

Biomechanical study of a drop foot brace

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Abstract: A person specific drop foot brace was simulated in the commercial finite element code Abaqus. The geometry was imported from a 3D optical scan of the actual surface and modeled as a composite material layup defined in a local discrete material coordinate system. The finite element model was used in order to model the stance phase in a normal walking. The material choice is a challenging task giving flexibility to the brace together with sufficiently stiffness and fatigue strength. The simulation has been compared with measurements from a strain gauge mounted foot brace tested in use. Based on simulations, a large number of expensive trial and error iterations can be avoided. Simulations show a strong geometry interaction with the loading of the material.

Keywords: Medico, composite materials, shell model, STL file import.

1. Introduction

Drop foot is a reduced or lack of action from the muscles that lift the foot (Kottnik, 2007). When these muscles lack function they are unable to dorsiflex the ankle which causes the foot to be dragged on the ground. For some people the lack of function is so severe that they are not able to walk without treatment, while others have a steppage gait. The recommended treatment depends on the etiology of drop foot. Sometimes surgery is necessary while some patients can be treated by wearing an ankle foot orthosis, a brace that stabilizes the foot and lifts it in an upright position while the foot swings.

A very large number of people suffering from drop foot but no exact numbers is to the authors knowledge available. Nevertheless, it can be estimated that 20 % of those surviving stroke suffer from drop foot (Wade, 1987). Worldwide 15 million people suffer from stroke every year, out of these 5 million die (Murray, 2002). This gives 2 million people suffering from drop foot only due to stroke. Many other diseases can lead to drop foot and as such the total number of people suffering from drop foot must be much higher. Approximately 30 % of all cases of drop foot are due to peroneal neuropathy (Rubin, 1998). Neural damages can be caused by trauma or nerve related injuries. The nerve roots and spinal cord are fragile to herniation of discs and other lesions of the nerves (Bojsen-Møller, 2005). Furthermore muscle impairments can lead to drop foot.

A great variety of ankle foot orthosis (also called AFO) are available on the market today. These have different designs and material properties. As shown in Fig. 1a, the ankle foot orthosis tested in this study is a person specific plastic brace with two rods, one on the lateral and one on the medial side of the ankle, see (Flexbrace, 2010). The rods are in the investigated brace reinforced with a folded and twisted carbon glass fiber webbing. The geometry of the person-specific brace is extracted by the company Zebicon (Zebicon, 2002) which performing an optic 3D scan of the inner surface of the brace, see figure 1b. The resulting STL-representation of the surface is