World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:10, No:06, 2016

Multi-Plane Wrist Movement: Pathomechanics and Design of a 3D-Printed Splint

Authors : Sigal Portnoy, Yael Kaufman-Cohen, Yafa Levanon

Abstract : Introduction: Rehabilitation following wrist fractures often includes exercising flexion-extension movements with a dynamic splint. However, during daily activities, we combine most of our wrist movements with radial and ulnar deviations. Also, the multi-plane wrist motion, named the ‘dart throw motion’ (DTM), was found to be a more stable motion in healthy individuals, in term of the motion of the proximal carpal bones, compared with sagittal wrist motion. The aim of this study was therefore to explore the pathomechanics of the wrist in a common multi-plane movement pattern (DTM) and design a novel splint for rehabilitation following distal radius fractures. Methods: First, a multi-axis electro-goniometer was used to quantify the plane angle of motion of the dominant and non-dominant wrists during various activities, e.g. drinking from a glass of water and answering a phone in 43 healthy individuals. The following protocols were then implemented with a population following distal radius fracture. Two dynamic scans were performed, one of the sagittal wrist motion and DTM, in a 3T magnetic resonance imaging (MRI) device, bilaterally. The scaphoid and lunate carpal bones, as well as the surface of the distal radius, were manually-segmented in SolidWorks and the angles of motion of the scaphoid and lunate bones were calculated. Subsequently, a patient-specific splint was designed using 3D scans of the hand. The brace design comprises of a proximal attachment to the arm and a distal 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 first wire is released and the second wire is strained towards the radius. The opposite occurs when the wrist flexes. The splint was attached to the wrist using Velcro and constrained the wrist movement to the desired calculated multi-plane of motion. Results: No significant differences were found between the multi-plane angles of the dominant and non-dominant wrists. The most common daily activities occurred at a plane angle of approximately 20° to 45° from the sagittal plane and the MRI studies show individual angles of the plane of motion. The printed splint fitted the wrist of the subjects and constricted movement to the desired multi-plane of motion. Hooks were inserted on each part to allow the addition of springs or rubber bands for resistance training towards muscle strengthening in the rehabilitation setting. Conclusions: It has been hypothesized that activation of the wrist in a multi-plane movement pattern following distal radius fractures will accelerate the recovery of the patient. Our results show that this motion 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 splinting to induce combined movement is beneficial to the rehabilitation process, 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.

Keywords : distal radius fracture, rehabilitation, dynamic magnetic resonance imaging, dart throw motion
Conference Title : ICBE 2016 : International Conference on Biomedical Engineering
Conference Location : Paris, France
Conference Dates : June 20-21, 2016