Investigation of a method to identify socket-limb displacements of trans-radial amputees

Keywords: ultrasound, socket displacements, trans-radial amputees

Background:

Providing secure fastening requires fundamental design and construction features for sockets. Due to the stiffness of the socket, motion between the socket and the residual limb (pistoning) can affect myoelectric control. Pattern recognition based myoelectric control provides more intuitively and naturally control. However, classification problems due to electrode shifts can limit prosthesis control. In literature, pistoning are less documented for upper limb prosthetics. The aim of this work is, therefore, a determination of an adequate method to measure socket-stump displacements in trans-radial amputees.

Material and Methods:

To quantify displacements three trans-radial amputees (S1, S2, S3) were measured synchronously with a 3D motion capture (14 infrared cameras) and an ultrasound system in four conditions (baseline, with weight, after first donning-D1 and after second donning-D2) and three arm positions (hanging arms, 90° elbow flexion, above head). All trials were repeated five times. Custom made test sockets with similar features like daily used sockets were constructed by an experienced orthopaedic technician. Gaps in the socket surface enable detecting of the proximal radius head via ultrasound. The probe was prepared with cluster markers to define the position and the orientation in the capture volume. The captured ultrasound points were subsequently transformed to 3D space. Two observers measured distances between the transformed points and a rigid marker attached to the socket in each condition and positions. To compare the conditions, the distances between the baseline and the other conditions, as well as the difference between observer 1 and observer 2 were estimated.

Results:

Differences between the observers are in the range of -0.09 to 1.16 mm for S1, -0.28 to 0.80 mm for S2 and -1.39 to 2.68 mm for S3. The mean distance differences overall subjects are 0.48 ±1.24 mm with weight, -0.91 ±1.19 mm in D1 and -1.46 ±1.24 mm in D2. In arm hanging position, all subjects show increased distances when weights affect the prostheses (with weight: 1.23 mm, 1.90 mm, 2.65 mm). The results of D1 and D2 vary within the subjects. In some cases subjects show reduced and in other cases, they show increased distances from baseline to D1 or D2.

Conclusion

In conclusion, pistoning is a key factor for clinical outcomes and studies in biomechanics and prosthetics. The results show homogenous values between observers. In arm hanging, distances of the socket and the anatomical landmark are increasing, because the sockets probably move against weight. D1 and D2 do not indicate such consistent results overall users because the distances increase and decrease within these positions. The maximum distance is about 6 mm overall users. In literature distances around 1 cm are likely in a

clinical situation. Thus, a displacement about 6 mm could lead to limitations in myoelectric use.