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Research Interests: *"Biofabrication for Oral and Maxillofacial Bone Regeneration"*

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.

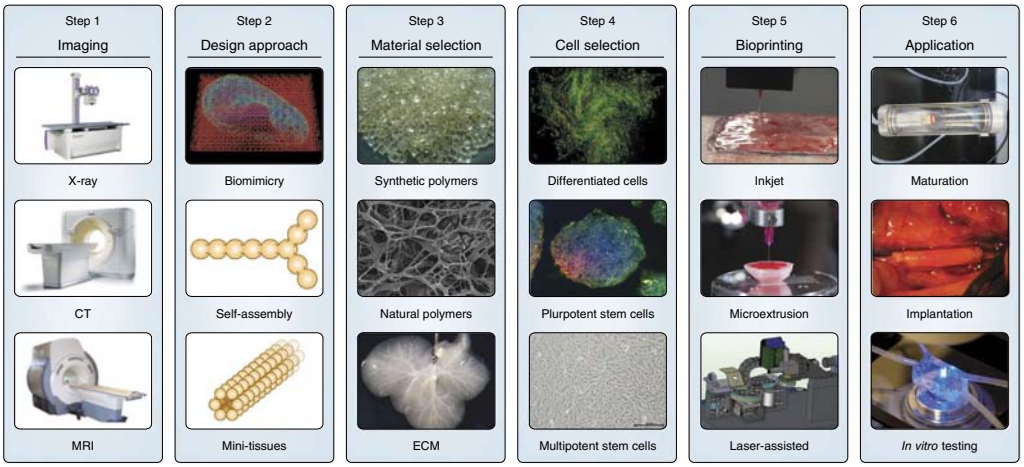


Figure 1: Conceptual sequential approach for 3D Bioprinting in Tissue Engineering. Murphy & Atala Nat Biotechnol 2014;32(8):773□85.

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.

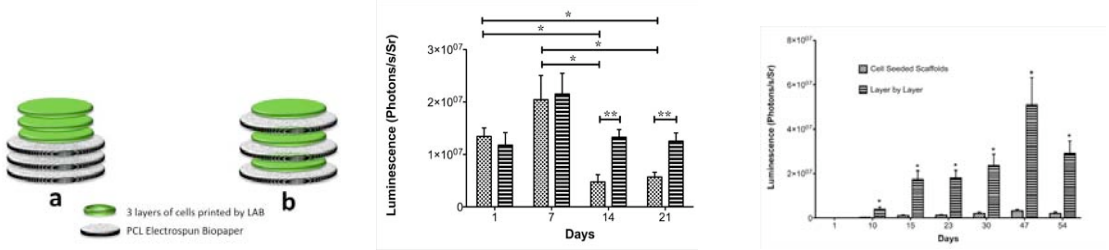


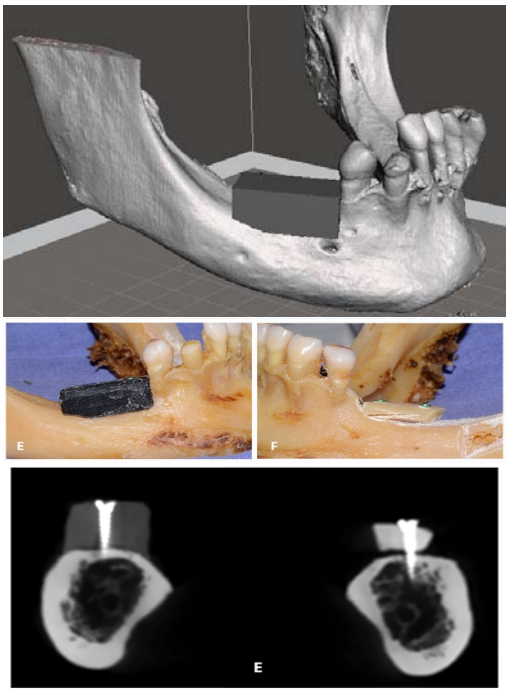
Figure 2: Layer-by-Layer Bio-assembly: Principle (Left); Cell Proliferation in vitro (middle) and in vivo (Right)

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. Substractive 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).

Figure 3: Preparation of custom part by FDM for bone augmentation in a human mandible: Upper row: modelization; Middle row: implantation of the printed custom part (left) and autologous bone graft prepared manually (right); Lower row: CT scan of the implanted parts

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:

1. **S Catros**, L De Gabory, D Stoll, C Deminière, JC Fricain. Use of Gutta Percha points in CT scan imaging for patent nasopalatine duct. International Journal of Oral and Maxillofacial Surgery 2008; 37:1065-1066
2. **S Catros**, L Pothuaud, M Dard, JC Fricain. Collagen Fibrils of human Acellular Extrinsic Fiber Cementum. Journal of Periodontology 2008; 79(6):1095-1100
3. **S Catros**, N Zwetyenga, R Bareille, B Brouillaud, M Renard, J Amédée, JC Fricain. Induced membranes have no osteoinductive properties on macroporous HA-TCP in vivo. Journal of Orthopaedic Research 2009; 27(2):155-161
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-

betaTCP: animal model study and preliminary results in patients. International Journal of Oral and Maxillofacial Surgery 2009; 38(12):1289-1297
5. F Guillemot, A Souquet, **S Catros**, J Lopez, M Faucon, B Pippenger, R Bareille, C Cholet, M Remy, P Chabassier, MC Durrieu, JC Fricain, J Amédée. High-throughput Laser Printing of Cells and Biomaterials for Tissue Engineering. Acta Biomateriala 2010; 6(7): 2494-2500
6. V Keriquel, F Guillemot, I Arnault, B Guillotin, S Miraux, J Amédée, JC Fricain, **S Catros**. In vivo Bioprinting for Computer and Robotic assisted medical intervention: preliminary study in mice. Biofabrication 2010; 2:014101 (8pp)
7. F Guillemot, A Souquet, **S Catros**, B Guillotin. Laser-assisted cell printing: principle, physical parameters vs. cell fate, and perspectives in tissue engineering. Nanomedicine (Lond) 2010; 5(3):507-515
8. B Guillotin, A Souquet, **S Catros**, B Pippenger, S Bellance, R Bareille, M Rémy, J Amédée, F Guillemot. Laser Assisted Bioprinting of engineered tissue with high cell density and microscale organization. Biomaterials 2010; 31(28):7250-7256
9. **S Catros**, B Guillotin, M Bačáková, JC Fricain, F Guillemot. Effect of laser energy, substrate film thickness and bioink viscosity on viability of endothelial cells printed by Laser-Assisted Bioprinting. Applied Surface Science 2011; 257:5142–5147
10. **S Catros**, JC Fricain, B Guillotin, B Pippenger, R Bareille, E Laplaud, B Desbats, J Amédée, F Guillemot. Laser-Assisted Bioprinting for creating on-demand patterns of human osteoprogenitor cells and nano-hydroxyapatite. Biofabrication 2011; 3:025001 (11pp)
11. **S Catros**, F Guillemot, A Nandakumar, S Ziane, L Moroni, P Habibovic, C Blitterswijk, B Rousseau, O Chassande, J Amédée, JC Fricain. Layer-by-layer biofabrication using laser assisted bioprinting and electrospinning enhances cell proliferation in vitro and in vivo. Tissue Engineering Part C Methods 2012; 18(1):62-70
12. **S Catros**, B Wen, P Schleier, D Shafer, M Dard, M Obrecht, M Freilich, L Kuhn. Use of perforated custom scaffold retaining abutment to achieve vertical bone regeneration around dental implants in the minipig. International Journal of Oral and Maxillofacial Implants; 2013;28(2):432-43
13. J Guerrero, **S Catros**, SM Derkaoui, C Lalande, R Siadous, R Bareille, N Thébaud, L Bordenave, O Chassande, C Le Visage, D Letourneur, J Amédée. Cell interactions between human progenitor-derived endothelial cells and human mesenchymal stem cells in a three-dimensional macroporous polysaccharide-based scaffold promote osteogenesis. Acta Biomaterialia 2013; 9(9) :8200-13
14. F Laval-Meunier, PE Bertran, E Arrivé, JF Paris, M Monteil, S Nguyen, C Moussu, A Rouas, **S Catros.** Frequency of Barodontalgia among military or civilian pilots and aircrew members. Aviation, Space and Environmental Medicine, accepté, sous presse 2013
15. JC Fricain, S Schlaubitz, C Le Visage, I Arnault, SM Derkaoui, R Siadous, **S Catros**, C Lalande, R Bareille, M Renard, T Fabre, S Cornet, M Durand, A Léonard, N Sahraoui, D Letourneur, J Amédée. A nano-hydroxyapatite-pullulan/dextran polysaccharide composite macroporous material for bone tissue engineering. Biomaterials. 2013;34(12):2947-59
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
17. **S Catros**, A Molenberg, M Freilich, M Dard. Evaluation of a PEG-OP1 system on alveolar bone regeneration in the mini-pig. Journal of Oral Implantology, 2014, in press
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

cavitational sinus lift for the filling of sub-antral space. A human cadaver study. Journal of Oral Implantology, 2015 ;41(6) :657-61
19. E De Mones, S Schlaubitz, **S Catros**, JC Fricain. Statins and alveolar bone resorption: a narrative review of preclinical and clinical studies. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, 2014, in press
20. S Schlaubitz, SM Derkaoui, L Marosa, S Miraux, M Renard, **S Catros**, C Le Visage, D Letourneur, J Amédée, JC Fricain. Pullulan/dextran/nHA macroporous composite beads for bone repair in a femoral condyle defect in rats. Plos One, 2014 ;9(10) : e110251
21. J Guerrero, H Oliveira, **S Catros**, R Siadous, M Derkaoui, R Bareille, D Letourneur, J Amédée. The use of total human bone marrow fraction in a direct 3D expansion approach for bone tissue engineering applications: focus on angiogenesis and osteogenesis. Tissue Engineering Part A. 2015 ;21(5-6) :861-74
22. H Oliveira, **S Catros**, C Boiziau, R Siadous, J Marti-Munoz, R Bareille, S Rey, O Castano, J Planell, J Amédée, E Engel. The proangiogenic potential of a novel calcium releasing biomaterial : Impact on cell recruitment. Acta Biomaterialia 2016;29:435–445
23. H Desrus, B Chassagne, F Moizan, R Devillard, S Petit, R Kling, **S Catros**. Effective parameters for film-free femtosecond laser assisted bioprinting. Applied Optics 2016, in press

Patents:

1. Bioprinting station, assembly comprising such Bioprinting station and Bioprinting method. F Guillemot, V Keriquel, **S Catros**, JC Fricain. EP10305224.7
2. Porous polysaccharide scaffold comprising nano-hydroxyapatite and use for bone formation. C Le Visage, M Derkawi, D Letourneur, **S Catros**, JC Fricain, J Amédée. EP 10 305 932.5

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
- **2007-2010**: PhD « Laser Assited Bioprinting for Bone Tissue Engineering » University of Bordeaux, INSERM U577. Thesis Directors: Dr Fabien Guillemot and Pr JC Fricain.
- **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:

ReaserchGate: https://www.researchgate.net/profile/Sylvain_Catros

BxCR: Bordeaux Consortium for Tissue Engineering: https://bcrm.u-bordeaux.fr

BIOMAT : The French association for the development of biomaterials, Tissue Engineering and Regenerative Medicine: http://www.biomat.fr

SFCO: French Society of Oral Surgery http://societechirorale.com/fr/

International Team of Implantology http://www.iti.org/