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Donor site morbidity after vascularized fibula free flap: gait analysis during prolonged walk conditions

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Abstract. The aim of this study was to determine the effect of vascularized fibula free flap (VFFF) harvest on gait variables during the six-minute walk test (6MWT). Eleven patients who had undergone VFFF harvest and 11 healthy peers participated in this case–control study. The main evaluation consisted of the collection of gait variables using the GAITRite system during three periods of the 6MWT: beginning (0–1 min), middle (2:30–3:30 min), and end (5–6 min). The 6MWT was significantly shorter in the VFFF group than in the reference group (−31%, $P < 0.001$). Most gait variables differed significantly between the groups for each period (P-value range 0.04–0.0004), including toe in/out on the operated side (P-value range 0.005–0.01). The increase in toe in/out on the operated side suggests a functional modification caused by an imbalance of the agonist–antagonist muscles. On comparison of the different periods, gait velocity decreased between the beginning and middle periods and increased between the middle and end periods in both groups. However, a significantly lower velocity between the beginning and end periods was found only for the VFFF group ($P = 0.026$), suggesting an alteration in physical management. In conclusion, these results suggest that VFFF harvesting could alter gait and joint integrity.

Key words: donor site morbidity; vascularized fibula free flap; head reconstruction; physical activity; gait; 6MWT; physical rehabilitation.

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The fibula is a common donor site in microvascular bone reconstructive surgery[1,2]. The vascularized fibula free flap (VFFF) was first introduced in the 1970s by Taylor et al.[3] and Gilbert et al., and was improved by Hidalgo in the late 1980s, who adapted this technique for the rehabilitation of segmental mandibulectomy defects[4]. The VFFF has become a standard flap for reconstruction of the oral and maxillofacial structures due to its readily available bone stock, the option of a composite flap, and the good quality vascular pedicle[5,6]. Generally, the VFFF is collected as a long segment of the fibula, and it is usually harvested with a skin paddle and the flexor hallucis longus or soleus muscles to close soft tissue defects[6].

Although it is generally considered that the VFFF is associated with a relatively low donor site morbidity rate (for a review, see Ling and Peng 2012[7]), several muscles of the leg and the foot are inserted in the fibula (e.g., tibialis posterior, peroneus longus, peroneus brevis, extensor digitorum longus, extensor hallucis longus, and flexor hallucis longus), and their detachment or the occurrence of a secondary lesion during VFFF harvest could induce deficits in donor leg function[8].

The role of the anterolateral and posterior leg muscles is to stabilize the talocrural articulation when mechanical compressions are created by the sudden change in tendon alignment[9]. The flexor hallucis longus, for example, plays an important role during the support and progression phases of the gait, by stabilizing the metatarsophalangeal joint in extension and increasing the support of the forefoot during the end of the support phase (i.e., from 30% to 55% of the gait cycle)[9].

Several studies have investigated the effect of VFFF harvesting on gait function. However, most of these studies only performed a subjective evaluation of the functional defects based on questionnaires and clinical examinations of walking[10–17], looking for signs of limping or ankle instability[13,18], the use of walking assistance[19], and questioning patients about any limitations in their walking distance[13,20]. These studies found that the donor site morbidity was generally small for most patients, principally related to the success of the harvested flap and the post-operative consequences.

To improve the analysis of morbidity following VFFF harvest, in particular related to gait function, some studies have used objective biomechanical temporal–spatial variables such as speed, cadence, and stride length. These objective studies found controversial results: several studies found that VFFF harvest did not result in a significant difference in general temporal–spatial gait variables between the control and operated groups[21–23] or between the operated and non-operated legs[24], whereas other studies showed that VFFF harvest could cause gait modifications such as a lower comfortable velocity[25,26], shorter step and stride length along with a longer stance phase[25], and an increase in coefficients of variation of stride time[26] in the operated group.

These previous studies evaluated gait over short distances. Only one study was conducted during prolonged walk conditions after a VFFF harvest; this study used the six-minute walk test (6MWT)[27]. After VFFF harvest, the patients walked on average 400 metres during the 6MWT, suggesting limitations in their walking ability. Indeed, the 6MWT has been considered a good evaluation of patient autonomy and a better determinant of the real effect of VFFF harvesting on everyday life activities[28]. Hence, measurements of the temporal–spatial variables during the 6MWT could bring new insights into the evolution of gait disorders in patients who have undergone VFFF harvesting — for example, determining when during gait the significant changes start.

Therefore, the aim of this study was to determine the effect of VFFF harvesting on temporal–spatial gait variables during the 6MWT.

Materials and methods

Participants

This was an observational case–control study. Patients were selected from a pool of patients who had undergone VFFF harvesting between January 2004 and February 2014 in the University Hospital of Besançon. Patients were operated on by two experienced surgeons and were included if they met the following eligibility criteria: (1) had undergone VFFF harvest for mandibular or upper limb reconstruction, (2) had no tumour or trauma in the lower limbs, (3) had no other neurological or orthopaedic deficits that could interfere with gait, and (4) had no cognitive deficits preventing an understanding of the test instructions. In addition, healthy persons were included as a reference (control) group. They had no motor or neurological deficit that could interfere with their gait. They were matched (±10%) to the patients for age, weight, height, body mass index, and sex. This study was approved by the local research ethics committee. Written informed consent was obtained from all participants.

Evaluation

Participants were evaluated for this study at the Laboratory of Clinical Functional Exploration of Movement at the University Hospital of Besançon (France). After providing written informed consent, the participants completed a questionnaire for the collection of demographic data. A practitioner then examined the participants to determine their clinical characteristics.

The gait evaluation was then performed in a dedicated room. After appropriate instructions and familiarization, the participants were provided with standard sports shoes and asked to perform the 6MWT. The test was performed in accordance with the American Thoracic Society instructions[29]. The 6MWT instructions were read before starting the test. The participants used any assistive device that they typically used and walked around the circuit, which was 24 metres long. Encouragement was given every 30 seconds (Fig. 1A).

During the 6MWT, temporal–spatial variables were recorded with a GAITRite system (CIR Systems, Inc., Havertown, PA, USA), an instrumented walkway embedded with pressure sensors sampled at 120 Hz. Three identical assessment periods of 1 min each were considered for further analysis: ‘beginning’, from baseline (0) to the end of the first minute; ‘middle’, from 2 min 30 s to 3 min 30 s; ‘end’, from the fifth to the sixth minute (Fig. 1B). An average 20 steps were recorded for each participant for the temporal–spatial analysis.

Ten gait variables were considered in this study: distance walked in 6 min (m), velocity (m/s), cadence (step/min), stride length (m), stride time (s), base of support (m), double support time (%), stance time (%), step length (m), and toe in/out (°). Toe in/out corresponds to the angle between the line of progression and the midline of the footprint. A positive value for toe-out occurs when the midline of the footprint is outside the line of progression; a negative value occurs when the footprint is inside the line of progression. For each participant, the stance time, step length, and toe in/out were measured for the operated side (left side for the reference group) and the non-operated side (right side for the reference group).

Statistical analysis

Given the sample size and non-normal data distribution, descriptive statistics were summarized as the median value and first and third quartiles. Comparisons between groups (i.e., VFFF vs. reference) were performed with the non-parametric Mann–Whitney *U*-test or the χ^2 test. Friedman one-way repeated measures analysis of variance (ANOVA) tests were conducted to compare periods (i.e., beginning, middle, and end) within groups, and post-hoc testing was performed with the Wilcoxon signed-rank test. This study used a level of significance of $P < 0.05$. The statistical analysis was conducted using Statistica version 10 software (StatSoft, Inc., Tulsa, OK, USA).

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