INTRODUCTION

Generally, a prosthetic wrist has one degree of freedom in a supination/pronation sense. Some do allow bending of the wrist [1-4], however, due to the complexity of integration and operation, they are not as commonly used. The restricted motion of the prosthetic wrist is compensated for by additional motion of the shoulder and elbow. Not only can this additional motion appear awkward making the person self-conscious [5], but it may also increase the risk of joint injury [6].

In an attempt to balance function, cosmesis, and “dynamic cosmesis” (minimal compensatory motion), the prosthesis aligns the wrist with the forearm in some combination of flexion/extension and ulnar/radial deviation. Changing the alignment once it is fixed requires significant effort. Therefore, having a sense of the optimal alignment would be very beneficial. Guidelines for wrist alignment do exist [7 and 8], but while some consider them “very applicable”[9], others feel “there is a need for updated text materials” [10]. These guidelines were written over thirty years ago (1958 and 1971 respectively) and this lag of standards behind technology has left prosthetists to develop their own alignment procedures that sometimes contradict those of their colleagues. Where one prosthetist aligns a wrist at 10 degrees extension, another uses slight ulnar deviation and flexion [11-13]. While the experienced prosthesis has a practical knowledge from which to decide on an individual wrist alignment, the novice practitioner requires guidelines on which to base decisions.

Our goal was to determine which, if any, of the wrist alignment angles commonly used allows elbow and shoulder motions to be closest to “normal”, resulting in optimal dynamic cosmesis.

TEST METHODOLOGY

We compared the upper-body motion of normally-limbed people performing activities of daily living (ADLs) under two conditions: 1) the wrist unrestricted (normal, N), and 2) the wrist splinted in five different alignments: 0° Straight (S), 10° Extension (E), 10° Flexion (F), 10° Radial deviation (R), and 10° Ulnar deviation (U). In addition to restricting wrist motion to imitate a prosthetic wrist, the hand was splinted for all tests to imitate the grip of a myoelectric hand. We subsequently repeated the experiments using 20° offsets with a different subject population [14].

For each of the experiments, the ten, adult subjects (five female, five male) sat at a desk, and at their own pace, performed four ADLs: Cup (C) - drink from a cup, Spoon (S) – eat soup with a spoon, Sandwich (W) – bring a sandwich level with the mouth, and Zipper (Z) – zip a jacket. A 3-camera VICONTM 140 motion analysis system was used to record 3D coordinates of reflective markers attached on the trunk, head and right arm of each subject. The marker...
coordinates were used to calculate upper-body motion (ubm) angles of the head, shoulder girdle, glenohumeral joint, and elbow joint

RESULTS

For both 10 degree and 20 degree offset tests, the ubm angle data for the ten subjects was averaged to result in one data set per wrist alignment for each ubm angle and each ADL. As an example of the data, Figure 1 shows forward/backward extension of the glenohumeral joint during the zipper activity. To determine which, if any, of the fixed wrist alignments caused significantly less compensatory motion than the rest, extreme (max/min) mean values were compared. Radial deviation showed a statistically significant (p<0.05) advantage over straight, extension, and ulnar deviation alignments, but only in reducing elbow flexion by at most 7°, and only for the cup and spoon ADLs.

Results showed that not only were the extreme values close (less than 8°) among the fixed alignments, but the patterns of motion are also very similar during the entire activity.

Results also provided clear evidence that compensatory motion did occur. While the fixed wrist alignment measures were similar to one another, normal (unrestricted) wrist alignment often caused less motion. Statistically significant differences were seen between normal and fixed alignments in all but the sandwich activity.

Results for the tests with 20° offsets yielded similar results without any consistent differences between the orientations tested.

CONCLUSION
No optimal fixed wrist alignment was clearly distinguished among the alignment angles tested. It can therefore be concluded that a person will move approximately the same regardless of the prosthetic wrist alignment selected within +/- 20° of flexion/extension or +/- 20° radial/ulnar deviation. Therefore, when fixing a wrist alignment, dynamic cosmesis should be less of a concern than function and cosmesis. Stated another way, the act which changes compensatory motion is fixing the wrist, and the angle at which the wrist is fixed has only a small effect on the compensatory motions.

Recommendations for future work include testing other ADLs, testing alignments that combine flexion/extension with radial/ulnar deviation, modifying the wrist splint to be more rigid, and modifying the splint to control forearm supination/pronation.

REFERENCES

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