True rapid design and manufacturing of a custom made skull implant using DMLS

Fast processing from the patient's CT data to 3D model using Mimics

The CT scan data of the patient is processed with the use of Mimics-software: the cranium and loose bone parts are calculated from the image data. To ensure that the inside surface of the implant does not interfere with the meninx, a Mimics segmentation of the meninx is also made.

When designing an implant that covers a large defect, it is important to use reliable design references to ensure a proper implant fit. The surgeon decided to use the loose bone parts lying on the meninx and the meninx as reference for this implant design.

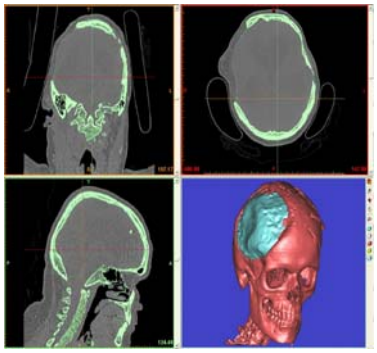

Fig. 1: Screenshot Mimics: cranium red, meninx cyan

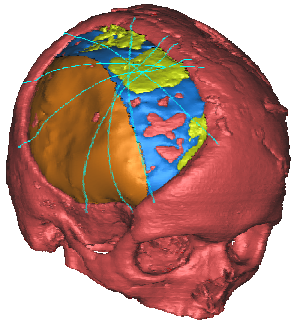

Fig. 2: Meninx (blue) and bone particles used as design reference

Trying out various designs to obtain the most optimal implant using 3Matic

The implant needed to have a thickness of 3-millimeter and a curvature so that it wouldn't touch neither the loose bone parts nor the menix after implanting it. 3Matic allows you to easily import the contours of the cranium, meninx and loose bone parts into a sketch. The wide range of CAD tools enables to draw the implant very precisely on this sketch. Via a section view in 3Matic, the designer verifies that the implant does not contact the meninx.
The final design steps, made in 3Matic software, were:

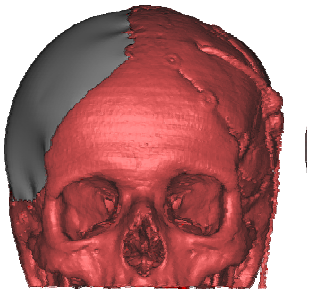

Fig. 3: Design 1: exploring 3Matic: recreating the symmetry of the skull

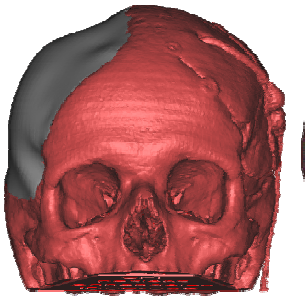

Fig. 4: Design 2: concave implant, ensuring the implant will not push onto the meninx

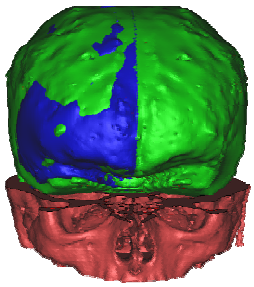

Fig. 5: Design 3: Original meninx (blue) and mirrored meninx (green)

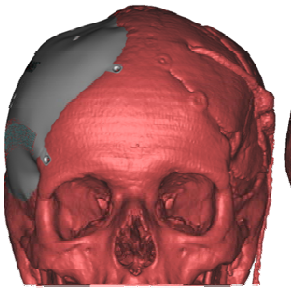

Fig. 6: Design 3: Implant designed on the mirrored meninx to compensate for the movement of the meninx that might be caused by the indentation of the positioning pillow during scanning

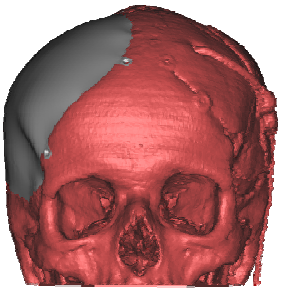

Figure 7: Design 4: Combination of concave design 2 and convex design 3, because of the complexity of the case

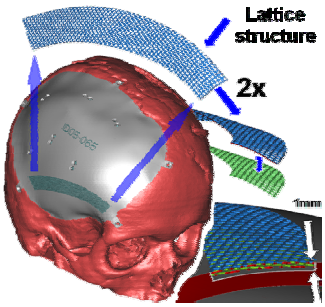

Figure 8: Design 5: Implant with muscle attachment lattice structure and a cross-section. Using 3Matic, the lattice structure was easily given the same outer shape as the original implant surface

Rapid manufacturing of the implant using DMLS

DMLS is a 3D printing technology that is developed by EOS. The implant can be manufactured by meting thin layers of titanium powder. This technology allows for building a fully dense implant. The resulting implant promotes osseo-integration of bone and soft tissue.

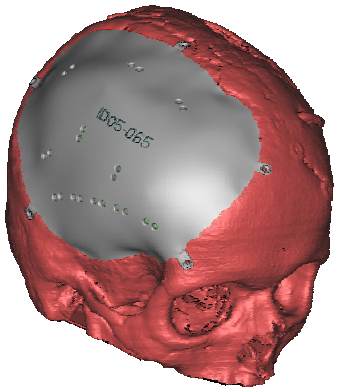

Figure 9: Final design

Conclusion

Using Mimics and 3Matic software to design a custom made implant decreased the design time by 68% in comparison to other CAD-software. This is the time measured without any redesigns/adaptations to the implant. The new DMLS production process reduces the production time with 53% in comparison with the conventional production process. The possibility to design a custom made implant will increase the surgeon's confidence in the implantation. This eventually can lead to a reduction of 70% of the operation time.

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