



Issues on osteogenesis due to the structural analysis of bone graft compression

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Context

Cleft lip and palate, standing as the most frequent craniofacial malformation (1/700 newborns) require several surgeries in the first year of life to close the lip, repair the nose and reform hard and soft palate. Alveolar cleft is left opened not to impair maxillary growth (Robertson, 1968). A bone graft is yet necessary to restore maxillary union, allow teeth eruption and provide a support for lip and nose (Witsenburg, 1985). Secondary alveolar bone graft (Boyne and Sands, 1972) present good but variable results (Borba et al., 2013; Dissaux et al., 2016).

Raised questions :

- What is the best age to perform the alveolar bone graft ?
- Which is the best bone to use ? What should be the right density, porosity ?
- What is the right compression to use while the surgeon places the graft ?
- Is the graft only osteoconductive ? Do the grafted cells really integrate and form new bone ?
- Do cells from the nasal floor play a role in osteoformation?

Despite its usual use in everyday surgical practice, bone graft integration biology and mechanism are not well understood.



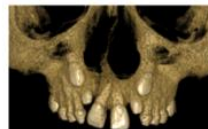
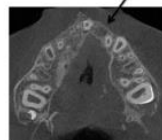
Unilateral Cleft Lip and Palate: involves lip, dental arch, soft and hard palate



Bone graft of the alveolar defect



Left alveolar graft



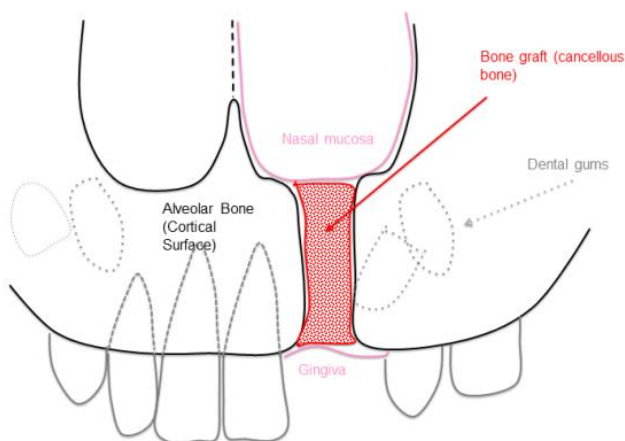
Cone Beam Imagery (CBCT) and its reconstruction in 3D alveolar bone graft

Objectives

- Alveolar bone graft can appear as a very complex process (Helm et al., 2007) but only a good comprehension of the mechanisms and the influencing factors could allow the surgeon to obtain better and more predictable results.
- First we study of the structure, the biological composition and the growth factors release of cancellous bone cylinders taken from human femoral heads.

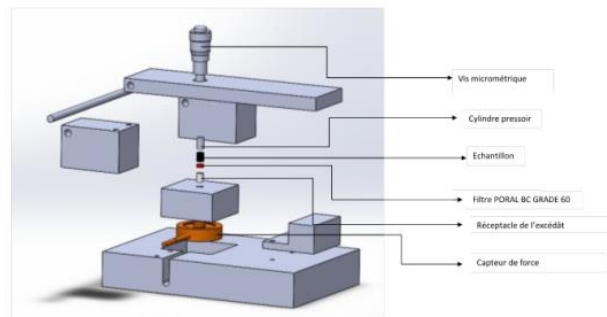
Particularity of the alveolar bone graft

The neo-osteogenesis occurring in the case of alveolar bone graft is different from fracture healing (Meyer et al., 2006) as two cortical bone surfaces are involved and bone synthesis in this small alveolar cleft space and cannot occur only by abrading. During alveolar bone grafting the surgeon places iliac cancellous bone in a 3-D space, between 2 cortical bones, with smooth upper and bottom layers (nasal floor, gingival mucosa) and applies a compression force on the graft, cortical bone.



Experiments

- A compression force is applied to a fixed geometry of cancellous bone. The force goes from 0 to 5kg .
- Analysis and Numbering of CFU-F (Cells colonies of stem cells).



Conclusion

This study is a first step to understand the biomechanical activity of cancellous bone when a surgeon applies a compression force at the time of the graft placement, before an in vivo phase where the interface between bone graft and recipient site will be analyzed.

Perspectives

- Second phase with small animal study
- Enter these experimental data to a numerical simulation model of bone reconstruction in alveolar cleft.

References :

- Borba AM, Borges AH, Vilarinho da Silva CS, Borozoski MA, Naclerio-Homen MG, Miloro M. Predictors of complications for alveolar bone graft. *Br J Oral Maxillofac Surg.* 52:174-178, 2013
- Boyne PJ, Sands NR. Secondary bone grafting of residual alveolar and palatal clefts. *J. Oral Surg* 1972 ; 3(2) : 87-92
- Dissaux C, Bodin F, Bridonneau T, Mattern JF, Grollemund B, Kauffmann I, Bruant-Rodier C. Evaluation of success of alveolar cleft bone graft performed at 5 years versus 10 years of age. *J Craniomaxillofac Surg* 2016 ; 44 : 21-6
- Helms JA, Amasha RR, Leucht P. Bone voyage: An expedition into the molecular and cellular parameters affecting bone graft rate. *Bone*, 2007, 41: 479-85
- Witsenburg B. The reconstruction of anterior residual bone defects in patients with cleft lip, alveolus and palate- A review. *J Maxillofac Surg.* 13:197-208, 1985