a notable loss of dorsiflexion may account for the demonstrated gait pattern.

In our study, the pressure under the hallux in the hallux rigidus patients was significantly less than the pressure under the hallux of the asymptomatic matched foot suggesting an element of off-loading from the painful area in the hallux rigidus patients. This is further confirmed by significantly increased pressures in the hindfoot and under the third and fourth metatarsal heads, fifth metatarsal heads, and the forefoot of hallux rigidus patients when compared with asymptomatic matched individuals suggesting offloading again from the painful hallux area and transferring weight onto the lateral and hindfoot regions. This gives us a good idea about how foot pressures are distributed both in the normal foot and in patients with hallux rigidus. This is helpful in choosing treatment options and managing hallux rigidus patients

Table 1
Foot pressure distribution

Pressure distribution	Abnormal foot (mean)	Normal foot (mean)	*p*
Pressure under the hallux	220.6	314.7	<0.05
Pressure under the first metatarsal head	255.5	276.8	>0.05
Pressure under the second metatarsal head	276.8	310.1	>0.05
Pressure under the third and fourth metatarsal head	265.6	159.5	<0.05
Pressure under the fifth metatarsal head	180.6	126.9	<0.05
Pressure under the midfoot	140.8	151.5	>0.05
Pressure under the hindfoot	317.8	254.6	<0.05

particularly when using conservative and foot wear considerations. Foot pressure considerations are helpful even in surgical management. Many surgical treatments of hallux rigidus have been described, including resection arthroplasty (Keller's procedure),[8] cheilectomy,[2] arthrodesis,[9] Moberg osteotomy,[10] and implant arthroplasty.[11] Foot pressures taken in these patients post-operatively again will be helpful to see if pressures and distribution of pressures are normalised following surgery. Our study does have its limitations as we need more patients and we only looked at Grade III hallux rigidus. The inclusion of different grades and postoperative patients would provide more valuable information.

Conclusion

This study has demonstrated an increased pressure transmitted through the outer aspect of the sole of the foot in patients suffering from hallux rigidus. The results of this study give us a good insight into foot pressure distributions in hallux rigidus patients and encourage further research in this area to develop new means to address this pathology and give us the opportunity to plan our treatment strategy and operations accordingly.

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