A comparison of various types and thicknesses of adhesive felt padding materials in the reduction of peak plantar pressure of the foot. A case study.

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Abstract

Introduction

This case report will have implications to any area of medicine that aims to redistribute plantar pressure away from a particular area of the foot. This could be for example in the short term care of people with diabetes, people who have insensate feet and people with poor blood supply to the foot coupled with plantar ulceration. The aim of the study was to investigate which type and thickness of Hapla felt padding material is the most effective at redistributing plantar pressure of the foot. This case report is the first of its kind.

Case Presentation

The participant was a healthy fifty year old white male with a high peak plantar pressure over the second metatarsal head of both feet who required removal of plantar callus on a periodic basis.

Conclusion:

The reader should note that different types of Hapla felt padding provide different forms of redistribution of plantar pressure on the foot. In the clinic it may be useful to measure peak plantar pressure using FScan before deciding on the most appropriate type of felt padding material.

Words

Felt, Padding, plantar, pressure, Foot, FScan.
1 Introduction.

A healthy 50 year old white male presented with long standing painful plantar callus over the second metatarsal head that has required podiatry treatment to remove the callus. After removal of callus the area was often painful and required the use of felt padding material to provide offloading of plantar pressure before orthoses were prescribed for long term treatment of the condition.

Felt padding has been used for a long time as a material for redistribution of foot pressure from various parts of the plantar surface of the foot, although there is little published research on the effect of felt on plantar pressure. According to Nube et al [1], the purpose of felt padding is to deflect pressure away from a particular area of the foot. They demonstrated that plantar pressure can be reduced in people with diabetes by the application of felt padding that is adhered to the foot. They argued that foot ulceration in diabetes is precipitated and perpetuated by many factors, chiefly peripheral neuropathy and biomechanical abnormalities but offloading of plantar pressure is a key element in the management of diabetic neuropathic foot ulcers. The technique principally involves the adherence of felt or felted-foam to the sole of the foot, with an aperture cut into the material which corresponds with the ulcer location. Varying thicknesses of felt and methods of adhesion are used. Homes [2] assessed the effect of a simple metatarsal pad on pressures transmitted to metatarsal heads. Using measurements of dynamic pressure for 100 participants with and without met pads using a Pedobaragraph. They concluded that, when properly positioned, met pads can be an inexpensive and effective means of reducing plantar pressure. This is similar to the findings of Hayda [3] who evaluated 10 volunteers with normal, asymptomatic feet. Plantar pressures were measured within the shoe. Test conditions included large foam, large felt and small felt situated at three different positions. They concluded that metatarsal pads can effectively decrease plantar pressure in the shoe. A study by Zimny [4] evaluated the effects of felted foam on wound healing in diabetic foot ulcers compared with a standard method of plantar pressure relief. All patients received identical standard ulcer wound care including debridement and daily careful monitoring of the ulcer. The patients were randomized to pressure relief in the ulcerated area either with felted foam dressing, or with a pressure relief half-shoe (Thanner, Hoechstaedt, Germany). They demonstrated that by using this felt and foam dressing using a combination of 0.635 cm thick rubber foam with a 0.158-cm layer of felt it appeared to be as effective as conventional plantar ulcer treatment using the pressure relief half shoe. They postulated that it may be a useful alternative in treating neuropathic foot ulceration, especially in patients who are not able to avoid weight-bearing reliably. Paton [5] studied the effect of 7mm semi-compressed felt plantar cover padding, with a U shape cut out to the 2nd metatarsal head, on forefoot peak pressure and forefoot pressure time integral. Both feet of 10 healthy subjects were studied. The F-scan in-shoe pressure analysis system compared the dynamic measurements for each subject, padded and un-padded. Related sample t-tests analyzed significant differences between test conditions. The peak pressure (PP) and pressure time integral (PTI) at the centre of the 'U' decreased by a mean of 25% and 29% respectively. The PP and PTI at the periphery of the 'U' increased by a mean of 44% and 58%, 24.178 kPa sec. Exactly what is determined as high peak plantar pressure in causing foot ulcers is debatable but Armstrong [6] found that peak plantar pressure was, as expected, significantly higher for patients with ulcers compared to controls [83.1 +/- 24.7 N/cm² (range, 10-125) vs. 62.7 +/- 24.4 N/cm² (range, 7.3-113), p < .001]. The ulcer group was clearly skewed toward a higher prevalence of elevated peak plantar forefoot pressure compared with the control group. They concluded that, while there is no optimal cut-point for clearly screening patients for risk of foot ulceration, the higher the peak pressure, the higher the commensurate risk. It can therefore be deduced from the literature that felt padding can play an important role in the management of patients foot health but more research is required in this area as there is a variety of types and thickness of felt available on the market.
Case presentation

A fifty year old healthy white male with a body mass of 108 kg had repeated callus form underneath the second metatarsal head. The patient had the callus removed every 6 weeks by a podiatrist and then had some padding applied to alleviate the pain. The aim of the case study was to investigate which combination of adhesive felt padding material and thickness of material is the most effective at redistributing plantar pressure of the foot compared to a control of no felt padding material.

In order to measure the amount of plantar pressure present on the second metatarsal head F Scan sensors were fastened to the inside floor of the patients shoes using double sided tape to avoid sensor movement and reduce likelihood of crinkling. The shoes were of a flat slip on type. The sensors were ‘conditioned’ prior to calibration as recommended by the FScan user manual. (This consisted of wearing in for 20 steps or so, allowing the participant to become accustomed to the sensors and sensors accustomed to temperature within the shoe.) The participant wore a standardised thin pair of socks so as to avoid any additional pressure redistribution. The F-Scan equipment was calibrated (using the participant’s previously recorded mass) using the point calibration procedure as recommended in the FScan user manual. Calibration was performed at the beginning and end of data collection to ensure the sensor was performing consistently throughout. The participant selected demonstrated a high peak plantar pressure over the second metatarsal head of both feet. Five different types of material that could be adhered to the plantar surface of the foot were obtained (see table1)

Not all thicknesses were available for all types of felt. A cardboard template was used to cut out the padding material to ensure the same amount of felt was used and the design of the pad remained constant.

![Figure 1 Plantar Cover Pad with U to second metatarsal head.](image)

The adhesive felt padding materials were stuck to the plantar surface of both feet using the adhesive sticky back integral to the felt pad. (See Figure 1) Readings were obtained from a cycle of gait lasting 20 seconds, this resulted in 15 complete gait cycles per foot. This was then repeated 5 times for each felt, so 75 readings per foot for each felt. A total of 450 readings were completed per foot including a control. The participant completed several gait cycles whilst wearing the FScan sensors to monitor...
plantar pressure. The participant was in control of triggering the start of the recording, allowing comfort and normality of gait to be achieved by the participant before recording began. A treadmill was used to find a comfortable walking pace for the participant, this pace (3.6km/h) was then used to keep speed of gait consistent. The readings which comprised the final data were taken when the participant was walking on the treadmill. The padding was then removed from the foot after 5 runs and another piece of material applied and the participant repeated the procedure until all five of the materials had been used and the results recorded before they were entered into SPSS version 20.

Readings were also taken of plantar pressure across the metatarsal head area with no padding material to act as a control. Sensors were used for a maximum of 10 runs to prevent the possibility of sensor degradation. Calibration was performed each time the sensors were changed. The F-scan software was then used to view the entire foot strike at one time, as a "stance". This groups one gait cycle (heel strike through to toe off) into one picture. It was decided to record the peak pressure across the whole metatarsal head area on the FScan software, the software still locates the point of highest peak pressure, but this point could be on any of the metatarsal heads. The alternative would be to take readings for each individual metatarsal head, however using the FScan software it is difficult to clearly, consistently and accurately define each individual metatarsal head.

The research participant exhibited overloading on the 2nd metatarsal head and the felt padding was designed to reduce the pressure under that point. However, if the off-loading then shifted peak pressure to another metatarsal head there would be a risk of this new point of peak pressure being overloaded. So, for example, a reduction of pressure under the 2nd metatarsal head from 500 kPa to 250 kPa would be useful but if pressure under the third metatarsal head is increased to a peak of 550 kPa then this may produce unwanted problems, so changes in pressure across the whole metatarsal head region were considered.

The metatarsal Head region was defined using the FScan software and the researchers’ knowledge of the foot. By using the stance function in the FScan software, a graphical representation of loading across the foot, for a full gait cycle can be seen. With a basic knowledge of the anatomy of the foot the metatarsal head region can then be visually defined by using the add/edit box feature within the software. This allows peak pressure readings to be obtained solely from the defined area.

In addition a full assessment of the peak plantar pressures at and on the periphery of the cut out on the felt padding was undertaken. This was necessary to establish if the cut out is increasing peak pressures in the periphery. To this end, we ran through one cycle of 7mm felt (14 data points). We used a box across the whole metatarsal area and boxed each periphery of the cut out. No increase in peak plantar pressure at the periphery of the cut out was found.

**Statistical analysis**

This is a single subject study with intra-participant replication. The mean peak pressure (with no felt) for the participant’s left foot was 586.68 kPa (n=75) with a standard deviation of 20.13 kPa and for the right foot the mean was 600.01 kPa (n=75) with a standard deviation of 20.03 kPa. This indicates that the variance is approximately the same between the two feet but the peak pressure under the right metatarsal heads is greater than that on the left (see figure 2).
The results for this study are presented graphically for visual analysis. The results for each felt (and control) were obtained from 75 repetitions. Because the results for left and right foot were different, they are presented separately.

For the left foot, the control condition (no felt) produced the highest pressures, with 5mm Mixture felt producing an approximately 30% mean pressure reduction. 5mm Soft felt produced a further slight pressure reductions. The three 7mm felts (Soft, Foam-O-Felt and Gold felt) gave the best pressure reduction (see figure 3).
Figure 3: Box plot of the peak pressures under the metatarsal heads for each felt, and without felt (control) for the left foot.

For the right foot, the pressure reduction was generally lower than for the left and the performance of the different felts was different to that seen previously. 7mm Foam-o-Felt gave the best pressure reduction, being slightly better than both 5mm Mixture Felt and 7mm Gold felt. 7mm Soft felt also shows a pressure reduction compared to the control. Interestingly, the 5mm Soft Felt produced a higher peak metatarsal head pressure than using no felt (see figure 4). The descriptive statistics for each foot and each felt are shown in Table 2.
Discussion

The aim of the study was to investigate which felt padding material would be the most effective at redistributing plantar pressure of the foot compared to a control of no felt padding material. Previous authors [1] [2] [3] found that felt padding was useful in the deflection of plantar pressure and in the prevention of tissue damage. This case study demonstrates that 7mm felt padding materials produce greater pressure reduction than the 5mm felt padding material. However, there were laterality differences in the redistribution of plantar pressure by the felt padding materials. For the left foot, where the peak plantar pressure for the control is lower than the right foot, then 7mm Gold felt padding, 7mm Foam-o-Felt padding and 7mm Soft felt padding produced the greatest pressure reduction and were similar to each other. For the right foot, where the pressure was significantly higher than the left foot, 7mm Foam-o-Felt padding gave the best pressure reduction, being slightly better than both 5mm Mixture Felt and 7mm Gold Felt which were statistically indistinguishable. 7mm Soft Felt also gave a statistically significant pressure reduction compared to the control. There was one anomaly in that there was an increase in pressure after using 5mm soft felt on the right foot. A possible explanation is that for this participant this form of felt may not be able to redistribute plantar pressure as the thickness may decrease immediately.

Two authors have stated that the application of appropriate padding material to the foot is useful in both first line treatments of ulcers [4] [6]. To this end, this study has provided an insight into which specific types of felt and which thickness of felt provides for optimum redistribution of plantar pressure. It may be useful to measure peak plantar pressure before deciding which type of felt padding material to use and this may be very useful when using felt padding materials for specific patient groups where redistribution of pressure is critical for example where a patient has diabetes and a plantar ulcer. The study design has the disadvantages of results from only one participant.
albeit with a significant higher peak plantar pressure under one foot (right) than the left foot. However, it had the advantage of holding other variables constant for example body mass and no anatomical variation or gait idiosyncrasies between different participants. It would be interesting in further studies to see what effect parameters such as foot type, variations in foot wear and increasing gait velocities would have on the results and to what extent the natural variability between individuals affects the effectiveness of different felts. Paton [5] demonstrated that cut outs in felt padding can increase pressures at the periphery of the cut out and this may be detrimental to a patient with for example poor tissue viability. Our study shows that the peak pressure with the padding, even at the edge of the cut-out, is lower than the peak pressure without padding over the second metatarsal head. Padding reduced peak pressure compared to the control and this included the periphery of the cut out as well as under all other metatarsal heads. This takes into account any undesirable shifting of high pressure from the padded area to the other metatarsal heads through, for instance, changes in gait resulting from the addition of the padding. The present study was not a longitudinal study and that no information is available at present to suggest how long the felt padding will be effective in pressure redistribution nor when the padding should be changed. In this study peak plantar pressure was measured immediately after its application but it would be interesting to find out what happens after a longer period of time has elapsed say 24 to 48 hours later. This could have some influence in the offloading effect especially in people with poor tissue viability.

6) Conclusion

7mm felt padding materials produce a greater reduction in force than 5mm felt padding materials. It may be worth measuring peak plantar using FScan as felt padding materials may behave differently with different levels of peak plantar pressure. Where peak plantar pressure is high 7mm Foam-O-Felt is the best choice of felt padding material. This study may have implications to any area of medicine that redistributes peak plantar pressure. This may be particularly important in the short term management of people with diabetes or those who have insensate feet and plantar ulceration.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Competing interests

The authors declare that they have no competing interests.

Authors Contributions

CR was responsible for setting up and using FScan and collating the data. JC provided advice on the statistics. MC interpreted the patient data. All authors read and approved the final manuscript.

Author’s information

MC is Associate Professor in podiatry at the University of Northampton and CR is a Research podiatrist. JC is a Professor and Statistician at The University of Northampton.

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References


Table 1 Types of material used and thickness.

<table>
<thead>
<tr>
<th>Type of padding material</th>
<th>Thickness of the material</th>
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<tbody>
<tr>
<td>Hapla Soft felt</td>
<td>5mm</td>
</tr>
<tr>
<td>Hapla Soft felt</td>
<td>7mm</td>
</tr>
<tr>
<td>Hapla Mixture</td>
<td>7mm</td>
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<tr>
<td>Hapla Gold</td>
<td>7mm</td>
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<tr>
<td>Hapla Foam-o-Felt</td>
<td>7mm</td>
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</tbody>
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Table 2: Peak pressure descriptive statistics

<table>
<thead>
<tr>
<th>Felt</th>
<th>Peak pressure (kPa) under metatarsal heads (mean (sd) [max, min])</th>
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<tbody>
<tr>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>Control</td>
<td>586.68 (20.13) [531,612]</td>
</tr>
<tr>
<td>5mm soft</td>
<td>362.91 (50.55) [255,525]</td>
</tr>
<tr>
<td>5mm mixture</td>
<td>409.49 (56.71) [295,554]</td>
</tr>
<tr>
<td>7mm soft</td>
<td>313.32 (42.74) [216,434]</td>
</tr>
<tr>
<td>7mm foam</td>
<td>309.45 (55.72) [208,472]</td>
</tr>
<tr>
<td>7mm gold</td>
<td>306.73(32.35) [215,377]</td>
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