Internship proposal

Multimodal MRI and µCT imaging of haemostatic sponges for sinus lift surgery prediction

Short Description of the project:

Physical and geometrical characterisation of collagen tissue structures is crucial for many clinical applications. Being compliant, haemostatic sponges made of collagen or gelatin (denatured collagen) are used as bone filler for mini invasive surgery such as sinus lift (Figure 1).

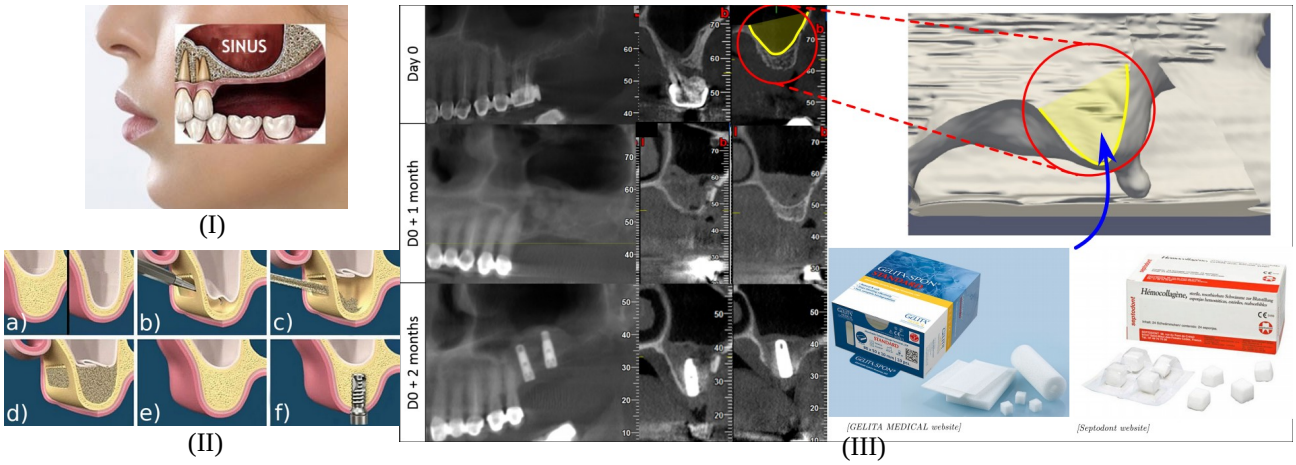

Figure 1: I) the problematic is located in the cranio-maxillo-facial area for dental application, II) when the bone thickness is not sufficient enough to set an implant the solution is to lift the sinus using granular bone substitute. While doing this surgery the sinus membrane might break creating a leak of particles into the sinus leading to surgical complication. III) To avoid this situation, a solution is to use collagen structure such as sponges to feel the void but it requires more time to become bone. To optimize the procedure it is crucial to predict how the implanted structure will evolve in the body (being hydrated) undergoing sinus mechanical loading.

In collaboration with the ICUBE laboratory of Strasbourg, multimodal imaging (µCT Figure 2.a, MRI Figure 2.b) is expected to capture fluid and structure geometries before, during and after tissue hydration (Figure 2.c) to mimic surgical use. Combined with finite element simulation this results will help designing predictive tools for sinus lift surgery and will be extended to other structures such as membranes.

Repositioning data in between modalities is a crucial step in the proposed procedure therefore a chamber has been designed to fit in MRI and µCT chambers to keep in position the sample while allowing its progressive hydration and mechanical loadings. A first version has been designed for the compression chamber; consequently, the first step will be to assess that it fully satisfies reproducing surgical events of the sponge. If not, one mission will be to improve the chamber.

Besides, a database of compression tests will have to be enriched to better know the sponge mechanical response (behaviour law) and predict the load state of a sample within the chamber in compression. This last step is essential because introducing force sensors within MRI and µCT might be complicated so knowing the imposed displacement, the sample geometry and its behaviour laws (dry and hydrated) will allow assessing the load state.

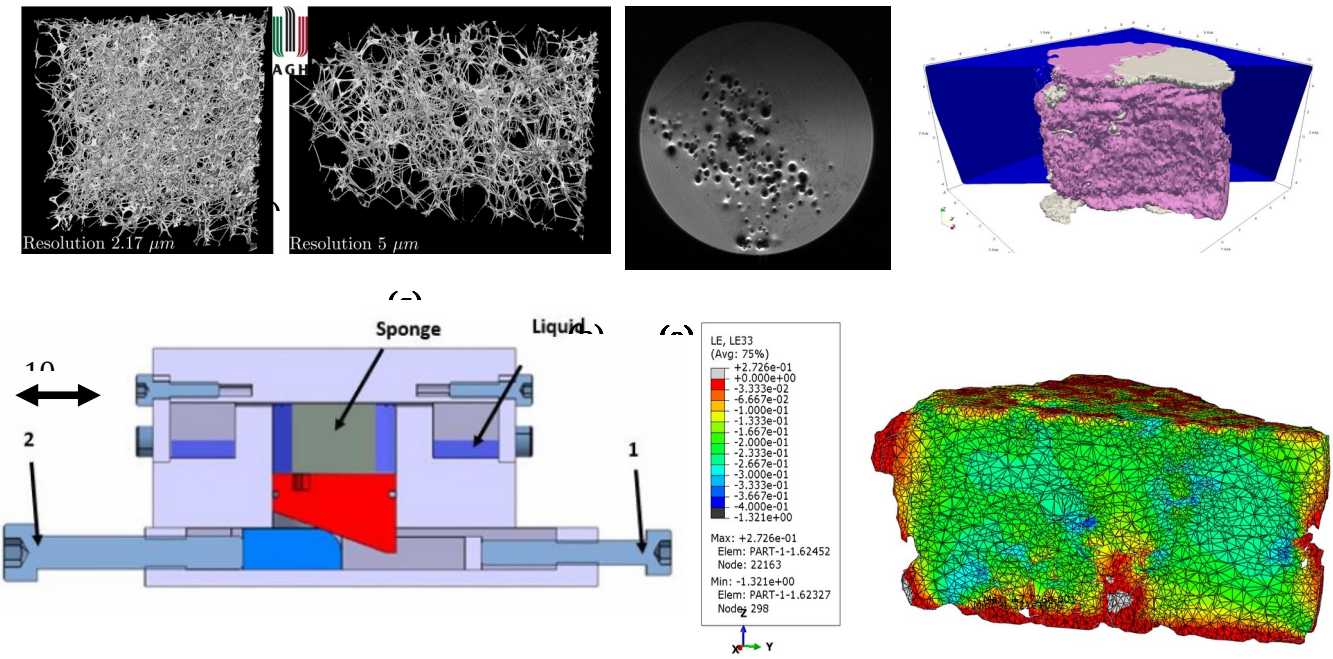

Figure 2: a) X-ray µCT scan of haemostatic sponge, b) MRI of a hydrated sponge, c) 3D segmentation of the MRI showing the fluid (blue), the air (pink) and the sponge (grey), d) designed chamber and e) finite element simulation on hydrated sponge.

Skills required:

- autonomy for travelling in between Metz and Strasbourg
- good reporting and communication skills (project in between biologist and mechanicians)
- design and manufacturing of polymer and stainless steel materials
- interest for computer program and sensor bench setups
- finite element simulation