Simulation of Lattice Structures in Orthopedic Corsets

Wolfgang Rieder
Switzerland Innovation Park Biel-Bienne, Switzerland

INTRODUCTION: Digitization is affecting more and more industrial sectors. In the field of orthopedic technology, new technologies such as 3D scan and 3D printing are used in production. This opens up new fields of application for FEM simulation. The example of a scoliosis corset shows how the new technologies intertwine and enable new, individualized products. Scoliosis refers to a spinal curvature that often occurs in girls during adolescence. Depending on the severity, corsets are also used for therapy. The corset production according to the prior art with plaster cast is done by hand and is very complex (Figure 1a, 1b). 3D Scan / 3D printing enables new, customized designs, e.g. with breathable lattice structures (Fig. 1c). As a result, the wearing comfort and acceptance can be increased, which has a positive effect on the success of the therapy.

Figure 1a. State of the art scoliosis corset (Orthoteam AG)

Figure 1b. Plaster cast

Figure 1c. Corset with lattice structures (Orthoteam AG)

COMPUTATIONAL METHODS: The corset with the lattice structures is imported as stp geometry and subsequently repaired, formed as an union and formed as composite faces (Fig. 2a). This ignores the edges between the faces and prepares it for efficient meshing with tets. The mesh is exported as .mphbin and afterwards imported in a new component (Fig.2b). The mesh is checked for maximum neighbor angle and partitioned where the angle exceedes 40 deg. Moreover the corset is partitioned at the opening with cylinders where boundary conditions are applied (Fig.2c).

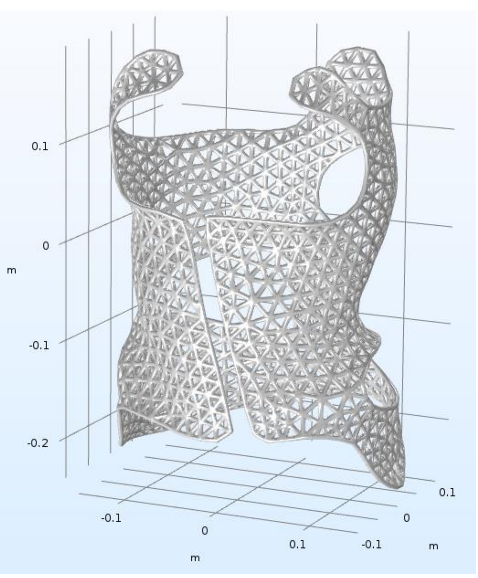


Figure 2a. Corset geometry

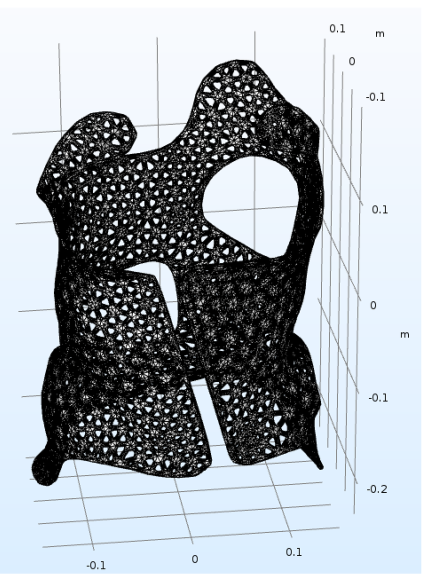


Figure 2b. Corset mesh

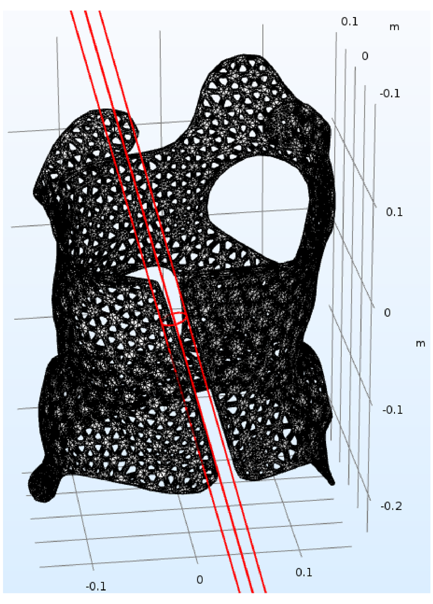


Figure 2c. Partition

One side of the opening is constraint fix, the other one as rigid connector with a prescribed displacement in x-direction, all other DOF free (Fig.3). The material is PA12 which can be used for 3D printing in SLS machines. PA12 has a break strain of 20 % in x-/y-direction and 10 % in z-direction. An elastic-plastic material characteristic is used with geometric nonlinearity included .

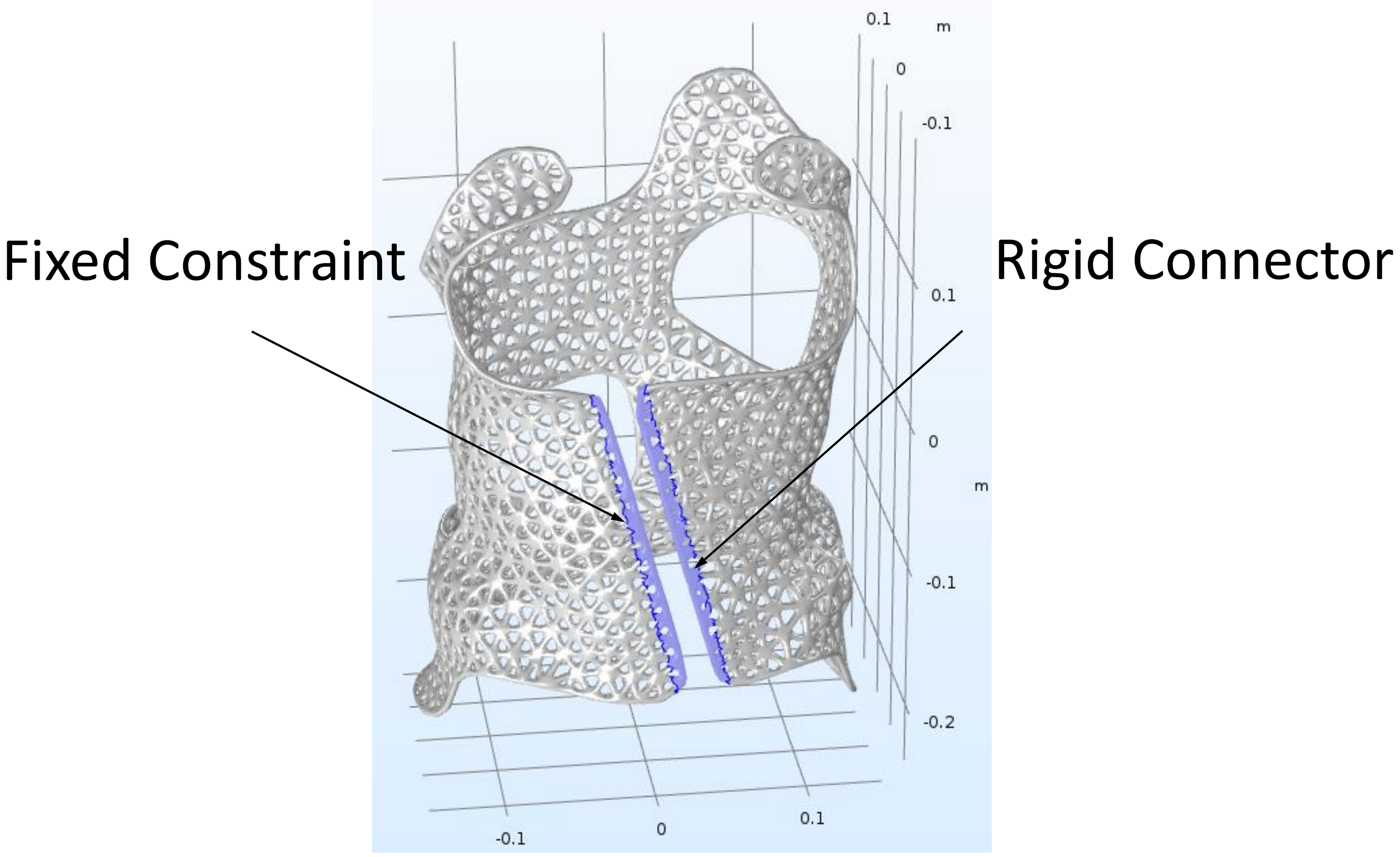
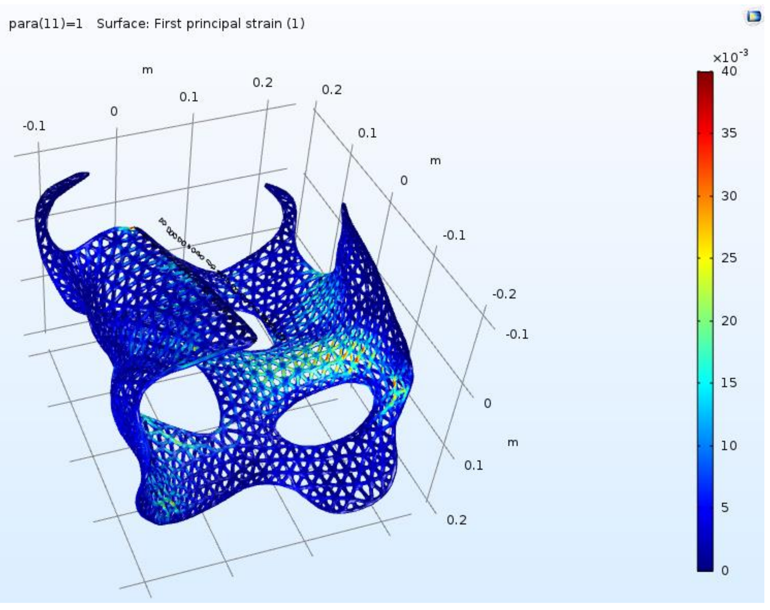


Figure 3. Boundary Conditions

RESULTS:



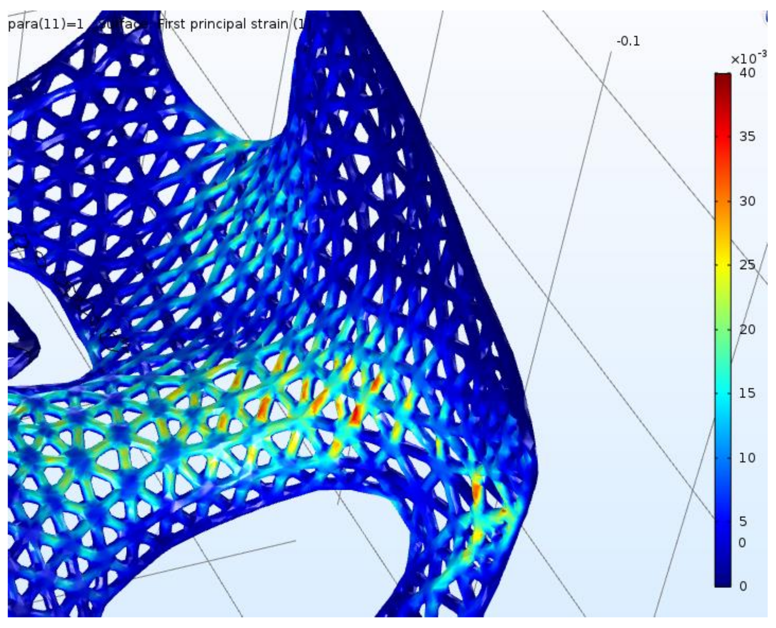


Figure 4. First principal strain distribution

First principal strain reaches a maximum of 4 % which is well below the break strain level of PA12 in all directions (Fig.4). The opening force is calculated as summation of the reaction forces over all nodes of the rigid connector. The opening force can be adjusted by altering the dimensions of the lattice structures .

CONCLUSIONS: Digitization in orthopedic technology offers new possibilities in design e.g. lattice structures. Simulation especially meshing of such complex geometries is a challenge. COMSOL® can handle it with specific import and meshing capabilities and therefor helps to secure the corset performance regarding max. principal strains and opening forces.