Biofabrication and Bone Tissue Engineering

Biofabrication could be defined as the micro-manipulation of biological elements (cells, proteins, biomaterials) to fabricate two- or tridimensional structures for Tissue Engineering applications: these applications can be 1/ Cell biology studies; 2/ Fabrication of *in vitro* physiological models; 3/ Tissue substitutes for regenerative medicine. The tools involved are mostly 3D printers, which are based on different technologies, each of them having a specific range of volume and rheology available for printing. Thus, depending on the application, a specific technology must be chosen (Figure 1).

During my PhD, I have gained an expertise in Laser Assisted Bioprinting (LAB) for Bone Tissue Engineering applications, thanks to a prototype set-up developed in our Lab with the company Novalase (Pessac). This printer can be loaded with Bioinks made of cells, proteins or biomaterials (nano-hydroxyapatite).

More recently, we have developed a high-resolution Fused-Deposition Modeling (FDM) printer, in collaboration with “TechnoShop” (IUT de Bordeaux, France). This printer allows the fabrication of scaffolds using medical grade polymers with a resolution of 25 µm.
Layer-by-Layer BioAssembly for Bone Tissue Engineering

One of the main limitations for clinical applications of bone tissue engineering is related to the limited penetration of blood vessels and cells inside the scaffolds, which leads to ischemic conditions inside the material (lack of oxygen and nutrients): then, newly-formed tissue in these constructs is not efficient and most of the cells grafted don’t survive after implantation. Thus, we propose in this project to perform a sequential assembly of cellularized membranes in 3D to favor the survival, proliferation and differentiation of cells after 3D assembly.

We are now using FDM to print thin porous polymer membranes that we seed with primary cells prior to layer-by-layer assembly. We have shown before that cell proliferation was significantly increased using this system compared to the more conventional approach of seeding a macroporous material with cells.

Alveolar Bone Regeneration for Dental Implant Surgery

Dental implant therapy has become a common treatment for edentulous patients. However, in several clinical situations, alveolar bone volume is limited and a bone graft is required prior to implant placement. Autologous bone graft is the reference technique, but it is available in limited amounts and it may provoke additional morbidity. Several biomaterials for bone substitution are available, but they don’t possess all the necessary properties for complete bone regeneration, as they lack osteoinductive and osteogenic potential. We are now working on new injectable biomaterials that could favor osteoinduction and we perform in vitro and preclinical experiments with these materials.
Custom Bone Grafts for Oral and Maxillofacial Surgery

Conventional surgical methods for bone grafting in the oral cavity involve several manual procedures to adjust the shape of autologous bone or biomaterials to the recipient site. These procedures are time-consuming, some of the grafts are not accurately adapted then some related surgical complications might occur.

CAD-CAM technologies may be used to prepare custom bone grafts, starting from a DICOM imaging and modelization of the missing part. Subtractive methods (milling machines for allografts / xenografts / synthetic biomaterials) or additive technologies based on 3D printing set-ups can be used to prepare these materials (Figure 3).

Keywords/expertise:

- Bone Tissue-engineering
- Regenerative Medicine
- Biomaterials for Bone Regeneration
- Computed-Aided Design – Computed-Aided Fabrication (CAD-CAM)
- Biofabrication
- Laser-Assisted Bioprinting
- Fused Deposition Modeling
- Pre-clinical studies
- Clinical trials
- Translational medicine

Selected publications:

4. N Zwetyenga, **S Catros**, A Emparanza, C Deminière, F Siberchicot, JC Fricain. Mandibular reconstruction using induced membranes with autologous cancellous bone graft and HA-
16. L Xiao, D Ueno, S Catros, C Homer-Bouthiette, L Charles, L Kuhn, M Hurley. FGF2 isoform (LMW/18 kDa) over-expression in preosteoblast cells promotes bone regeneration in critical size calvarial defects in male mice. Endocrinology, 2014 Mar;155(3):965-74
18. S Catros, M Montaudon, C Bou, R Da Costa Noble, JC Fricain, B Ella. Comparison of conventional transcrestal sinus lift and ultrasound-enhanced transcrestal hydrodynamic


**Patents:**


**Teaching Activities:**

- Oral Surgery at Dental School in Bordeaux (Graduate Students)
- Post Graduate lectures in Oral Surgery and Oral Implantology
- Master of Biomaterials (BIDIM, University of Bordeaux)

**Clinical Activities:**

- 2.5 days per week in the Dental Department at University Hospital in Bordeaux (CHU de Bordeaux)
- Oral Surgery
- Oral implantology
- Alveolar Bone Grafts for Oral Implantology

**Funding:**

- La Fondation des Gueules Cassées (2015)
- Conseil Régional d’Aquitaine (2014)
- ITI Foundation (2011 / 2013)
- Institut Français pour la Recherche Odontologique (2010)
Memberships:

- Fellow of the International Team of Implantology (ITI)
- Member of the French Society for Oral Surgery (SFCO)

Education and Positions:

- **2012**: Associate Professor. Oral Medicine and Oral Surgery, Dental School, University of Bordeaux, France
- **2012**: Research Assistant: Inserm U1026 "BioTissue Engineering", Bordeaux Segalen University, France
- **2011**: Post Doctorate (ITI Scholarship), University of Connecticut, Dental School, Department of Reconstructive Sciences, Farmington, CT, USA. PI : Dr M. Freilich / Dr LT Kuhn
- **2005-2006**: Master in Craniofacial Biology, Biomaterials and Tissue Engineering, University of Paris 7, France
- **2004**: Doctorate in Dentistry, University of Bordeaux, France
- **2001-2004**: Intern in Oral Surgery, University of Bordeaux, France
- **1995-2001**: Dental School, University of Toulouse, France

Links:

ResearchGate: [https://www.researchgate.net/profile/Sylvain_Catros](https://www.researchgate.net/profile/Sylvain_Catros)

BxCRR: Bordeaux Consortium for Tissue Engineering: [https://bcrm.u-bordeaux.fr](https://bcrm.u-bordeaux.fr)


International Team of Implantology [http://www.iti.org/](http://www.iti.org/)