KINEMATICS OF THUMB OPPOSITION

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INTRODUCTION

One of the most important hand functions is thumb opposition, which results from flexion, abduction and axial rotation at the carpometacarpal, metacarpophalangeal and interphalangeal joints [1]. The thenar muscles, innervated by the median nerve, are critical for coordinated thumb movements. It is commonly observed that thumb opposition is impaired with median neuropathy [2]. The clinical method to assess thumb motion capability is to measure the distance between the thumb tip and the fingertip, or between the thumb tip and distal palmar crease [3]. Goniometric measurement quantifies thumb range of motion in isolated planes, but does not provide information of the dynamic relationship between flexion and rotation. The purpose of this study was to examine the 3D movement of the thumb during opposition.

METHODS

Three young male subjects aged 25.6 ± 3.2 years without any musculoskeletal disorders of the upper extremity participated in the study. Six markers with diameters of 5 mm were attached to the hand (Figure 1). Three markers (1, 2 and 3) affixed to a small triangle plate were attached to the thumb nail. Three markers (4, 5, and 6) were placed on the outstretched fingers to establish a local coordinate frame (*OXYZ*). A motion capture system (VICON 460, Oxford, UK) was used to collect marker motion data. A normal vector (**N**) was defined from the three markers on the plate, pointing in the dorsal direction. The forearm was supinated so that the palm was in parallel to the horizontal plane and faced upward. All fingers were at full extension in parallel with the palm.

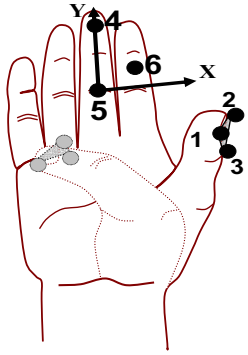

Figure 1: Marker placement on the right hand.

The subjects were instructed to perform thumb opposition, starting with the thumb at full extension in the palm plane, and then moving the thumb tip to the distal palmar crease of the little finger, and then returning to the starting position. Ten cycles of this movement were performed at self-selected paces. The thumb tip was approximated by calculating the middle point between markers 1 and 2. The flexion and pronation angles were determined by computing the projection angles of the vector **N** in the XY and XZ planes, respective.

RESULTS AND DISCUSSION

In the XZ plane, the thumb tip moved in a parabola trajectory during opposition (Figure 2). The thumb tip moved palmarly in the beginning phase and then dorsally as the tip approached the palmar crease. The movement magnitudes in the X and Z directions were 124.8 ± 8.6 mm and 54.2 ± 10.9 mm, respectively. The distal phalanx changed its orientation constantly during opposition, as shown by the non-parallel normal vectors (Figure 2). This change in orientation was produced by concurrent angular movements in flexion and pronation (Figure 3). The angle-angle curves showed piecewise coordination patterns. Thumb pronation was mainly produced in the beginning phase of opposition, perhaps contributing from the movement at the carpometacarpal joint. Flexion motion dominated at the later phase of opposition, likely resulting from movements at the metacarpophalangeal and interphalangeal joints. The ranges of motion in flexion and pronation were 166.7 ± 14.4 degrees and 144.0 ± 16.5 degrees, respectively. These kinematic analyses potentially allow for quantification and discrimination of abnormal motion patterns by hands with neuromuscular disorders such as carpal tunnel syndrome.

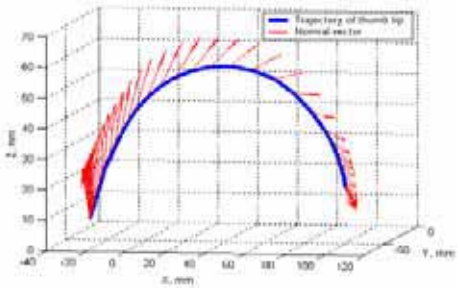

Figure 2: Trajectories of the thumb tip and the normal vector during thumb opposition.

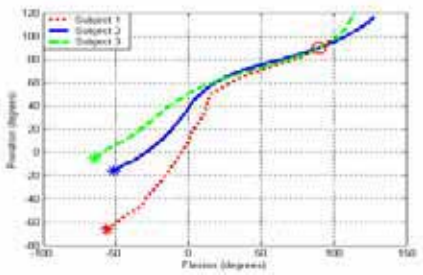

Figure 3: Relationship between flexion and pronation during thumb opposition.

REFERENCES

1. Cooney WP et al.. *J Bone Joint Surg [Am]* **63**, 1371-1381, 1981.
2. Aulicino PL. *The Hand*, Tubiana, Saunders: Philadelphia, 1981
3. Litchman HM & Paslay PR. *J Bone Joint Surg [Am]* **56**, 85-91, 1974.