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An Analysis of Skin Perfusion Over the Achilles Tendon in Varying Degrees of Plantarflexion

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ABSTRACT

Delayed wound healing and, less commonly, wound breakdown are significant complications following open Achilles tendon repair. Skin perfusion over the Achilles tendon may be reduced when the ankle is plantarflexed. The aim of this study was to analyse skin perfusion over the Achilles tendon with the ankle in varying degrees of plantarflexion in 20 volunteers. Skin perfusion was determined by measuring the transcutaneous skin oxygen pressure (tcPO2) using the Novametrix TcO2M 860 monitor. Measurements were taken at the medial edge of the Achilles tendon in 20 volunteers.
Skin perfusion was maximal with the ankle plantarflexed to 20°. With plantarflexion beyond this skin perfusion was reduced. At 40° plantarflexion skin perfusion was reduced by up to 49% (mean 35%, range 27% to 49%).
We conclude plantarflexion beyond 20° reduces skin perfusion in the region of the Achilles tendon. Though this study was performed on non-operated cases, and is thus limited, the findings may have clinical implications with regard to cast position following Achilles tendon repair.

INTRODUCTION

Open repair and application of a protective equinus cast is a common method of treating Achilles tendon rupture.[1,2,10] The optimum duration of immobilisation and degree of initial plantarflexion in cast varies. Major wound necrosis following open Achilles tendon repair is uncommon (0.4% to 2%).[2,6] However, minor wound edge necrosis and delayed healing occur more frequently (1% to 5%)[2] particularly in patients who are elderly, receiving corticosteriods, or suffering from connective tissue diseases.

We have observed that sustained blanching of the skin over the Achilles tendon occurs as the ankle is plantarflexed. This would imply a reduction in perfusion to the skin in that area. This may be clinically important as a similar effect may be induced by the application of an equinus cast.

Skin perfusion can be measured accurately and non-invasively by measuring the transcutaneous oxygen pressure ($tcPO_2$).[3,5] This has been shown to relate directly to blood flow in normal skin.[4]

The aim of this study was to determine the effect of plantarflexion on skin perfusion in the region of the Achilles tendon and to quantify any changes observed.

MATERIALS AND METHODS

The transcutaneous oxygen pressure was measured using the Novametrix TcO2M 860 monitoring system. The measurement probe consisted of a Clarke type electrode that was applied to the skin by a self-adhesive ring. The probe temperature was set at 44°C. At this temperature maximum cutaneous vasodilation was induced and therefore skin perfusion was not affected by changes in ambient temperature.

Oxygen diffusion through the skin was measured by the polarographic technique. The level of oxygen was displayed as $tcPO_2$ on the monitor. Prior to use the system was calibrated using an in built fully automatic two-point sensor calibrator.

Readings were taken when a steady state was achieved, usually after 15 to 20 minutes. All measurements were taken with the subject seated with the leg dependent. The position of the leg was not altered for the duration of the experiment.

Twenty volunteers were recruited with a mean age of 34 years (range 22 to 60). All were healthy with no underlying medical conditions and normal peripheral circulation. Smokers and diabetics were excluded.

The probe was applied to the medial edge of the Achilles tendon as shown in figure 1. Once an equilibrium was achieved the $tcPO_2$ was measured with the ankle in the neutral position, i.e. 0°. The ankle was then plantarflexed passively in increments of 10°, measured using a goniometer, until plantarflexion of 40° was achieved (Fig. 2). The goniometer used was

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accurate to 1° and was taped to the subject's ankle. The ankle was held in each new position by the investigator until a steady reading was obtained and this was recorded.

Reproducibility of the test within the subject group was confirmed on repeated testing. Data was analysed using the Student's t-test, repeated-measures one-way analysis of variance (ANOVA), and Spearman correlation.

RESULTS

In all subjects an ankle position of 20° plantarflexion gave optimal $tcPO_2$ readings. With further plantarflexion $tcPO_2$ levels usually began to fall. At 30° plantar flexion perfusion fell by an average of 13.6% (range 8% to 21%) ($p < 0.01$). The decrease in $tcPO_2$ became more pronounced ($p < 0.0001$) at 40° plantarflexion in all cases except three, with an average fall of 35% (range 29% to 59%). In three cases the $tcPO_2$ initially fell between 20° and 30° however it rose between 30° and 40°. In one case the rise in $tcPO_2$ was minor, in the remaining two the reading remained lower than that at 20°.

The $tcPO_2$ was also noted to fall as the ankle was moved from 20° plantarflexion to 10° plantarflexion and then to 0°. With average reduction in perfusion of 12.7% (range 5% to 20%) and 15% (range 9% to 23%) respectively ($p < 0.01$). The mean $tcPO_2$ values recorded at the above ankle positions are shown in table 1. Table 2 gives the mean reduction in $tcPO_2$ at 0°, 10°, 30° and 40° plantarflexion compared to the resting position of 20° plantarflexion. Percentage fall in $tcPO_2$ is also given.

Figure 3 illustrates the relationship between ankle plantarflexion and $tcPO_2$ for each subject. Given the range of age of the subjects in this investigation a correlation between subject age and $tcPO_2$ for each ankle position was performed. No significant relationship was found.

DISCUSSION

Wound breakdown following open Achilles tendon repair, when it occurs, leads to considerable morbidity and presents the surgeon with a significant management problem. Usually, wound complications are of smaller magnitude with focal areas of wound edge necrosis leading to delayed healing and/or sinus formation.[2]

The patients most prone to wound complications following Achilles tendon repair are those with poor skin quality and reduced healing capacity. The elderly, patients on corticosteriods and those with connective tissue disorders are at risk.

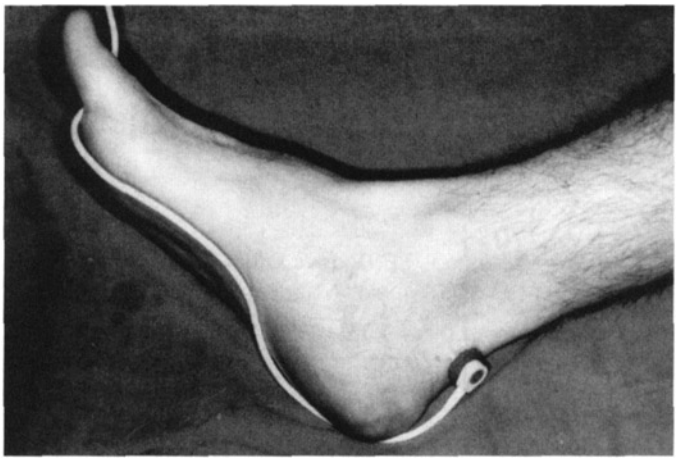

Fig. 1: Position of probe at the medial edge of the Achilles tendon.

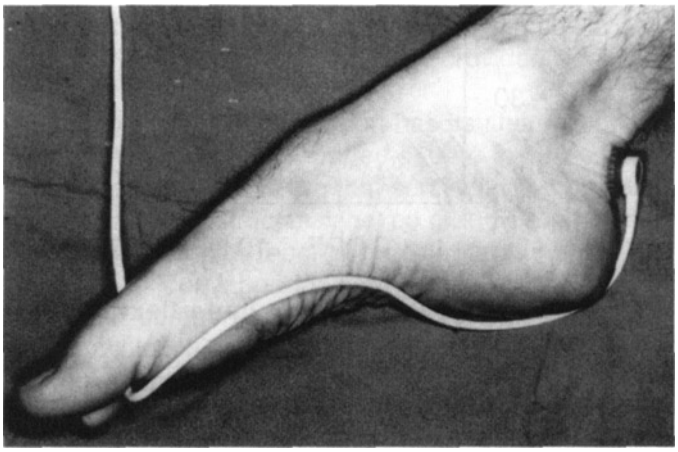

Fig. 2: Ankle fully plantarflexed.

Table 1: Mean $tcPO_2$ in varying degrees of plantarflexion

Degrees plantarflexion	Mean $tcPO_2$ ± SD (mmHg)	Range $tcPO_2$ (mmHg)
0	55.4 ± 8.4	40 - 75
10	56.8 ± 8.9	41 - 78
20	65.0 ± 8.8	50 - 82
30	56.2 ± 7.6	42 - 71
40	42.3 ± 8.1	29 - 59

Table 2: Mean reduction in tcPO2 with movement from the resting position (20° plantarflexion)

Degrees Plantarflexion	Mean fall in $tcPO_2$ ± SD (range)	Mean % fall in $tcPO_2$ ± SD (range)
0	9.6 ± 2.1 (7 - 14)	14.9 ± 3.3 (9 - 23)
10	8.6 ± 2.5 (4 - 12)	12.8 ± 4.4 (5 - 20)
30	8.8 ± 2.5 (4 - 16)	13.6 ± 3.3 (8 - 21)
40	22.7 ± 4.9 (15 - 35)	35.2 ± 6.9 (24 - 49)

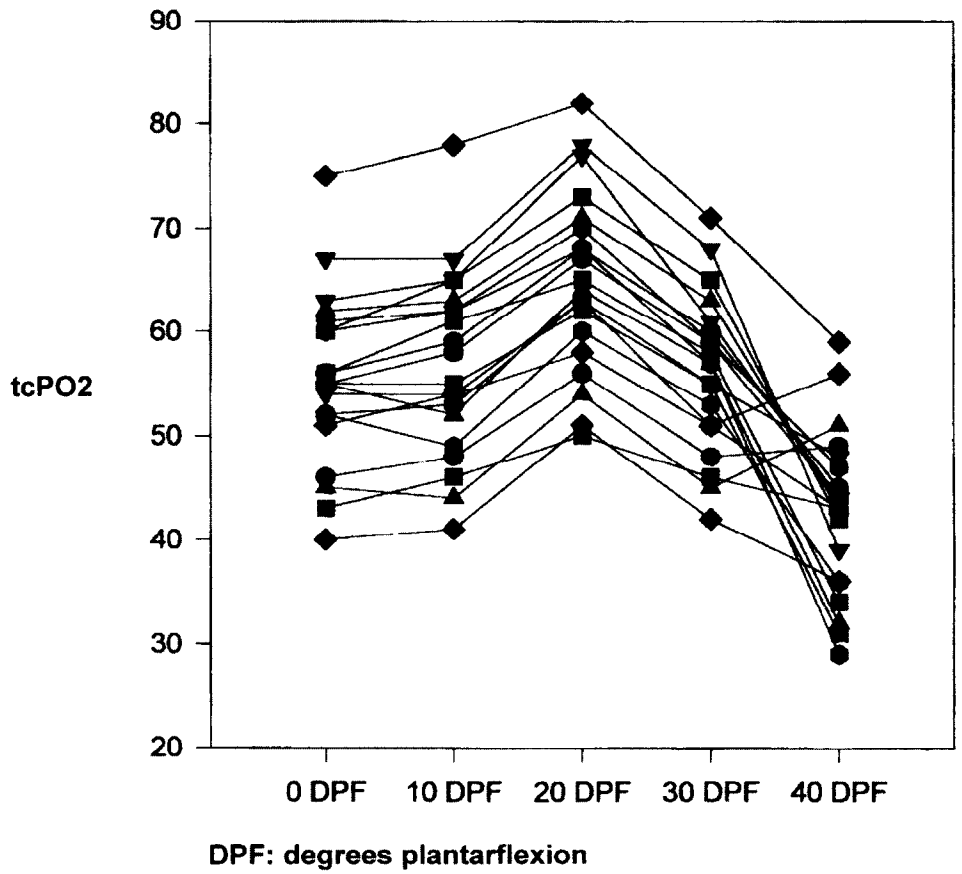

Fig. 3: $TcPO_2$ vs ankle plantarflexion.

The use of an equinus cast to protect an Achilles tendon repair is common practice.[9,10] The degree of plantarflexion used varies. From our own clinical experience it would appear that the poorer the quality of tissue repaired the more plantarflexion likely to be employed. This is particularly relevant to the above patient groups. This study has shown that $tcPO_2$ and hence skin perfusion in the region of the Achilles tendon varies with ankle position. Skin perfusion is at its maximum with the ankle in the resting position of 20° plantarflexion. Perfusion is reduced by plantarflexion beyond 20° and most significantly beyond 30°.

The findings of this study, while significant, are limited by certain factors. The subjects used did not have Achilles tendon repairs and thus the findings are not an accurate reflection of post-operative skin perfusion. Another methodological limitation was the use of a goniometer applied to the subject's ankle to measure ankle position. This may not give an accurate measure of true ankle position. It is however easy to use and is the method used in clinical practice and is therefore relevant.

Despite these limitations the findings of this investigation are significant. The reduction in skin perfusion observed may become an important factor in those patients with pre-existing skin compromise who are placed in a fully plantarflexed cast following open Achilles tendon repair. The question arises here whether reducing cast plantarflexion to improve wound profusion could possibly lead to an increased re-rupture rate. Several studies have shown that reducing plantarflexion or early mobilization does not increase re-rupture, however none specifically looked at compromised patients.[7,8,9]

In conclusion, an ankle position of 20° plantarflexion was found to give the best skin perfusion over the Achilles tendon. Plantarflexion beyond this may interfere with wound perfusion.

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