Smart sensor for wrist movements

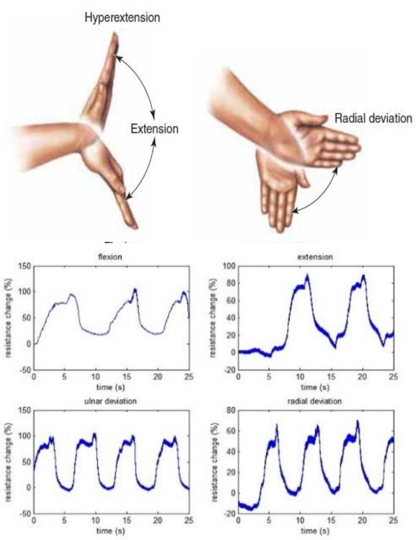
What if you could follow your own recovery after an injury? This project is about finding a way to evaluate the mobility of the hand and wrist using a conductive silicone painted on a glove.

Wrist fractures are the most commonly treated fracture in healthcare. In Sweden 20 000-25000 wrist fractures are registered every year. The treatment and rehabilitation varies depending on the injury. Sometimes it is enough with a plaster cast but in more difficult cases surgery might be necessary. Bone has the ability to remodel by size, shape and structure to adapt to the mechanical loading put on. Loading will thereby increase the bone mass while inactivity will reduce it. Since the bone can remodel it is important that the bone is put back in the right place to heal correctly, and after the fracture is healed the patient needs to exercise to obtain full strength and size.

In this project a prototype of a compression glove with added conductive silicone was made to evaluate the mobility. Four movements of the wrist were focused on; flexion, extension and radial and ulnar deviation. The strings of silicone were painted on the glove where the hand achieves the largest movements. On each stripe two wire attachments were added for the measurements. The resistance between two points changes when the fabric is stretched due to bending. This can be used to convert a measured resistance to an angular displacement from a given starting point.

The silicone used is called Elastosil lr1362. It is a conductive liquid silicone rubber. It was chosen because of its good mechanical and electrical properties. The resistance will change due to that the silicone contains carbon black particles. When stretching some of them are separated which cause a narrower path which will increase the resistance.

Strain or elongation is how much an object is deformed from initial state. A tensile test was done first to show linearity between resistance and elongation. Thereafter this was implemented on the prototype. To be able to compare the measured values to angular displacement the movements were filmed when doing the measurements. The measurements can be converted to angles by comparing the measured values to this video.



Top: Flexion extension and ulnar radial deviation. Bottom: The result of all four movements using the prototype.

The results show a large indication when stretching the fabric which made it easy to distinguish different movements and cycles. However the resistance in neutral state differed between the stripes. Another issue was that the magnitudes of the resistances did not always match the magnitudes of the movements when comparing the different stripes. Based on our results it would therefore be possible to use for counting cycles in a training program but it is difficult to measure an exact angle. However it is important to point out that the prototype was handmade with thick and viscous silicone. With more exact methods for producing the glove it might still be possible to get a better result.

The goal is to further develop this glove so the readings can be sent with a Bluetooth device to an app in the patients mobile phone. Both the doctor and patient should have access to the app. Instead of just evaluating an injury at the return visits to the hospital this would help both the patient and the doctor to follow the recovery on a daily basis.

This project was delimited to evaluate Elastosil as a suitable material, to develop a simple prototype, and to suggest how to proceed.