COVER SHEET

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Reference

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Abstract

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LOADING APPLIED ON TRANS-FEMORAL OSSEOINTEGRATED PROSTHESES

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INTRODUCTION

A lower-limb prosthesis is conventionally attached to the residual limb by a socket and often some suspension devices. Although this approach has been used for over 50 years, previous studies have pointed the phenomena that local limb pain and soft tissue breakdown are common. High pressure applied from the prosthetic socket onto the residual limb is the major cause of the problems.

Researchers are developing a surgical approach using osseointegration for directly connecting a prosthesis into the femur using a fixation system with a titanium implant (Brånemark, 2001). The absence of a prosthetic socket can alleviate the skin problems. This procedure increased significantly the quality of life of amputees. However, the current rehabilitation is long and some occasional mechanical failures of the fixation following a fall were reported. Understanding the load applied on the osseointegrated fixation is one important step to solve these problems.

This article presents the load applied on the fixation of twelve trans-femoral amputees during level walking.

METHOD

Twelve transfemoral amputees fitted with an osseointegrated fixation, representing approximately 15% global population in 2003, participated in this study. Three-dimensional forces and moments applied to the fixation were measured with a load transducer which was mounted between the fixation and the prosthetic knee joint (**Fig. 1**). A wireless transmitter was used to transmit data from the transducer to a nearly laptop computer (Forssard et al., 2003)

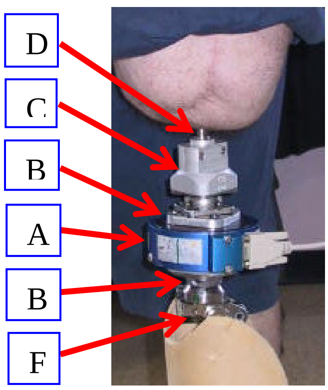

Figure 1. A commercial transducer (A) was mounted to specially designed plates (B) that were positioned between the adaptor (C) connected to the fixation (D) and the knee mechanism (F).

Subjects were asked to walk along a level walkway at self-selected comfortable walking speeds when the load was measured at a sampling frequency of 200Hz. The load data was processed by a Matlab software program. The first and the last strides recorded were discarded. Force and moment data for a complete gait cycle were plotted. Local extrema of each component of forces (F_{AP}, F_{ML}, F_L) and moments (M_{AP}, M_{ML}, M_L) for each step on the prosthetic limb were identified (**Fig. 2 and 3**). The mean and standard deviation of each local extrema was computed.

RESULTS

The forces and the moments on the antero-posterior (AP), medio-lateral (ML) and long axes (L) for a complete gait cycle of each subject are plotted in **Fig 2 and 3**. The three components of forces followed a pattern that was similar to the ground reaction forces obtained with force-plates. The local extrema of each component of forces and moments are tabulated in **Table 1**. Although there were noticeable differences in the magnitude of forces among different subjects, similar force and moment patterns were shown.

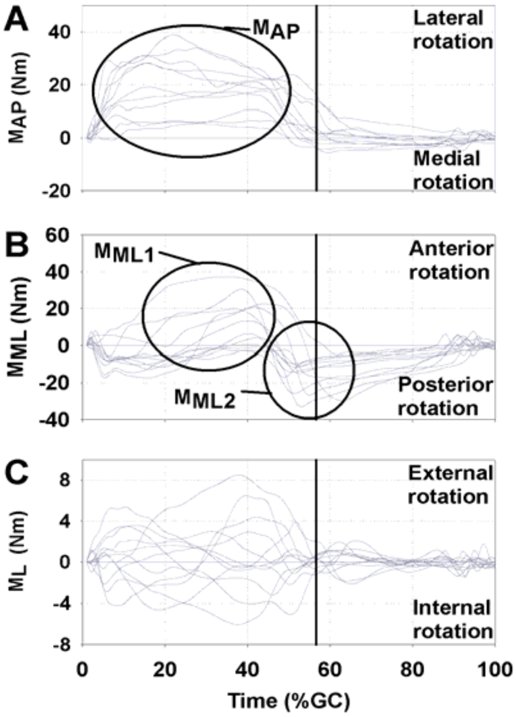

Figure 2. Forces, expressed as percentage of body weight, applied on the fixation versus percentage of gait cycle of 12 subjects.

DISCUSSION AND CONCLUSION

This study measures the load applied on the osseointegrated fixation. This increases the understanding of biomechanics of the bone-anchored osseointegrated prosthesis and will provide essential information on the design optimization of rehabilitation program and osseointegrated fixation addressing the mechanical failures. Future studies will apply experimental and analytical methods to study the stress/strain distribution at the bone-implant interface and the entire fixation system, as well as to perform mechanical design optimization using the existing load data.

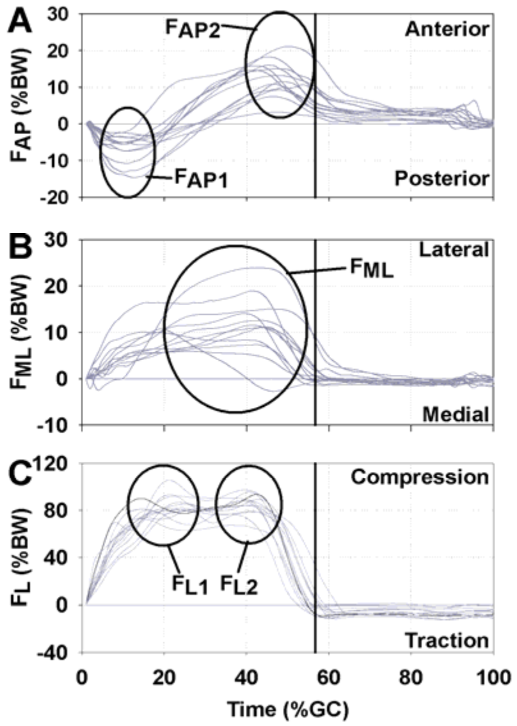

Figure 3. Moments applied on the fixation versus percentage of gait cycle of 12 subjects.

	F_{AP1}	F_{AP2}	F_{ML}	FL_1	F_{L2}	M_{AP1}	M_{ML1}	M_{ML2}
Subject 1	-5.07	10.80	10.80	105.00	97.20	10.90	4.31	-11.30
Subject 2	-9.82	14.50	14.10	91.80	87.90	39.10	6.10	-30.50
Subject 3	-13.20	21.70	7.36	80.70	83.40	6.32	0.75	-12.00
Subject 4	-5.78	14.60	8.42	87.00	94.40	17.90	13.60	-15.20
Subject 5	-15.40	10.20	11.60	88.50	102.00	29.00	6.73	-33.20
Subject 6	-4.22	3.22	23.60	96.50	93.70	28.10	38.10	-6.07
Subject 7	-11.10	15.90	19.20	97.30	99.60	19.20	-1.18	-10.70
Subject 8	-5.07	13.20	11.10	83.20	86.90	9.06	-1.96	-16.80
Subject 9	-7.46	11.50	11.40	79.10	72.20	28.20	-2.17	-26.70
Subject 10	-7.41	15.20	12.40	85.20	84.30	31.50	20.50	-27.60
Subject 11	-5.46	21.50	15.30	89.60	81.40	33.70	22.50	-28.40
Subject 12	-4.90	16.20	5.60	87.90	82.40	17.70	20.40	-14.90
Mean	-7.91	14.00	12.60	89.35	88.80	22.60	10.60	-19.50
Standard deviation	3.64	5.05	5.03	7.15	8.88	10.60	12.50	9.17

Table 1. Mean and standard deviation of the magnitudes of local extrema

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Brånemark, R et al. J Rehabil Res Dev, 38(2), 175-181, 2001.

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