Load applied on bone-anchored transfemoral prosthesis: Characterization of a prosthesis-A pilot study

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LOAD APPLIED ON THE ABUTMENT OF TRANSFEMORAL AMPUTEES FITTED WITH AN OSSEOINTEGRATED IMPLANT DURING LOAD BEARING EXCERSICES USING A LONG PYLON

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INTRODUCTION

As described by Hagberg and Brånemark (2002), the main sources of pain and discomfort experienced by transfemoral amputees are associated with the socket keeping the prosthesis attached to the residuum. Over the last ten years, a team led by Dr Rickard Brånemark attempted to alleviate these concerns by developing a new method of attachment of the prosthetic leg based on a direct skeletal anchorage (Brånemark et al. 2001). In this case, the socket is replaced by a titanium implant fitted into the shaft of the femur.

After the osseointegration of the implant, the amputees start a rehabilitation program involving a step-by-step increase of weights to be applied to their residuum (load bearing exercises) until they can tolerate their own body weight.

So far, only the forces and moments applied on the abutment during the load bearing exercises using a short pylon have been reported (Frossard et al, 2002).

This paper aimed to provide the forces and moments applied to the abutment of transfemoral amputees directly measured during the load bearing exercises while using a long pylon.

METHOD

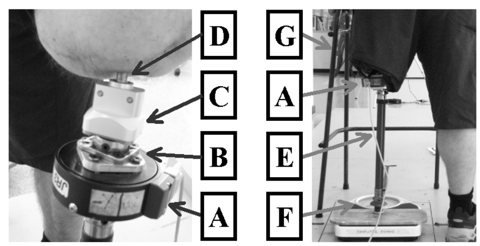

Figure 1. Example of a typical prosthetic leg setup used to directly measure the load applied during load bearing exercises. A commercial transducer (A) was mounted to specially designed plates (B) that were positioned between the adaptor (C) connected to the abutment (D) and the long pylon (E). This setup also included a commercial scale (F), used to monitor the load to be applied and a support frame (G).

Subjects: The two transfemoral amputees representing the whole existing population located in Australia, participated to this study (Subject 1: Male, 46 years, 1.82 m, 96.1 kg. Subject 2: Female, 38 years, 1.71 m, 68 kg).

Apparatus: The load was measured directly by a six-channel transducer at a sampling frequency of 200 Hz. The transducer was mounted between the adaptor and the long pylon (Figure 1).

Procedures: Initially, the subjects were standing in front of a scale and a frame. Then, they were asked to apply 10 kg, 20 kg, 40 kg and the maximum load (80 kg for subject 1 presented in

Table 1) on the scale with their prosthesis. The load was applied at a constant rate via self-monitoring of the scale. The subjects were asked to apply each load five times for a period of about five seconds.

RESULTS AND DISCUSSION

The example of results for the subject 1 presented in Table 1 showed: (A) the increase of the load applied to the long axis of the abutment is associated with a shift in translation and rotation of the load from posterior to anterior and from lateral to medial directions; (B) each load was applied rather constantly as demonstrated by the similar range and low CV for each axis; (C) the difference between the force applied to the long axis of the abutment and the force prescribed (28% for 10 kg, 14% for 20 kg, 5% for 40 kg and –1% for 80 kg) decreased as the force increased.

The method and the results presented here have some limitations as no information was collected about the general body shape. Therefore, a sound understanding of the results obtained with the transducer will required the simultaneous recording of the position of each body segment, using a 3D motion analysis system for example.

CONCLUSION

It is anticipated that this study might open up new perspectives for the multi-disciplinary teams facing the challenge to safely restore the locomotion of transfemoral amputees, particularly those fitted with ossoeintegrated implant. These results might lead these teams to refine the practical setting of the load bearing exercises and the rehabilitation program.

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Load (kg)	Forces (N)						Moments (N.m)					
	Mean	SD	CV	Min	Max	Range	Mean	SD	CV	Min	Max	Range
Antero-posterior axis												
10	117.86	1.06	0.01	115.11	121.97	6.86	0.13	0.29	2.31	-0.92	0.76	1.68
20	121.12	1.78	0.01	116.63	127.22	10.59	-0.70	0.72	-1.03	-2.41	0.97	3.38
40	126.42	1.39	0.01	123.15	131.18	8.03	-5.48	0.26	-0.05	-6.35	-4.61	1.74
80	131.38	1.94	0.01	126.88	137.54	10.66	-15.28	2.24	-0.15	-19.26	-11.08	8.18
Medio-lateral axis												
10	-58.81	1.57	-0.03	-64.32	-54.82	9.50	-1.15	0.22	-0.19	-1.69	-0.36	1.33
20	-47.48	1.68	-0.04	-52.38	-42.69	9.70	-1.06	0.58	-0.55	-2.12	0.39	2.51
40	-18.66	1.07	-0.06	-22.47	-15.80	6.66	-2.08	0.38	-0.18	-2.81	-0.90	1.91
80	42.05	6.66	0.16	28.35	55.37	27.02	-6.34	1.21	-0.19	-8.28	-3.83	4.45
Long axis												
10	137.03	6.38	0.05	120.37	157.77	37.40	0.10	0.06	0.61	0.00	0.31	0.31
20	226.93	6.37	0.03	213.86	245.41	31.55	0.06	0.10	1.88	-0.16	0.41	0.56
40	411.90	3.59	0.01	402.01	424.21	22.20	-0.30	0.07	-0.24	-0.44	-0.03	0.41
80	776.22	6.63	0.01	751.43	797.01	45.58	-1.26	0.24	-0.19	-1.66	-0.66	1.00

Table 1. Example of mean, standard deviation (SD), coefficient of variation (CV), minimum (Min), maximum (Max) of the three components of forces and moments applied to the abutment of subject 1 when 10 kg, 20 kg, 40 kg and 80 kg was applied to the scale.

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