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Original article

Distance and speed of walking in individuals with trans-femoral amputation fitted with a distal weight-bearing implant

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ABSTRACT

Introduction: Preservation of femoral condyles in patients with knee disarticulation amputation (KDA) facilitates distal support inside the socket, compared to trans-femoral amputation (TFA), and allows the direct transfer of weight-bearing loads toward residual limbs.
Hypothesis: The hypothesis was that the gait distance and speed of TFA patients after a surgical femoral implant that allowed the distal support of the residuum would improve.
Material and methods: Twenty-three TFA patients received a titanium implant that allowed the distal weight bearing of the residuum inside the socket. The post-intervention follow-up period lasted 14 months. Gait distance and speed were assessed with the 2-minute walk test (2MWT).
Results: The amputation etiology was trauma in 11 patients (48%), peripheral vascular disease in nine (39%) and oncologic disease in three (13%). The mean 2MWT distance was 103.6 ± 34.7 m prior to femoral implant and 128 ± 38.9 m at 14 months, which implies an improvement of 24% ($p < 0.001$). The mean gait speed was 0.86 ± 0.29 m/s prior to femoral implant and 1.06 ± 0.32 m/s at 14 months ($p < 0.001$).
Discussion: After implant placement, distance covered increased by 24%. This value is higher than those described by other groups, such as Rau (12.6%) and Darter (19.2%), who assessed improvement in distance covered with the 2MWT in a younger population and after completing different physiotherapy programs. Our results showed improved distance walked and gait speed as well as in the physical functioning score in TFA patients 14 months after receiving a femoral implant that permitted distal residuum loading.
Type of study: An experimental prospective study.
Level of proof: III, case-control study.

1. Introduction

Despite advances being made in medicine and emphasis placed on disease prevention, limb loss continues to be prevalent in our society with impacts on function and quality of life as a result. In 2005, 1.6 million people were estimated to be living with limb loss, and by 2050, this rate is expected to double to 3.6 million in the United States [1]. The incidence of amputations is most commonly related to vascular conditions, trauma, malignancy and congenital deficiency; 60% of patients are male, and 80% are aged over 65 years [2]. In the literature, successful prosthetic fitting has been related to several factors, including level of amputation. In the geriatric population, reported prosthetic fitting rates vary between 47–90% for transtibial amputees and 14.5–70% for femoral amputees [3]. Thus it is ideal to retain the knee joint of a patient who requires amputation given its contribution to preserve ambulation [4].

When transtibial amputation is not viable, a more proximal knee disarticulation (KDA) or trans-femoral amputation (TFA) should be considered. KDA preserves femoral condyles, which facilitates fitting the socket with distal support for the residuum. In clinical terms, this distal support is the most important advantage that a KDA procedure offers because it permits a direct load transfer to the residual limb, which encourages greater walking independence and implies a lower energy consumption than TFA [5–10]. KDA, combined with polycentric (exoskeletal) prosthetic joints,

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can confer geriatric patients considerable walking stability [10], and therefore achieves better walking ability [11,12]. Hence KDA is preferable to TFA whenever possible [2]. In a preliminary study, Guirao et al. [13] reported the utility of femoral implant in a group of 10 TFA patients, which allowed the distal load of the residuum, and showed improved distances walked and gait speed for amputees 14 months after having received trans-femoral implant, especially in male patients, those aged older than 50 years, and patients with amputations of a vascular origin.

Distance and speed of walking achieved are considered determining factors in amputees' perception of quality of life, while inability to walk quickly is considered a sign of poor quality of life by 59% of patients [13,14].

We hypothesized an improvement in the walking ability, using the 2MW, after placing the distal weight bearing femoral implant in trans-femoral amputee patients. The goal was to assess the improvement in walking distance and speed, once they had the distal support of the residuum.

2. Methods

2.1. Participants

An experimental prospective study was performed on a group of 29 TFA patients who received a titanium implant that allowed the distal weight bearing of the residuum. Participants were recruited from March 1, 2011 to March 1, 2014 in the outpatient department of rehabilitation of the participant hospitals: hospital de Mataró (Barcelona - Spain), hospital La-Fe (Valencia - Spain), hospital Ntra. Sra del Rocio (Seville - Spain), hospital Ntra.-Sra.-De-la-Macarena (Seville - Spain) and hospital Ntra.-Sra.-De-la-Candelaria (Tenerife - Spain). The demographic sample data are shown in Table 1.

The inclusion criteria were as follows: unilateral femoral amputation; femur length of the amputated limb of at least 15 cm measured from the greater trochanter; use of prosthesis for at least 12 months and for more than 6 h per day prior to enrollment; ability to walk indoors or outdoors with or without supervision, and with or without ambulation aids. The exclusion criteria were: cognitive impairment that hinders the ability to follow instructions or to perform tests; body weight over 100 kg; active oncological pathologies; psychological disorders; previous residuum infection; active infection; residual femur length shorter than 15 cm measured from the greater trochanter; pregnancy; hip flexion deformity greater than 30°. Patients' maximum weight was determined by the biomechanical tests performed.

The post-intervention follow-up period lasted 14 months, and each patient underwent pre- and post-operative controls to assess the study variables. All the patients maintained the same prosthetic knees and feet used previously, and underwent surgery by the same surgical team. This study was approved by the ethical committee of Mataró Hospital. All the participants gave their informed consent.

2.2. Implant

The femoral implant used in this study was composed of three pieces (Fig. 1) [13]. The femoral stem consisted of a titanium alloy (Ti-6Al-4 V) to facilitate anchoring inside the residual femoral canal. The second piece was a spacer made of high-density polyethylene (UHMWPE), which was distally connected to the stem by the third piece, this being a titanium screw/a polyethylene plug. The spacer or cushion allowed the distal support of the residuum inside the socket (Fig. 2). No changes as regards the preliminary study by Guirao et al. were made [13].

Table 1
Demographic characteristics of the study sample.

Variable	Value**	*p*-value***
Age (years)*	51.3 ± 15.2	
Sex**		
Males	18 (80%)	
Females	5 (20%)	0.001
Mass (kg)*	67.6 ± 12.8	
Height (cm)*	166.3 ± 10.8	
Length of residuum (cm)*	27.7 ± 5.2	
Amputated side**		
Right side	12 (52%)	
Left side	11 (48%)	0.768
Cause of amputation		
Vascular	9 (39%)	
Traumatology	14 (61%)	0.140
Social situation**		
Lives with a partner	13 (56%)	
Lives with family	6 (26%)	0.003
Lives alone	2 (9%)	
Institutionalized	2 (9%)	
Comorbidity**		
Cardiovascular disease	9 (39%)	
Diabetes mellitus	9 (39%)	
Others	4 (18%)	0.013
Respiratory disease	1 (4%)	
Walking aids**		
Independent	9 (39%)	
1 cane	9 (39%)	0.352
2 canes	5 (22%)	
Level of functionality (K level)**		
K2 level	6 (26%)	
K3 level	17 (74%)	0.001

* Values are given as the mean and standard deviation.
** Values are given with the percentage based on the total in parentheses unless otherwise specified.
*** Values were obtained through Student's *t*, Chi^2 or Fisher's exact test when appropriate.

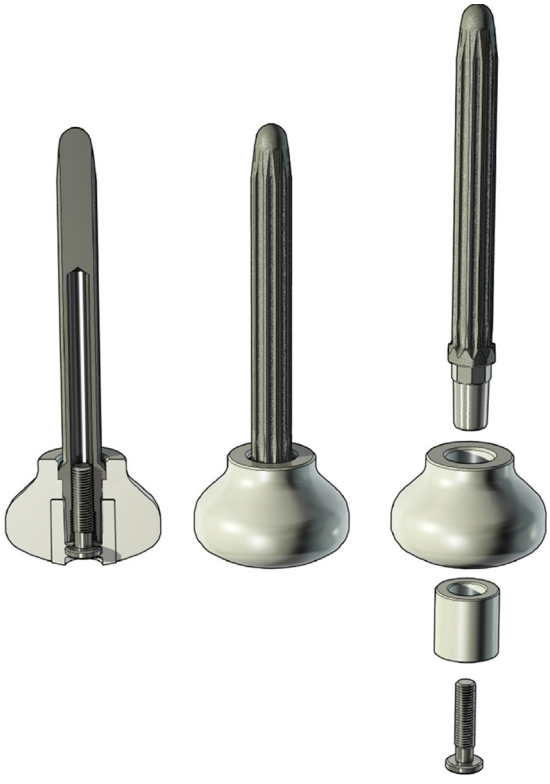

Fig. 1. The femoral implant is composed of three pieces.

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