Introduction
Because of ageing and loss of teeth, alveolar bone volume has a tendency to decrease, contrary to basal bone volume which seems to have no significant modification. The practician will have, if possible, to intervene before bone anomaly installation by intercepting bone resorption. (1)
Bone volume diminution in posterior maxillary alveolar ridge is a combination of several simultaneous and independants mechanisms: (2)
- Bone height loss because of sinusal pneumatization
- Bone height loss from the ridge: old edentulism, periodontal disease
- Ridge width diminution because of maxilla centripetal resorption.

Bone height loss with sinusal origin : pneumatization.
The permanent air circulation into sinusal cavities maintains the pneumatization. These forces, though limited and weak, are continuous and lead to a permanent augmentation of sinus. This volume augmentation is easier if sub-sinusal teeth are missing (2d premolar, 1t and 2d molars) and their roots can’t support the sinusal floor anymore. (3).

Height loss with crestal origin
Mechanism of resorption depends on the cause of tooth loss (4).
Vertical alveolar bone insufficiencies are oftenly due to periodontal disease or tooth extraction, leading to an alveolar ridge sinking, especially in molars areas. (1)
- Periodontal disease.
In case of periodontitis, the resorption is larger, lack of alveolar wall avoids alveolus filling, as bone walls are a guide. (5).
Abrams (6) notes in a study that 91% of patients with periodontal disease have a large crestal loss in edentate areas.
Becker (7) shows that most serious bone loss due to periodontal disease are located in posterior maxillary areas.
Then, Goldmann (8), with an average of 22 years of maintenance therapy, confirms that the maxillary molar are more often lost than other teeth.
- Old edentulism
Tooth extraction systematically leads to an alveolar bone resorption or alveolysis. This resorption is very active during first months of bone healing.
It intervenes between 6 months to 2 years following teeth loss (9) and is faster from the 3d post-extractionnal month in vertical, horizontal and cross-sectionnal direction. (10)
The chronical resorption, as described by Atwood, progressive, non reversible and additional is more serious on trabecular bone than cortical bone (11).
One year after an extraction, an vertical alveolar bone loss of 2 to 3 mm in average is noticed at the maxilla (12). Radiographical and clinical assessment of Lekovic and coll. (13) confirm a threedimensional alveolar bone loss after a tooth extraction. Chanavaz (14) also talks about the resorption as an involution due to a disbalance between osteogenesis and osteolysis. This diminution is actually the result of a double bone healing, alveolar cortical resorption in their upper part, and osteosynthesis into the alveolus.

The resorption leads quickly to a morphologic changing of extraction site which can compromise implant placement with functional and esthetic result. Misch (3) explains the accelerated resorption with diminution of alveolar bone vascularization and lack of muscular stimulation when the teeth are here. The roots conduct mastication forces toward bone tissue, in a higher way in posterior areas than in anterior areas. This induced stimulation keeps alive the apposition- resorption process which maintains alveolar process structure. Chanavaz (14) notes that a premature extraction of the 1st molar can lead to a total disappearance of bone floor and then create an unfavourable bone volume. The bone volume loss following the tooth loss can be located on a wall of the alveolar ridge or more extended, associating horizontal, cross-sectional and/or vertical bone defects.

From these last associations, an imbalance of bone remodeling process leads to a diminution of basal and alveolar bone, responsible of a severe atrophy of edentate areas. Misch (3) notices sometimes the lack of crestal cortical bone in posterior maxilla. Furthermore, quality of extraction surgery is a dominating factor in the following resorption. This is why exodontia techniques will have to be thrifty with bone volume.

Preservation of buccal and palatal walls requires non traumatizing surgical acts. The preliminar setting of roots by keeping the periapical bone is the chosen technique. The section of multirooted teeth and the separation of roots protect interroot walls which permit an anchorage improving primary stability of implant. Healing time after extractions must be reduced to 2 or 3 months to limit centripetal resorption of alveolar ridge and periapical bone in sinusal floor (4).

An atraumatic extraction with immediate placement of implant or alveolar filling are the essential criteria to avoid bone resorption. However, loss of one or several bone walls make the therapy more complex and bone grafts become necessary. (1)

Depending on indications, specific surgical process permit to stop the resorption:
- immediate implant, technique firstly described by Schulte and coll. (15) where we place implant in the same time of extraction
- alveolar filling with bone substitute or autologous bone when implant placement is delayed
- loss of one or several bone wall and augmentation of alveolar ridge are bone grafts techniques.

Immediate implantation needs an extraction site assessment, by checking:
- an extended infectious phenomenon
- a perforation, gap or fenestration
- cortical wall fracture
- a buccosinusal communication that can injure to the osseointegration.

**Ridge width diminution with centripetal resorption of the maxilla.**

With no teeth, there’s also a diminution of residual ridge width because of centripetal resorption of alveolar bone at the maxilla. In the posterior maxilla, the resorption is more important in buccal aspect (16).
Then, according to Atwood (11), the edentate alveolar ridge resorption is depending on each individual and is the consequence of submitted functions (Wolf’s law) in interaction with the 4 following factors:

- anatomic factor, bone quality, cortical thickness
- metabolic factor, vascularization, ageing of bone tissue
- functional factor, intensity, frequency, lasting of occlusal forces
- prosthetic factor: prosthesis quality about sustentation, stability, occlusal overload.

Then, we have edentate ridge with insufficient bone volume under the sinus to place our implants. Indeed, several years after the loss of teeth, we just have a thin bone thickness under the sinus. In case of lack of bone height under the sinus, there’s no simplified protocol corresponding to every clinical cases.

The treatment planning depends on each clinical case of each patient. It depends on type of edentulism, residual bone structure, personal comfort, by favouring for example, if the indication permits it, a reduction of surgical interventions.

We have two possibilities.

Method of surgical approach with filling or method without filling.
The principle is to create a space maintaining the sinus membrane away from bone walls, either thanks to filling technique, or easily by using implants like stake of tent.
This space is filled up with blood clot which progressively turns into bone.

- Sinusal filling with crestal approach

The sinusal filling with crestal approach is a technique described by Summers (17) and modified by others authors (18) in order to perform a sinus filling in a less invasive way with a different approach.
When the crestal bone height under the sinus is equal or upper to 4 mm, the crestal approach by osteotomy is less invasive than lateral one to obtain a good bone height to place our implants.
The obvious advantages of this technique are:
- simultaneous placement of implants in the same time of sinus filling. Indeed, in a low mineralized bone, using of osteotomes associated with drills, permit to place an implant by compacting the bone of residual walls toward the sinus membrane.
- Protection of intraosseous vessels of lateral part of maxilla

In spite of obtained success (19), it’s nevertheless a controversial and limited technique, because of following reasons:
- surgical act is performed “blind”
- so it depends on skill of practitioner
- so the membrane can be perforated
- weakness of bone walls on the path of osteotome can leads to a fracture
- eventual intrasinusal wall in the path of osteotome can compromise the indication
- the filling is made just around the implant and isn’t homogenous, for an extended filling, this technique isn’t recommended
- in case of high resoprtion of the maxilla, this method is contraaindicated
- if a bone correction is necessary to improve the prosthetic space, this technique isn’t advised.

According to the authors, expected bone gain is between 3 and 5 mm.
Success rate with crestal approach and implantation are equal to those obtained with non grafted bone and upper to those obtained with placement of sort implants in a residual bone height lower than 10 mm (21).

With material supply, bone growth is more important and give a good radiographic image. As this technique is low invasive, it’s not logical to take an autogenous transplant. Bone substitute give identical results in lasting of reconstructions.

If conditions and precautions previously seen are respected for a crestal approach and immediate implantation, this method is apparently easy. However, if there’s a perforation of sinusal membrane or effraction of bone walls, their checking isn’t immediate and repair of membrane or wall can’t be anticipated.

This is why this intervention is qualified as a “blind” one, and this isn’t a consensus one.

- **Sinus filling with lateral approach.**

This technique was advised for type SA 3 bone (residual bone height between 5 and 8 mm) according to Misch classification (22). Currently, it’s advised when bone is equal or lower to 4 mm. It allows a bone height augmentation of 3 to 6 mm.

Between 3 and 6 mm of residual crestal bone height, several filler material are used with equal success (autogenous bone (23), allograft or xenograft (24), alloplastic material (25), bone substitute and autogenous bone mix (26)). Under 3 mm in large sinus, just autogenous bone with high quantity of cancellous bone is necessary to induce a new bone formation.

A large volume to graft often requires an iliac or parietal taking. (27)

During the detachment of Schneiderian membrane, a round edge rugine or a piezoelectric flat insert, separator of Schneiderian membrane, contribute to the elevation of the membrane and to the detachment of lateral window linked to this membrane if we don’t want to keep it. Use of large base rugine, rather than a narrow base one, to elevate the membrane, prevents the perforation in a more effective way. This last maneuver begins in posterior area to end in anterior part. Nevertheless, the risk of perforation isn’t nil as well as complications that can lead to. Sinus filling has a high success rate, but we can have several complications:

  - in pre-operative: perforation of sinusal membrane
  - in post-operative:
    - perforation of soft tissue without infection
    - sinusal infection
    - hemosinus, infected or not
    - loss of filler material or loss of implants

Perforation of sinusal membrane is the most common complication (10 to 30 % of cases) (Pict.1-2)

**Pict.1:** this dissection shows the creation of a bone window to perform a lateral sinus filling with torn of thicken sinusal membrane.

**Pict.2:** this dissection shows the creation of bone window to perform a lateral sinus filling with torn of thin sinusal membrane.

It’s due to:

- membrane extremely thin (0,3mm)
- presence of bone septum
- type of instrument used
The perforation increases the risk of infection because a more important number of bacteria can invade the transplant. These bacteria can go into the sinusal cavity up to the ostium, preventing then the normal drainage of mucus. Depending on the lesion size, therapeutic changes:
- perforation upper to 5 mm: suture of mucosa with absorbable wire or placement of collagenic membrane. The intervention is stopped if the filler material is in chips or granules.
- Perforation lower to 5 mm: same therapeutic but intervention can be done.
- Perforation lower to 2 mm: more favourable prognosis, almost if we use autologous bone.

Placement of exogenous membrane, to protect Schneiderian membrane and the filling if the lateral bone window is removed is necessary. (Fig.3)

Fig.3: this dissection shows the placement of collagenic membrane to fill up the torn sinusal membrane.

Protection of filler material or Schneiderian membrane can be made with:
- exogenous absorbable membrane at 18 weeks
- endogenous membrane obtained by platelet centrifugation (PRF), which oftenly add a cost and intervention length.

A conclusion about bone derivatives is unanimous. Doubt about pathogen transmission, unknown at this day with allograft or xenograft can be currently justified without any study confirming it after 15 years of using of these materials. However, the unlimited quantity of these materials is an incitation to use them. Patient must firstly be informed about the length of new bone formation:
- 4,5 months for autogenous bone
- 7 to 9 months for an allograft or xenograft
- more than 9 months for an alloplastic material

These deadlines can be considered a a choice criteria for filler material. In the long-term, an allograft, a xenograft, or an alloplastic material give the same results with rare cases of failures. (28) As the material is radiolucent during first weeks, evolving of the transplant is just possible after the beginning of mineralization process. What is important when we use a biomaterial is to have a good analysis of the case to avoid to be out of indications of these products, to have good required esthetic, clinic and functionnal results, and to maintain them in long-term.

**Two others solutions are possible without filling:**

**Placement of implant without supply of filler material.**

We know also the implantation without supply of filler material. Implants can go into the sinus, lifting the sinusal membrane, and they can be conventionnaly used for the prosthesis. This is what we call the implantation in “stake of tent” in the sinus. Then we wait for bone construction around implants by the osteogenic Schneiderian membrane. The principle is to create a space by maintaining the membrane away from bone wall. However it’s better to have a minimal bone anchorage and a perfect primary stability.
Lundgren (2004) published a study of 12 sinus lift without filler material with immediate placement of 19 implants. Analysis of Ctscan after 6 months shows a spontaneous bone formation. Implants had a good stability during all the length of the study. (29)

In 2007 Chen gives the results of a retrospective study on 47 implants placed in the same time as the sinus lift. No filler material is used. All implants are functionnal after 2 years of loading (30).

These publications show that using of filling in success of sinusal grafts must be studied and it may have easier and faster surgeries.

However, in these studies as in interventions, minimal height of bone ridge is never lower to 5 mm. Implants have then a perfect primary stability.

It’s important to have an implant apex pushing the sinusal membrane without injuring it. An implant has been set, with a CSO apex (IDI) (Concave Securit Osseo wedging). The non traumatic round shape of apex “securit” limits risks of lesion of sinusal membrane. (Fig. 4-5-5a-5b-5c).

If it’s not the case like in figures 6 and 7, the implant will perfor the sinusal membrane. This clinical case shows that in spite of perforation, there’s no sinusal infection. Nevertheless, the sinus has its own function.

These functions permit to have a good local homeostasy.
They’re in general controlled by properties of mucosa and ostium. (31)

**Protection against infections or immune functions.**

The sterility of sinus is made with several histologic components, featuring the mucosa.

Epithelium: this epithelial ridge is sufficient in normal conditions to ensure protection of the sinus. The mucus covering the epithelial surface has a major rule in the maintaining of sterility of cavities. It’s the result of secretive activity of intra-chorial glands and epithelial caliciform cells. It’s ensure the mechanic and biomechanic protection of the mucosa it covers. This one catches airl particles, gaseous polluants and bacteria, avoiding pathogens adhesion o mucous surfaces. This mucus carrier of strangers particles will be then eliminated by drainage.

Lymphoid tissue: cells of white branch like macrophages, lymphocytes and mastocytes are here, in a low rate, in mucous chorion. Presence of these carrier of immune and inflammatory process shows that there’s 2 functions in the sinus, even in basal state. So we can conclude that immune function of the sinus is efficiently ensured by epithelium and white branch cells.

**Sinusal drainage:**
This function permits to evacuate physiological and pathological secretions of the sinus through the ostium. This drainage is just made with muco-ciliar movement. (32)

The ciliar activity or biological mechanism of evacuation is identical to the one existing in respiratory system. It’s the result of coordinated beating of cilia, making the thin layer of mucus produced by caliciform cells and sero-mucosal glands moving.

In the maxillary sinus, the ciliar flow has a star shape on all aspects from the floor, up to the ostium. The ostium is covered with a mucosa which has a double layer of cilia (32) permitting, by its sinusal aspect, to make a drainage of cavitary secretions and, by its nasal aspect, to move these secretions away from it.

Then, for Uziel and Guerrier (33), the mucous carpet of large sinus would be fully renewed in 20 mn. Furthermore, this muco-ciliar movement resists against hygrometry variation, temperature, concentration of intrasinusal oxygen (particularly its decreasment).

So we can say that sinusal membrane musn’t be injured. Just a round implant shape permits it.

**Placement of shorts implants**

There’s a growing interest for this type of implant, beside more conventionnal implants (longer, narrower).

These implants with large diameter are recommended if the bone ridge has at least 6 mm height and 8 mm width in bucco-palatal direction.

Implant of 6 mm length will permit to work in low bone height area to avoid any bone reconstruction surgery.

For patients with low bone volume, implantology becomes possible without any reconstructive intervention thanks to these implants available in diameter 4 and 5 mm.

Nevertheless, bone resorption limits this using.

Furthermore, the prosthetic crown height – implant height ratio is unfavourable for occlusal forces. Physiological bone resorption or simply post-extractionnal can give qualitative or quantitative bone defects, particularly in the posterior maxilla in front of maxilla sinus.

There’s some alternatives to bone grafts for the designing of new implants shape.