Efficiency Trends of Upper Extremity Prosthetic Cable and Housing

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INTRODUCTION

Transradial patients are the most common level of upper extremity amputation seen by prosthetists (Black 2005). However, at this level, prostheses have a 10.5% rejection rate with reasons for rejection including pain, lack of functional benefit, poor cosmesis and weight of prosthesis. The most common upper extremity prosthesis currently used is a body powered system with a hook terminal device. This is due to durability, clear sight of grasped objects, and ease to clean (Millstein 1986, Lake 2006). Black notes that “unilateral upper limb amputees are roughly three times as likely to suffer repetitive motion or overexertion type injuries as the general workforce” (Black 2005). Decreasing the force required to operate a body powered upper extremity prosthesis could lead to a reduction in the rate of overuse injury to the contralateral arm. The purpose of this study is to compare the efficiency of different cable housing configurations and the forces needed to operate the terminal device for each of these.

METHOD

The same 5XA terminal device (TD), Hosmer tension bands, load machine and test personnel were used throughout the study. The force of activation was measured with a calibrated load machine. A fixture was used to evaluate the force required to operate the TD without housing, this was later used as a base line for comparison with the different housing configurations in the second part of the study. Base line data was collected at single band intervals from 1 – 10 bands, each measurement repeated for 12 cycles. A second testing fixture was constructed using 50th percentile anthropomorphic data (average of male and female) for arm and forearm lengths. The two cable housing attachment points were positioned at midpoints between elbow-shoulder and elbow-MCP joints with an elbow flexion angle of 100º. Base plates and retainers were used as connection points between cable housing and fixture. The cable housing lengths between connection points were 0.5cm greater than the linear measurements from mid-humerus to mid-radius to create a curve in the cable housing. All four housing configurations used Hosmer products and were as follows: standard cable and housing, standard housing and cable with paraffin wax, standard cable with HD housing and Teflon insert, and standard cable with paraffin in HD housing with Teflon insert.

RESULTS

Forces were recorded at the beginning of TD opening and maximal TD opening (before the TD reached the mechanical stop). These two forces were averaged for each cycle. Mean pull forces for 5, 7, and 9 bands in each of the cable housing configurations are shown in Table 1. A α=0.05 was used for statistical analysis. No significant difference was found between Teflon and base line data. Paraffin with Teflon was found to require significantly greater force to operate the TD than baseline alone, however there was no significant difference between paraffin with Teflon and Teflon alone. Significantly more force was required for operation of paraffin than paraffin with Teflon and for housing alone compared to paraffin.

Table 1: Mean force to operate a 5XA terminal device.

Number of bands	5	7	9
	Force in pounds		
No Housing	19.6	27.4	34.3
Housing only	25.5	34.7	42.8
Paraffin	24.6	33.9	42.0
Teflon	20.0	27.4	33.6
Paraffin + Teflon	20.7	28.1	34.2

The relationship between the number of tension bands and the force required to operate a terminal device is approximately 4 pounds per tension band in an ideal situation. Approximately 25% more force is required to operate the TD when a Teflon insert is not present.

DISCUSSION

This data shows that the use of Teflon inserts reduce the force required to operate the terminal device to a scenario similar to zero bend radius and no cable housing. A small amount of band fatigue was seen in the data after only 12 cycles and may explain two of the Teflon housing scenario results measuring less than the control scenario. Statistical analysis was not performed to determine the significance of band fatigue in this study.

CONCLUSION

The use of a Teflon insert reduced the pull force required to operate the terminal device. This reduction in force could increase the use and wear time of the prosthesis and reduce the incidence of overuse injury to the contralateral limb.

CLINICAL APPLICATIONS

This data shows that a Teflon insert provides a significant benefit to a patient and could be used as justification of medical necessity to reduce or delay the chance of an overuse injury to the contralateral limb.

REFERENCES

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