Elaboration of a positioning elbow orthosis for patients suffering from spasticity

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Elaboration of an positioning elbow orthosis for patients suffering from spasticity

Master thesis conducted by **Lou Gevaert** with the aim of obtaining the degree of Master in Biomedical Engineering

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Patients suffering from elbow spasticity, as a consequence of a stroke or a disease such as multiple sclerosis or cerebral palsy, see their quality of life decrease. Their spastic limb is constantly contracted and its regular elongation is needed to avoid further damages. Immobilization devices are commonly used to force the extension of the elbow. Several solutions are available on the market but they do not fully satisfy the needs of the patients. Static orthoses are described as uncomfortable, pre-fabricated positioning orthoses (the position of the arm can be changed) are usually bulky and lead to hygiene issues and custom positioning devices either deform easily and need regular adjustment or require a long and laborious production process.

This work presents two models of 3D printed orthoses (see Figure 2) made according to the patient anatomy and whose opening angle can be chosen and frequently changed. The anatomical data of the patient is captured using a 3D scanner. Two models are developed, one using a BOA dial, a small device able to shorten or lengthen a cable embedded in the splint. As the length of the cable changes, the splint's opening angle increases or decreases. The second model uses a blocking hinge that allows the splint to be blocked to a finite number of opening angles. Once the ideas were initially defined, both solutions were optimized by changing the design and the parameters according to the issues encountered. Resistance analysis are also conducted on both designs. The BOA model is shown sufficiently strong using an analytical analysis (see Figure 3) and the blocking hinge design is studied through *Solidworks* simulations and analytical computations (see Figure 4).

Finally, one patient tried the BOA design for 8 days and gave his feedback. The patient was satisfied and found the orthosis comfortable and easy to adjust (with external help). His physical therapist noticed a relaxation of the elbow joint but a larger study would be needed to assess the effects of the splint, independently of the other treatments of the patient. The blocking hinge design is available in two sizes (Small and Large). The Small model offers increments of 16.4° and allows many positions but it is less resistant than the Large one. The large model is advised for patients exerting a greater flexion force on the orthosis but it offers fewer positions (increments of 18°). The blocking hinge design has not been tested on patients yet.

(a) BOA model (b) Blocking hinge model

Figure 2: Prototypes of the two models proposed.

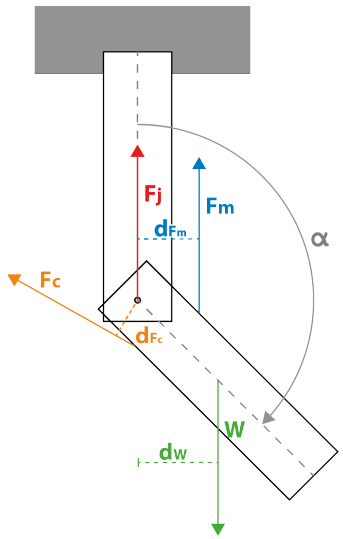
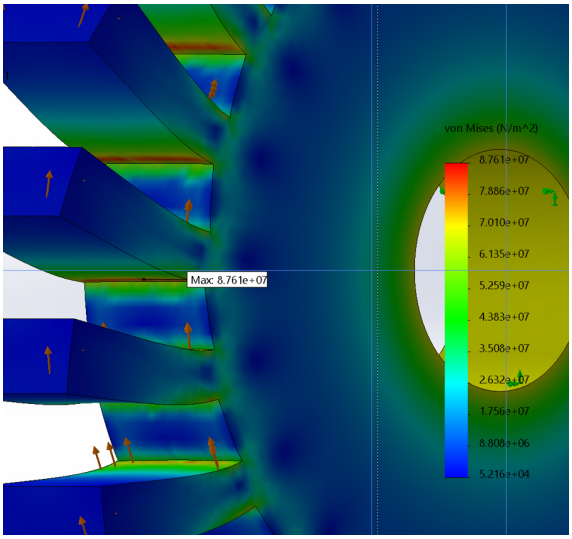
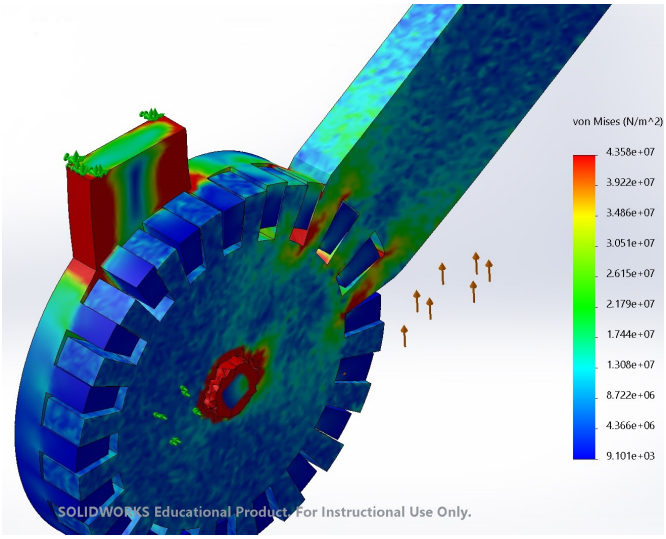


Figure 3: Free body diagram used for the analytical analysis of the BOA model.



(a) Simulation of the blocking hinge design, showing the stress concentration on the critical zone of the teeth.



(b) Simulation of the blocking hinge design, showing the stress concentration as the parts interact.

Figure 4: Illustrations of some of the resistance analysis done in *Solidworks*.