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Donor site morbidity of the medial plantar artery flap studied with gait and pressure analysis☆

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ABSTRACT

Background: The medial plantar artery flap (MPA) allows transfer of both glabrous (smooth and free from hair) and sensate tissue. It has been suggested that the non-weight bearing instep area of the foot provides tissue for transfer with minimal donor morbidity. However the abductor hallucis muscle and plantar fascia are dissected during flap harvest which may affect foot mechanics.
Methods: Patients were included who had undergone MPA flap harvest and were walking unaided. The majority of the patients studied had problems with soft tissues of their heels rather than trauma as a starting point. Laboratory normals and the patient's contralateral limb were used as controls. Gait and pressure analysis were performed using 3D gait analysis and high resolution pressure analysis.
Results: This study included 6 patients, with 5 chronic wounds (4 ipsilateral, 1 contralateral) and 1 traumatic ankle defect.
Questionnaire results: Enneking scores: 67.9% return to function; Foot Function Index scores: 39.1% loss of function.
Gait analysis: Significant differences were seen in kinetic and kinematic data.
Pressure analysis: The donor site group had significantly less pressure in the great toe (38.1 kPa vs. 78.1 kPa, $p = 0.013$), significantly slower transition through the midfoot (445.2 ms vs. 352.07 ms, $p = 0.016$) and increased impulse in the heel (3.1 kPa/s vs. 11.7 kPa/s, $p = 0.038$).
Conclusions: This study demonstrates subjective and objective evidence of MPA donor site morbidity. Comparison to other studies looking at gait and pressure changes seen after flap reconstruction of the plantar region suggest that much of this difference may be attributable to ipsilateral reconstruction. As the majority had chronic problems with the soft tissues over the heel some of these biomechanical responses could be related to learned behaviour preoperatively or continued discomfort in the heel pad. Nonetheless it demonstrates accurately the effect of the technique overall on the function of the foot. The changes in the region of the great toe may be solely attributable to MPA harvest. These results suggest that MPA harvest is not free of donor morbidity.

1. Introduction

The possibility of transferring glabrous (smooth and free from hair) skin to replace "like-with-like" from the instep originated in Mir y Mir's description of an instep graft to cover heel defects in 1954 [1]. The medial plantar artery flap's vascular anatomy has been studied in detail by Shahanan et al. in 1979 [2], and its use as a free flap described by Morrison et al. in 1983 [3]. Since then it has been used to cover local wounds around the foot and medial ankle [4] and as a free flap to cover hand and finger defects [5].

In the senior author's experience, it has proved a reliable and useful source of durable tissue in the management of plantar foot and ankle defects. The MPA donor site has previously been reported as having minimal morbidity [6,7], and is generally reconstructed with a split skin graft [6,7]. However in the harvest of this flap the plantar fascia is breached and a portion harvested with the flap. The abductor hallucis muscle is also sometimes divided to allow access to the neurovascular pedicle and

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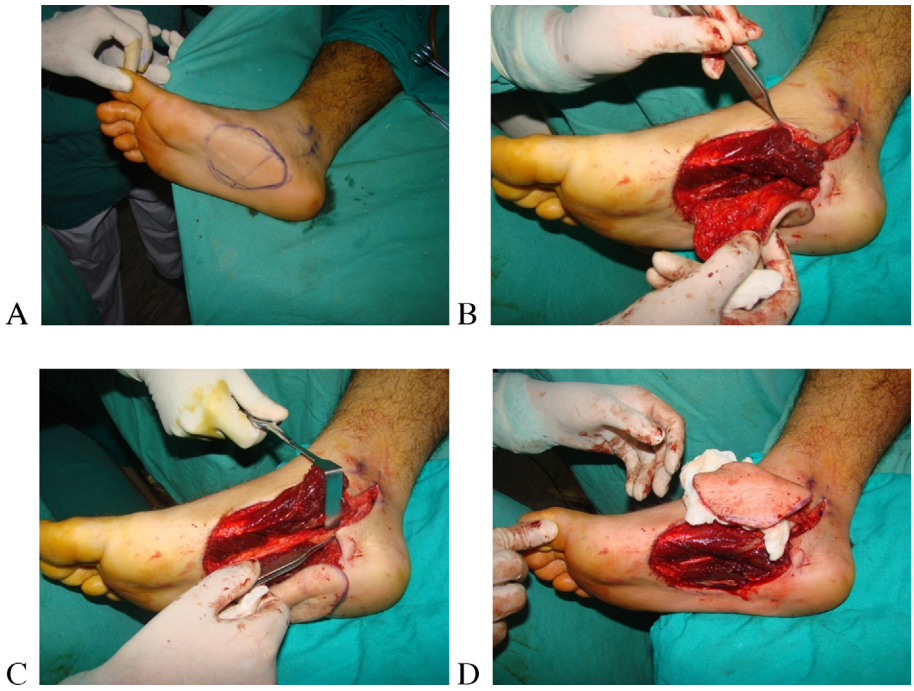

Fig. 1. Harvest of a medial plantar artery flap. (A) Markings of flap and planned incision for access to pedicle. (B) The flap is raised using a siege technique, plantar fascia is included in the harvest. The pedicle can be seen running under abductor hallucis muscle (held in the forceps). (C) Abductor hallucis muscle has been divided and retracted to allow access to the neurovascular pedicle. (D) Once the flap has been raised on the pedicle proximally, the abductor hallucis muscle is repaired.

subsequently repaired [7]. The steps in raising the MPA flap, summarised in Fig. 1, could have implications for the integrity of the medial plantar arch and hence foot and lower limb function.

To investigate the donor functional morbidity formally patients who had undergone a MPA flap reconstruction were assessed using a subjective Foot Function Index (FFI) questionnaire [8], and an Enneking questionnaire [9], as proxy markers for return of lower limb function and an assessment of pain. The donor side was objectively compared to the contralateral limb using 3D video gait analysis and dynamic pedodynographic analysis.

2. Patient selection and methods

Ethics approval was granted for this study by the South West regional ethics committee.

All patients who had undergone a reconstruction using a MPA flap from 2006 to 2011 at Frenchay hospital in Bristol were identified from medical and operative records and contacted for inclusion into this study. Patients who could not walk unaided or who declined to attend were excluded. The study group attended a clinic at the University of the West of England's Human Analysis Laboratory.

The 17 question FFI questionnaire and the 8 question Enneking score questionnaire were used to quantitatively assess subjective lower limb function. These were completed by a single investigator before the objective analysis. The donor site was then examined and photographed.

3. Gait analysis

The setup used was a 10 oqus camera Qualisys system sampling at 240 Hz, using Track Manager Version 2.5 software. The cameras emit pulsed infra-red light which allows collection of data from reflective markers strategically positioned on the research participant [10]. This produced three-dimensional information about kinematic data. The cameras were set up to cover a central run-way through the laboratory (5 m long and 2 m wide), with the Kistler force plate in the centre. This allowed calculation of resultant forces in active gait. The data acquisition field was calibrated for the Qualisys system in accordance with manufacturer's guidelines (Qualisys Inc., Gothenburg, Sweden). Data was analysed using Visual 3D version 4 software (www.c-motion.com) to generate temporal parameters, kinematic and kinetic graphs. This setup required that the force plate was walked on for each recorded run. Five runs were completed for donor and contralateral sides.

3.1. Pressure analysis

Dynamic plantar pressure data were collected during barefoot walking using the Footscan 3D 0.5 m pressure platform (www.rsscan.com) set flush in a 6 m long × 1.5 m wide walkway. The pressure platform was positioned on top of the Kistler force platform and constantly recalibrated by the Kistler to ensure accuracy. The pressure platform is a matrix containing 4096 force sensing resistor (FSR) sensors mounted on an aluminium plate with an elastic overlay, sampling at 500 Hz. Data were analysed within the software and converted to system international (SI) units. Five runs were completed for donor and contralateral sides.

3.2. Statistical analysis

Differences in objective data from gait and pressure analysis were compared between the donor and contralateral sides between patients with a paired Student's *t*-test. It was used under the assumption of heterogeneous variances of dependent sample sizes for comparison. A non-paired Student's *t*-test was used to compare donor data with laboratory normal values.

Due to the explorative observation nature of the study, a multiplicity correction was omitted. Data were considered statistically significant at a value of $p < 0.05$.