DESIGN AND 3D PRINTING OF A DYNAMIC WRIST SPLINT IN THE DART THROW MOTION PLANE

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INTRODUCTION

Rehabilitation following a wrist fracture often includes exercising flexion-extension movements with a dynamic splint. Current studies show that these sagittal wrist movements are not representative of the natural daily wrist movements. We actually perform most of our daily functions, with our wrist moving on a Dart Throw Motion (DTM) plane, also defined as the plane between radial-extension and ulnar-flexion [1]. The DTM may be considered a more stable and controlled motion, since most motion occurs at the midcarpal joint with the proximal row of carpal bones remaining relatively immobile [2]. This might prove advantageous in rehabilitation following wrist fracture, where the ligaments are intact, since minimal pain is expected as a result of minimal bone movement in the proximity of the injured site.

To date, no dynamic brace exists which facilitates wrist exercise in the DTM plane. Also, it has not been reported whether the DTM plane angle is similar for the dominant and non-dominant hand. If DTM is similar between hands then the DTM splint can be used for injuries of both dominant and non-dominant hands. Also, we would be able to calculate the individual natural DTM plane of the patient from the uninjured hand and design the splint characteristics according to the calculated plane. Our aims are therefore (1) To characterize the DTM plane in the wrist bilaterally during daily activities, and (2) to design and 3D print a subject-specific dynamic wrist splint that facilitates wrist exercise in the DTM plane.

METHODS

First, the DTM plane was calculated using a wrist electrogoniometer placed on both wrists (Fig. 1a) of healthy subjects (N=36; 28 females; age 30.5±12.8 years), performing twelve activities of daily living (ADL), e.g. using a hammer, opening a jar, pouring water from a bottle, throwing a ball, and answering the phone. The activities were performed once with the dominant hand and once with the non-dominant hand. The geometry of the splint was designed in Solidworks to fit to a 3D scan of the arm, wrist and hand (Fig. 1b). The brace design comprise of a proximal attachment to the arm and a distal accurate envelope of the palm. An axle with two wheels is attached to the proximal part. Two wires attach the proximal part with the medial-palmar and lateral-ventral aspects of the distal part: when the wrist extends, the medial wire is released and the lateral wire is strained towards the radius. When the wrist flexes, the lateral wire is released and the medial wire is strained towards the ulna. The splint was attached to the wrist using Velcro as two wires attached to two pulleys, situated on a joint axis, pull the hand to move in the desired calculated plane.

RESULTS AND DISCUSSION

As hypothesized, no significant difference was found between the DTM plane angles of the dominant and non-dominant hands, while performing daily activities. In several of the tasks, the angle of the plane of motion was negative DTM plane (radial-flexion to ulnar-extension). The most common ADLs occurred at a DTM plane angle of approximately 20° to 45°. The printed splint fitted the wrist of the subject, was easy to don and doff and constricted movement to the desired DTM plane. The design is adjustable for different DTM planes by calculating the lengths of the wires and the diameter of the two wheels. Hooks were inserted on each part to allow the addition of rubber bands for resistance training towards muscle strengthening.
CONCLUSIONS

It has been hypothesized that activation of the wrist in the DTM plane following distal radius fracture will accelerate the recovery of the patient and enable him or her improved functionality. Our results show that the DTM angle can be determined from either the dominant or non-dominant wrists. The design of the patient-specific dynamic splint is the first step towards assessing whether DTM splinting is beneficial to the rehabilitation of individuals following distal radius fracture, compared to conventional treatment. The evaluation of the clinical benefits of this method, compared to conventional rehabilitation methods following wrist fracture, are a part of a PhD work, currently conducted by an occupational therapist (KCY).

REFERENCES


Figure 1: The brace was designed following calculation of the DTM plane during different tasks of daily activities, monitored by an electrogoniometer (a). A 3D scan of the hand and forearm (b) was used to design and print a subject-specific wrist brace (c) according to the wrist geometry of the subject.