LUCIAN BLAGA UNIVERSITY OF SIBIU

THE FACULTY OF MEDICINE

DOCTORAL THESIS

THE EVALUATION OF BONE STABILITY OF IMPLANT PROTHESIS IN BONE DEFECTS RECONSTRUCTED WTIH AUTOLOGOUS BONE

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Introduction

Patients who addressed dental offices for oral rehabilitation want fixed prosthesis at the end of their treatment. No patient will ask the physician for removable appliances. The introduction of dental implants has made it easier to achieve this.

The idea of replacing lost teeth with different metallic devices does not belong to the present time but finds its origins in China and Ancient Egypt, more than 2000 years ago. The late maya civilization had developed the tools needed to insert into the mandible some devices that restored the oral functions.

The 20th Century knows the true implementation of implants as a routine procedure in dental offices. In 1913, *Greenfield* published one of the first reports of a new device that was inserted into the bone. It was made of precious metals like iridium and platinum covered with 24k gold. There were also different dimensions depending on the tooth to be restored, larger diameters for molars and smaller as we approach the median line.

Although the father of modern implantology is known as *Per Ingvar Branemark* with the first patient to receive titanium implants in 1965, the research was started about 25 years ago by *Bothe* and colleagues who noticed bone growth around titanium osteosynthesis screws. *Branemark* is the one who set the foundation of implantology science by introducing the concept of osteointegration, when studying rabbit tibia with the help of titanium chambers. When removing them from the surgical site, he noticed the impossibility of doing this procedure, and so the phenomenon recognized today is the basis for the use of implants: the osteointegration of titanium devices in bone sites. The implants underwent many designs from *Greenfield*'s well-known basket implant and *Linkow*'s blades, which in the 1950s became the most widely, used implants in the world, to the specific shape of today's root form implants.

The end of the 20th century and the beginning of the 21st century substantiate the science of implantology by understanding the physiological phenomena related to extraction and implantation and by implementing two new concepts that approximate the patients' wishes to have fixed teeth but as quickly as possible from the extraction. Thus, today we use the techniques of immediate postextractional implantation in the same session with the immediate extraction and loading of the teeth with temporary work performed at the same implantation session. In this area, we have to mention *Paolo Malo* who introduced the concept of *All on 4* of implantation and full load of the mandible and so full rehabilitation of the patients is accomplished in one day.

But with all these innovations in the field of implantology, we still cannot stop bone atrophy as a result of tooth loss. Dental implants to be successful, must first have a stable bone bed suitable for 3D morphology. Most of the times this bone base is reduced both in quantitative and qualitative terms. With the development of implantology the question *How do we restore lost bone volume?* has become an essential component of medical research in this field. *Branemark* had used, since the 1970's, autologous bone as a transplant to a deficient site. Techniques were cumbersome and the lack of proper tools led to important comorbidities. There have been numerous materials, synthetic, animal or even human, used in deficient

areas. Unfortunately, many of them did not produce the desired result, despite the stronger marketing of manufacturing companies.

In recent years, we are happy to witness the return of the use of autologous bone, considered a *gold standard* by the one who reorganized the implantology science: *Carl Misch*. Today we have minimally invasive methods of harvesting and fixing transplants, largely through the work of great clinicians such as Professor *Khoury* with the method that bears his name and Dr *Istvan Urban*. The two use the patient's own bone in two different ways, but both are based on years of study and international reporting.

We also have modern paraclinical methods of mathematical analysis and quantification of the bone substrate, at different intervals from the end of the prosthetic-implantological treatment. The most important weapon is conical beam tomography or CBCT. The technology has been available for more than 30 years, but digital devices with low radiation exposure comparable to 2D technology have emerged in recent years. Costs have dropped considerably, allowing us to expand their use. The *Khoury* method involves the transplantation of bone blocks without other materials, and the *Urban* method involves the mixture of autologous chips with slowly resorbable bovine material covered by membranes. Both methods have been in practice for over 10 years but there is no direct comparison between the two methods in terms of bone stability. This is the basis of the research undertaken in this doctoral thesis, in which we proposed based on a clinical practice to follow in time 2 groups of patients who benefited from one of the two methods of reconstruction. The findings of this research will be the first in our country and will help implantologists to choose the treatment method case-by-case basis. We will have a complete clinical and tomographic image of the entire complex of gingiva-implant-bone.

For the guidance throughout the years of study and support in the project, I express my gratitude and thanks to my scientific coordinator Prof. Univ. Dr. Dan Sabău, Victor Papilian Faculty of Medicine, Lucian Blaga University of Sibiu. Also, I would like to express my gratitude to those who have given me voluntary help in carrying out the doctoral research project, including: Radu Neacsu, Department of Maxillofacial Surgery Military Hospital Sibiu, Dr. Vlad Petrescu Seceleanu Department of Maxillofacial Surgery Elias Hospital Bucharest for the valuable clinical aid offered in the past but also today, Prof. Univ. dr. Nicolae Vasile Implantology Clinic Faculty of Dental Medicine Victor Papilian, Lucian Blaga University Sibiu, Prof. Univ. dr. Viorel Ibric Cioranu, Euroclinic Hospital, who guided my first steps in surgery and beyond, and also to all collaborators dentists. I also thank the family that was close to me even when I was away.

The author

Physiology of bone augmentation

The bone block either vertical or horizontal is a bone transplant taken from a donor area and fixed in the defect area. The block may be cortical, cortical-spongious or spongious depending on the donor site or the sampling technique.

The survival and integration of the block depends on block immobilization, its revascularization from the receptor site [1], and cell viability inside the block. Cellular quality is dependent on the sampling technique and time to attachment to the receptor site [2].

An imperfectly fixed graft will lead to cellular hypoxia with cartilage tissue formation or even cell death with graft necrosis, and secondary infection [3].

Osteocytes and surface cells will undergo the phenomenon of cellular apoptosis irrespective of the rapidity of the harvesting procedure or the non traumatic harvesting technique, so the cellular quality inside the block is important [4]. These cells will be reactivated with revascularisation [5], but also the surface of the bone block itself has osteoconduction potential that is added to the osteoinduction represented by the active cells.

At the same time there is a process of removing necrotic material by osteocytes, the empty spaces will be filled with viable material by the colonization phenomenon and thus a new functional micro architecture will be created [6]. This remodelling process may take many years but the graft will be stimulated by inserting the prosthetic-implant restoration at 4 months, to avoid bone size reduction. [7].

Resorption of graft at the receptor site occurs due to transplantation with osteogenic and cytokine cells from the donor site and graft type (cortical, spongy or mixed bone) [8]. Also, the receptor site will release remodelling elements to harmonize the transplanted structure with local biology with commissioning. That is why a long waiting time for healing is not desirable.

The cortical bone, devoided of osteogenic cellular elements, has a lower potential for osteoinduction as the spongy, so it will be resorbed by the body that will continue the processes of apposition and resorption. The difference, however, is given by the much larger bone mass of the cortical bone which, even if subjected to intense resorption processes, will provide a much better bone bed for implantation [9].

Mixed cortico-spongy grafts combine the benefits of the two bone elements through cellular and vascular rich bone marrow delivery and increased cortical bone density. The medulla ensures osseoinduction and cellular osteoconduction, and the cortex will provide a supportive, volumetric maintenance role in the osteoreduction pathway [10].

Biology of bone healing in guided bone regeneration

Guided bone regeneration, abbreviated with the GBR acronym, involves the application of bony bone material (autologous, xenogenic, allogenic, alloplastic or a combination) and

covering it with resorbable or non-resorbable barrier membranes that may be fixed to the receptor site. GBR is based on the migration of osteogenic cells from the periosteum and bone marrow to the grafted material and prevents the advancement of epithelial and connective tissue forming cells [11]. Thus, the rate of osteoblast advancement should exceed the migration of fibrocytes and epithelial cells from soft tissue tissues [12].

The basis of healing is the principle of PASS [13]:

- Closing *per primam*

- Angiogenesis

- Space for osteogenesis

- Graft stability

In the first 24 hours of surgery, clots containing cytokines (interleukins) and healing stimulation factors such as cell growth factors are organized. The clot is resorbed in time and replaced by granular tissue rich in neoformation vessels necessary for the migration of mesenchymal cells and the organization of primary bone tissue. Within 3-4 months, the fibrous bone is formed, which mineralizes and forms the lamellar bone that will develop into compact and medulla.

Implant success

It is considered an implant-prosthetic success when [14]:

- There is absence of pain

- There is a fixed gingiva attached around the implant

- There is no infection

- There is no radiotransparency around the implant

Failure is considered when [15]:

- Patient feels pain in functionality

- The implant has horizontal mobility

- Mucosal inflammation

- Progressive peri-implant bone loss

Principles for the success of a transplant [16]:

1. The receptor site has a suitable vascular bed. Cells must maintain their viability from harvesting to fixation after this time. In the first 5 days, bone cells feed on imbibition, a process called plasma circulation. If the receptor site has an increased capillary capacity, the rate of imbibition also increases. The development of capillary vessels in the graft takes about 21 days and begins on day 3. This neoangiogenesis depends on the number of capillaries present at the receiving site at the time of the intervention

2. The recipient site should be free of infection. Revascularization lasts for 3 weeks, during which leukocytes and immunoglobulins cannot protect the graft. Grafts placed in compromised sites or grafts exposed into the oral cavity and thus saliva in the first 14 days will fail. If dehiscence occurs after revascularization, the graft is protected from infection and the reepithelialisation process will begin but it will lead to partial graft resorption.

3. Graft stability for at least 21 days. Neoangiogenesis and the formation of growth factors are susceptible to shear forces. The capillaries do not have protective adventitia and have a very small diameter of up to 6-8 μm and are thus are sensitive to breaking forces. Destruction of capillaries compromises osteogenesis.

The anatomical regions most used in autologous bone harvest

Intraoral

Mandibular symphisis

Is the indication of choice when augmenting the anterior mandible, because there is a single surgical site. The bone volume that can be harvested is around 2cm3 [7]. The bone has a thin vestibular cortex with a generous bone marrow. The lingual cortex is thicker (2.5-3 mm) than vestibular (1.5-2 mm) [17].

Local contraindications:

- bone defects larger than 4 teeth [18]

- Long roots of mandibular fronts

Ramus

Bone volumes of up to 12-15 mL or 3 / 1.5cm blocks can be harvested [21].

External oblique ridge

Is the most used site for autogenous bone harvesting. The bone is predominantly cortical with a thin medulla. The maximal harvested bone volume is 4.4 cm2 [19].

Local contraindications:

- Intrabony tumours

- Recent mandibular fracture

- Mandibular canal in superior position [20]

Extraoral

<u>Calvaria</u>

The parietal region is the site of choice for autologous bone harvesting. The parietal bone is used in various bone reconstructions of approximately 100 years [11]. The bone is bicortical-spongious. The average thickness is around 7mm ranging from +/- 1.6 mm [22]. The parietal bone has the same origin and ossification as the maxilla. There is a generous donor bone volume. Bone blocks of 5/2 cm with a thickness of 2-3 mm can be harvested [23].

Complications [24, 25, 26]

- Injury to the sagittal sinus by not respecting the safety distance of 2-3 cm

- Cerebrospinal fistula

- Exposing the dura

- Extradural haemorrhage

- Neurological disorders

- Dehiscence with donor site infection by inappropriate suture or sepsis caused by parietal plumage material

- Alopecia by electric coagulation

- Very rarely cerebral cortex stroke

<u>The iliac crest</u>

It can be harvested as a cortico-spongios block, bicortical-spongious or just medulla block. The anatomical limits for harvesting are bounded by the anterosuperior and posteriorsuperior crests.

Complications [27, 28, 29]

- Secondary infection leading to a significant reduction in graft volume or even graft loss

- Skin paresthesia by injuring the branches of the cutaneous femoral

- Hematoma requiring drainage

- Disturbances in walking due to pain, usually transient up to 3 months

- Late fracture of the crest at 2 post-operative weeks

Fibula

In large reconstructions for advanced post tumour resection with mandible through and through defects, free vascularized composite flaps are harvested from the fibula. Grafts can be harvested up to 25 cm [30]. Multiple osteotomies can be made in the graft to shape the bone and approximate it according to the initial form of the mandible. Implants can usually be placed after at least 3 months after the first operation [31].

Preparing the receptor site

Preparing the recipient site is as important as having a quality graft. The overlying mucosa must be of good quality, without fistula, and preferably with a keratinized tissue of adequate width. The design of the flap that will cover the flap should ensure perfect bonding and graft protection during the healing period.

In order to gain passive fit of the flap, periostal releasing is practiced, so the mucosa gains elasticity and can cover the whole graft. At the edges of the flap electrocautery or laser should preferably be avoided. In the posterior mandible, the lingual flap should be relieved by stripping off the milohioid muscle of the internal oblique line which leads to a significant elasticity of the mucoperiosteum.

The transplant is trimmed for a better approximation to the defect. The trimming is done under high cooling with physiological saline using even the harvesting instruments: drills, discs, oscillating saws, piezosurgery machines.

After the flap is elevated, the decortication of the receptor site is performed with small spherical drills, which accelerates the revascularization allowing the access of the capillaries from the sponges to the graft [32]. The trauma of decortications itself leads to the appearance of numerous mediating factors of inflammation that lead to accelerated healing. The presence of platelets, growth factors and osteogenic cells is also increased.

The bone transplant is fixed [33, 34, 35] at the receptor site with osteosynthesis titanium screws of diameter of 1-1,6 mm with different lengths of 6-12 mm depending on the area of work. Ideally, the block is anchored with 2 asymmetric screws to avoid rotating the block. Any micromovement will cause connective tissue invagination between the graft and defect, thus leading to imperfect osteogenesis. Also a good fixation results in graft compression on the receiving bed and a better fit. Any space left between the graft and the bone bed will be filled with granulated bone to avoid conjunctive tissue migration [36].

Adequate stabilization and intimate contact between the block and the receptor site influences the bone regeneration rate more than the origin of the autologous bone [37].

THE SPECIAL PART

The study aimed to clinically and radiological assess the stability of the bone level in a horizontal and vertical plane in the case of bone defects reconstructed before implant insertion.

The study is a prospective study that we started in October 2014. Patients' analysis started in October 2010 and lasted until May 2017. Patients were diagnosed, treated and monitored in the Maxillofacial Surgery Clinic of the Sibiu County Hospital, in the Ambulatory Clinic of Dental Medicine and Oral Implantology and Department of Maxillofacial Surgery of the Military Hospital "Alexandru Augustin" Sibiu, Department of Maxillofacial Surgery of the Queen Maria Euroclinic Hospital Bucharest and in the Department of Maxillofacial Surgery of the University Hospital Emergency Elias Bucharest.

During the study, we followed a group of 165 patients who underwent bone reconstruction followed by insertion of implants, insertion of oral prosthesis and clinical and radiological monitoring to determine whether the bone level differs in time.

The objectives of the study were:

- Clinical investigation and preoperative imaging of patients

- Saving CT data on the original bone bed volume

- Using autologous bone as a basic material in bone reconstruction

- The use of classic bone blocks techniques as well as modern reconstruction with barrier membranes

- Postoperative patient comfort analysis according to intraoperative techniques

- Establishment of a clinical and imaging monitoring protocol

The novelty of this study stands from the fact that in our country there are no follow-up studies for pre-implant autologous grafts. After graft healing and implant insertion there is an amount of graft reduction, considered to be a physiological action of the human body. There is no published data on bone stability at regular intervals of time after implant prosthetic treatment. The authors also want to make a comparison between the two methods of autologous bone augmentation: bone block and bone chips, regarding the stability of the bone level over time.

The patients presented in our department looking for prosthetic reconstruction of edentulous spaces due to extractions, tumour resections, sequela of the labio-maxilo-palatine clefts or due their periodontal status they would become edentulous in the near future. The bone atrophy class was diagnosed based on exoorale clinical examination (frontal and lateral norm) and intraoral, but especially paraclinical, by radiological examination which included: panoramic radiography, profile teleradiography, conical beam CT. The bone atrophy class did not allow the insertion of dental implants without bone grafts.

Surgical methods

Patients were divided into 2 groups, thus group A (No = 95) to which bone grafts were applied in the form of transplanted blocks and group B (No = 70) using the bone chips grafting technique.

Description of surgical procedure for group A

Depending on the severity of atrophy, bone blocks are harvested from an intraoral or extraoral site, so for defects or up to 3-4 teeth the blocks are taken intraoraly, for medium hemiarcade defects ipsi- and controllateral intraorally. For large hemiarcade or mono and bimaxilar defects, an extraoral donor site is required. This implies the need for hospitalization and general anaesthesia interventions. The block is trimmed to conform to the defect in order to reconstruct the anatomical curvature of the bone. Usually it is cut on the length or it is split and the outer edges are rounded in order not to interfere with soft covering tissue. It is fixed with osteosynthesis screws. The spaces between the graft and the defect are covered with autologous bone chips and the block is covered with xenograft to prevent resorption during the healing period.

Description of surgical procedure for group B

The bone is harvested with autoclavable or disposable scrapers that have a plastic handle for ergonomics, a metal cutting blade for harvesting and a collector with a rotating cap. It is also possible to use special collecting drills which have the active part in the form of a spiral with an autoclaved metallic or silicone house. These drills have increasing diameters depending on the required bone size: from 4.5 to 6 mm. The drills are mounted at the surgical contra-angle and are used at 300-500 rpm under cooling with sterile physiological saline. After harvesting, the donor site can be grafted with xenograft bone or allowed to heal spontaneous as a 5-sided alveolar defect after a dental extraction. After harvesting the bone is stored for a maximum of 20-30 minutes in a sterile container in wet or mixed with capillary blood. The bone is mixed 50-50% with xenograft, which increases the volume of the graft, but in particular it prevents the osteoclastic phagocytosis.

The graft must be covered with a barrier membrane after insertion. If only a horizontal reconstruction is required the membrane may be crosslinked collagen, if a vertical atrophy is present than a rigid barrier such as titanium mesh or PTFE is used. The membranes are fixed with pins, tacky or osteosynthesis microscrews.

The second surgical step is to uncover the graft. Preoperatively a radiological examination is performed to verify graft integration and osteogenesis. The future implant-prosthetic reconstruction is also planned. This period of healing takes between 4-10 months depending on the size of the defect and the technique (4-5 months for blocks, 6-10 months for membranes). At uncovery, the fixation screws and the conformation membrane are removed, and dental implants are placed under local or intravenous anesthesia. After 3-4 months, the prosthetic stage is performed

After these stages, the follow-up phase is from 6 to 6 months, with clinical and radiological examinations. The first year represents the maturation period of the graft that also continues throughout the following years, but it is more important in the first year postoperative.

Subsequent bone resorption is influenced by patient hygiene, smoking, prosthetic reconstruction, and occlusal status of the patient.

The prosthetic and monitoring steps are similar for both groups.

From a clinical point of view the following parameters are monitored:

- Presence of pain, inflammation, infection, mobility

- Implant sulcus depth, bleeding index

- Gingival aspect of restorations

From a radiological point of view we monitor:

- Perimplantary bone level at the spiral portion of the implants - the vertical component of the bone reconstruction

- Funnel shaped resorption at the neck of the implants

- Vestibular cortex thickness - measured on CBCT – the horizontal component of bone reconstruction

- Any perimplant translucency

In the study, we registered the preoperative bone level (T initial), at the time of graft integration (T1), at completion of the prosthetic stages (T2) and at exact control intervals (T3). We analyzed these data comparatively to see if there are differences between the two methods of reconstruction in terms of their longevity following the clinical and radiological criteria outlined above. The statistical relevance of the samples was analyzed by the Kruskal Wallis test.

In terms of age, we registered the following classes: young adult (18-35 years), middle aged (36-55 years) and old adult (over 55 years) [38]. The most common class was middle aged (41.8%) followed by old adult (34.5%).

Table 1. Age distribution in the 2 groups

Age groups	Group A		Group B	
Young adult 18-35 years	21	22,1%	17	24.2%
Middle aged 36-55 years	41	43.1%	28	40%
Older adult >55 years	33	34.8%	24	34.8%

Depending on sex, the predominance was for female sex in both groups.

Sex	Group A		Group B	
F	54	56.8%	41	43.2%
M	43	61.4%	37	38.6%

Table 2. Sex distribution in the 2 groups

Surgical Procedures

Bone blocks were extra and intraorally harvested: iliac crest (21.05%), external oblique ridge (20%), vertical mandibular ram (16.8%), menton (15.8%), parietal calvaria (10.5%), maxillary tuberosity (6.3%), fibula (5.2%), anterior palate (4.2%).

Collagen membranes (40%), mesh and titanium membranes (35.7%), PTFE membranes (24.3%) were used at group B.

Tehnique	No of cases	% group	% of total no of cases
Iliac crest	20	21,05	12.1
Calvaria	10	10.5	6
Fibula	5	5.2	3
External oblique ridge	19	20	11.5
Ramus	16	16.8	9.7
Chin	15	15.8	9
Tuberosity	6	6.3	3.6
Anterior Palat	4	4.2	2.4
Colagen Membrane	28	40	17
Titanium mesh	25	35.7	15
PTFE	17	24.3	10.3

Table 3. Surgical technique distribution in the groups

In group A we had horizontal atrophy in 59.8%, vertical 10.45% and mixed in 29.25% and in group B horizontal atrophy 34.2%, vertical 38.4%, mixed 27.4% .

Depending on the jaw involved, the mandible was reconstructed by oblique crest blocks (26.6%) followed by titanium membranes (11.6%) and the least by PTFE membranes (8.1%); the upper jaw was reconstructed mainly by collagen and titanium membrane technique (35.7%) and least by mandibular blocks (3.3-7.8%); bimaxilar defects were mostly reconstructed through blocks of parietal calvaria and collagen membranes (37.5%) followed by anterior iliac crest blocks (25%).

Fig 1. Surgical technique distribution regarding the jaw involved
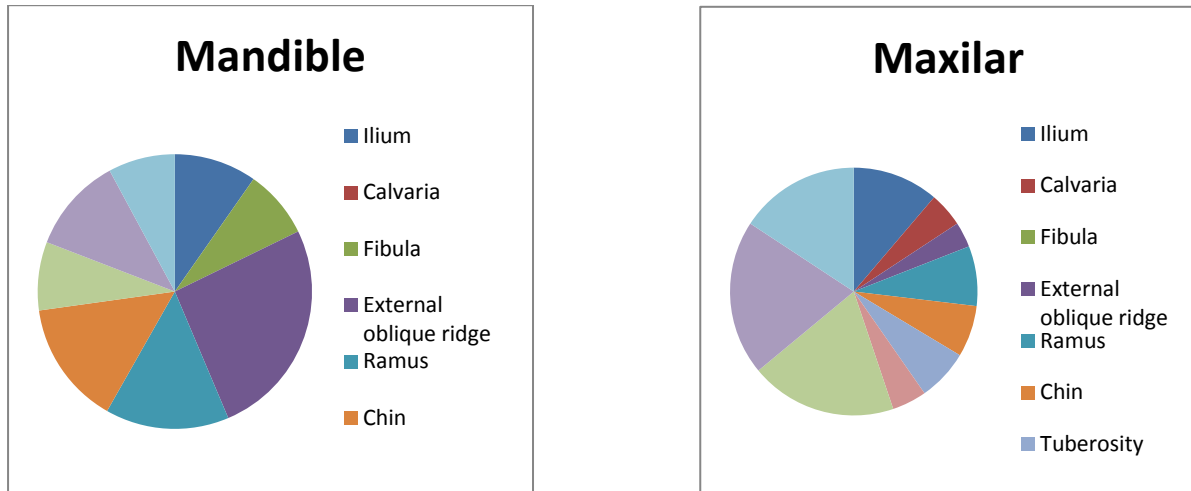
The donor sites for patients in group B were:

- Posterior mandible (retromolar area + external oblique crest) 35 cases (50%)

- Anterior mandible: chin 23 cases (32.9%)

- Maxilla: tuberosity + zygomatic-alveolar crest 12 (17.1%)

Immediate postoperative complications related to the donor site for group B were: alveolar nerve sensitivity disturbances (No = 11), secondary haemorrhage (No = 8), teeth vitality disorder (No = 6), dehiscence (No = 2) and infection (No = 1).

Immediate postoperative complications related to the donor site for group A:

- *Intraoral grafts*: alveolar nerve sensitivity disorders (No = 13), secondary haemorrhage (No = 5), adjunctive teeth vitality disorder (No = 3), dehiscence (No = 1) No = 0).

- *Extraoral grafts*: Nervous Sensitivity (No = 2), Hematoma (No = 3), gait disorder (No = 3), Dehiscence (No = 1) and Infection (No = 1).

All patients received a home questionnaire to analyse the degree of postoperative comfort and to compare the two surgical methods regarding the recovery period. The patients received the same drug protocol with NSAIDs, antibiotics, mouthwash, diet instructions and oral hygiene. Patients with extraoral grafts receiving other anti-inflammatory and antibiotic treatment were excluded and who had no other surgical treatment option to choose. This resulted in a group of 135 patients: 80 with bone blocks (A) and 65 with sandwich reconstructions (B).

Pain analysis was based on the numerological scale of pain [39]:

- 0 = absence of pain

- 1-3 = slight pain

- 4-6 = moderate pain

- 7-10 = severe pain

- 10 = the most intense pain felt

After the data is recorded, the following results are obtained:

- Mild pain: at 24h B> A (p = 0.7595); at 7 days B> A (p = 0.4273); at 21 days B <A (p = 0.5043)

- Moderate pain: at 24 h B <A (p = 0.6315); at 7 days B <A (p = 0.7224); at 21 days B << A (p = 0.9838)

- Severe pain: at 24 h B <A (p = 0.6072); at 7 days B << A (p = 0.3155), 21 days in group B no data were recorded.

After processing the data, it resulted from the strict point of view of the postoperative pain the technique that uses the bone chips is much easier to tolerate for the patient at home during the first postoperative days (24h) and later (7-21 days).

The quality of life was tested after the OHIP 14 test [40] which included the following questions:

1. Do you have difficulty pronouncing words as a result of limited language or opening of the mouth?

2. Have you noticed altered taste?

3. Have you seen acute oral pain?

4. Have you noticed problems eating?

5. Have you been concerned about your condition?

6. Did you feel tense?

7. Have you noticed that you cannot eat enough?

8. Have you discontinued meals due to discomfort?

9. Was it hard for you to relax?

10. Have you felt embarrassed?

11. Have you felt irritated?

12. Have you noticed difficulties at work?

13. Have you noticed a decrease in life satisfaction?

14. Have you not been able to carry out your daily routine?

The answers are coded as follows: O = never, 1 = sometime. 2 = fairly often 3 = very often, 4 = all the time.

Quantification of the answers:

- 1-14: Not at all affected

- 15-28: A bit affected

- 29-42: Affected more

- 43-56: Affected alot

Answers	Group A		Group B	
	No	%	No	%
Not at all affected	2	2.5	4	6.1
A bit affected	29	36.2	26	40
Affected more	36	45	25	38.4
Affected a lot	13	16.3	10	15.5

Table 4. Answers' distribution for OHIP 14 in the 2 groups

After the data is recorded, the following results are obtained:- a bit affected group B> A: (p = 0.1914)- Affected more B> A: (p = 0.7918)- Affecedt a lot A> B: (p = 0.733).

There is a difference in the postoperative comfort of the patients in group A vs. group B, so the bone blocks cause a greater degree of discomfort in physical and social functionality than the bone chips.
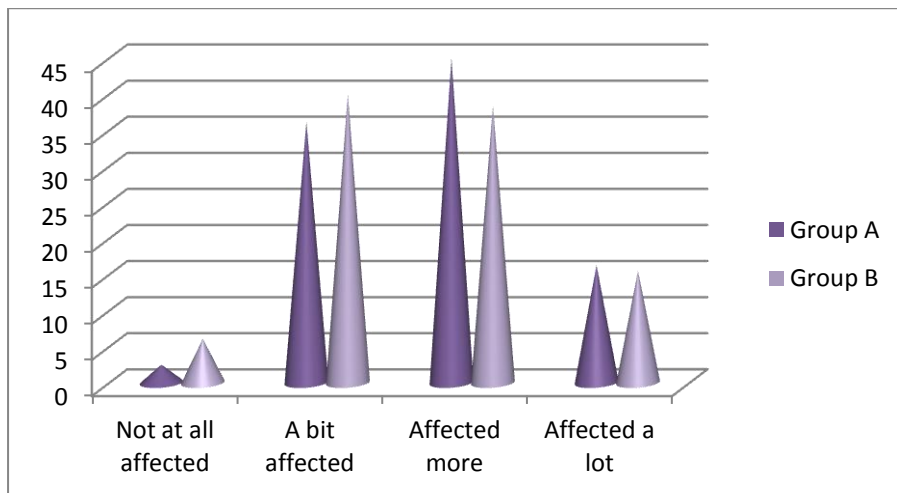
Fig. 2. Postoperative confort in the 2 groups

Techniques and tools used at group A

The instruments used for harvesting were: surgical drills (spherical and Lindeman), surgical disks and surgical saws, piezotom. Group A was divided from the point of view of instrument type and cutting pattern into 3 groups: A1 (classic drills), A2 (high precision discs and saws) and A3 (minimally invasive piezotom) and patients per each group: A1 (31), A2 (38), A3 (36).

For the extraoral graft harvesting, precision instrumentation (4.2-9.4%) versus the classic (1.05-6.3%) was used, the harvesting of the intraoral grafts from the posterior mandible used less invasive techniques (7.3-8.4%) and in the anterior mandible, mainly classic rotary instrumentation (6.3%), at the jaw harvest were used mostly minimally invasive instrumentation. Overall, the classical drills and micro saws (72.6%) prevailed over the minimally invasive (27.4%) instrument.

All patients received a home questionnaire to see the degree of postoperative comfort and to analysis which of the three methods is the least invasive during the recovery period. The patients received the same drug protocol with NSAIDs, antibiotics, mouthwash, diet instructions and oral hygiene.

After the data was recorded, the following results are obtained:

- A*bsence of pain* at 24h was not registered in any of the groups, at 5 and 14 days the highest frequency was for group A3 followed by A1 and A2. *Intensive pain* at 24h : A3 <A2 <A1. M*ild pain* at 24h was: A1> A2> A3 (p = 0.8144)

- *Intensive pain* at 24 hours and 5 days we observed in increasing order in group A3 followed by A2 and A1, at 14 days in groups A3 and A1 no values were recorded and in group A2 2.6%

- *Moderate pain* at 5 days: A2> A3> A1 (p = 0.7281), 14 days: A3> A2> A1.

- At 24 hours postoperatively, *mild pain* had the highest prevalence in all groups: A3> A2> A1 (p = 0.608) and *moderate pain* A2> A3> A1 (p = 0.8725) at 5 days and at 14 days *no pain* was noted in A3> A1> A2.

In conclusion, harvesting with the piezosurgery device brings more postoperative comfort to patients during the period of soft tissue healing.

Postoperative complications at the receptor site

The complications were: dehiscence, infection and failure of resorption grafting.

The postoperative dehiscence occurred in 10 cases (group A) and 12 cases (group B).

Secondary infection: 5 cases (group A), 4 cases (group B).

Impossibility of insertion of implants: 8 cases of which 5 with graft removal and 3 with resorption of the block (group A); 7 cases of which 4 with infection and graft compromise and 3 with advanced bone resorption of grafting material (group B).

At the time of graft uncover from a total of 165 patients, 15 could not receive implants due to graft failure: group A 8 patients, 7 patients in group B. For group A the graft predominantly failed in iliac crest reconstruction (3.3%), followed by tuberosity blocks and anterior palate (2.2%), and at group B in collagen membranes (6.6%) followed by titanium membranes (3.17%).

Bone quality at the time of insertion of the implants was assessed in the CT or intraoperative examination in cases where the CT scan was missing at the time of bone healing. Regarding surgical technique, the D2 bone was most frequently encountered in reconstruction with iliac crest (47%), D1 (73.7%), ramus (81.2%), D3 in tuberosity bone (75%); in group B was predominantly the D2 + D3 type (74.5%), followed by D4 type (14.7%). A cortical D1 + D2 bone (56.3%, 28.6%) was recorded int group A.

Bone denity	No cases	% group A	% griup B	% of total no cases
D1	62	56.3	20.6	41.3
D2	54	28.6	46	36
D3	30	13.7	28.5	20
D4	4	1.4	4.7	2.6

Tabel 5. Bone density in the 2 groups

Preoperatively the width of the crest was on average 3.16 mm and the height was 9.22 mm. Implant insertion in 15 cases did not provide sufficient bone for primary stability. At the moment of insertion of the implants for the 150 cases the average width of the ridge was 8.32mm and the height of 12.27mm according to the subadiacent table:

Tehnique	Initial Width	Width at T1	Initial height	Height at T1
Iliac crest	2.95	9.80	8.45	12.75
Calvaria	3.1	8.15	7.80	13.15
Fibula	0	9.70	0	12.20
External oblique ridge	3.45	9.15	8.75	11.20
Ramus	4.05	7.95	10.80	11.40
Chin	3.25	8.20	11.45	11.75
Tuberosity	3.65	6.75	11.95	11.95
Anterior palat	3.80	7.10	12.55	12.55
Colagen membrane	3.55	8.10	10.85	13.40
Titanium mesh	3.40	8.35	9.5	12.80
PTFE	3.55	8.25	9.4	13.15

Table 6. Width and height at Ti and T1 according to the surgical technique

For group A, at the moment of implant insertion, the width and mean height were 8.35 and 12.11 mm respectively, and for group B 8.25 mm respectively 13.1. For group A the increase in width at T1 was on average 5.32 and for height of 3.15 mm, and for group B an average of growth of width 4.73 mm and in height of 3.2 mm.

At the time of insertion of the prosthetic work (T2), a second radiological examination was performed, 4 months after the insertion of the implants.

From a total of 530 implants, 11 implants had to be explanted, 3 for group A and 8 for group B. Of the remaining 519 implants, 38 (20 group A, 18 group B) bone resorption was as follows:

- Small <1.0 mm: 21: (13 in group A, 8 in group B)

- Medium 1-2 mm: 17 (7 in group A, 10 in group B)

- Large> 2mm: 0 cases
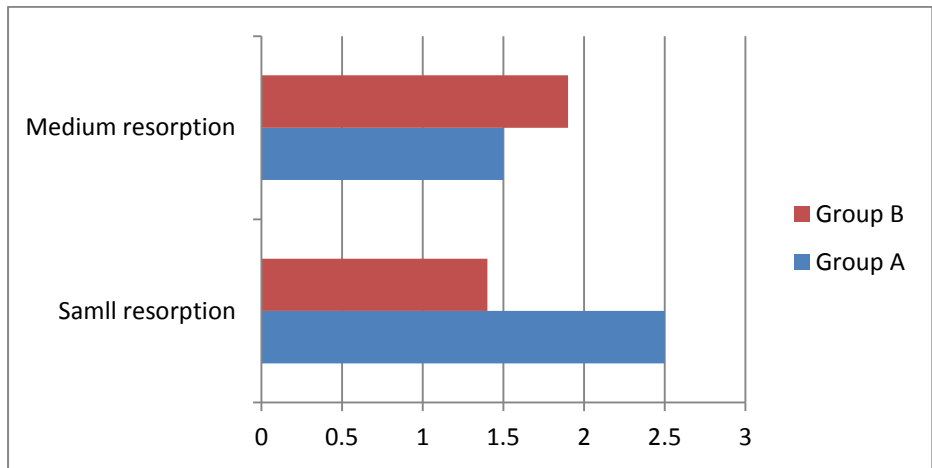
Fig. 3. Resorption rate in the 2 groups at T2

At T2 we have for group A: an average width of 8.11 mm, average height 11.91 mm, and for group B average width of 8.03mm, average height of 13 mm.

Six months after insertion of prosthetic work (T3) or 14-18 months after bone grafting, a new clinical and radiological check-up is performed. Of the 165 patients, 150 were recalled to control (15 graft patients failed). Of the 150 selected patients, 112 patients presented: 79 from group A and 33 from group B. Of these, 51 from group A perform radiological examination and 22 from group B. At T3 we have for group A an average width of 7.94mm and an average height of 11.55mm, and for group B an average width of 7.71mm and an average height of 12.63mm.

Group	Initial		T1		T2		T3	
	W	H	W	H	W	W	W	H
Group A	3.03	8.96	8.35	12.11	8.11	11.91	7,94	11.55
Group B	3.50	9.91	8.25	13.1	8.03	13	7.71	12.63

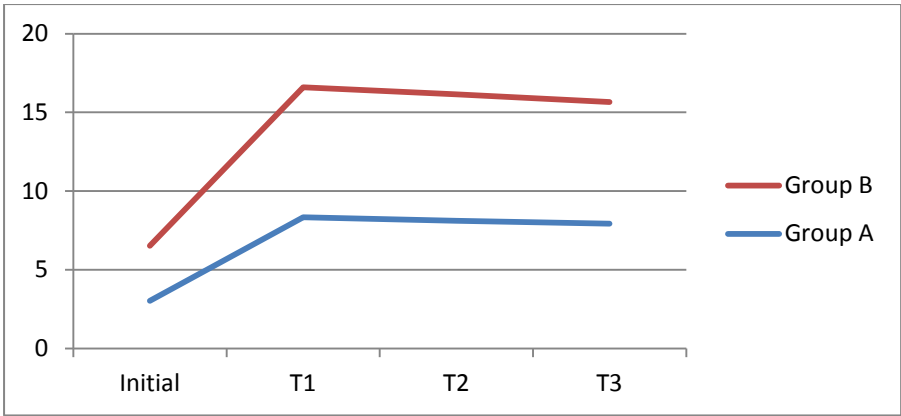Table 7. Width and height in group A and B at Ti, T1, T2, T3

Fig. 4. Width and height variation at T1, 2 and T3

When the prosthetic phase was accomplished a questionnaire was delivered to the patients related to the quality of life. The questions were [41]:

1. Are you satisfied with the quality of life?

2. Are you satisfied with the aesthetics of the final restoration?

3. Has the gum remained stable over time?

4. Would you still perform the same intervention once?

The answers were: strong yes, yes, not sure, no, strong no.

There is a slightly increased quality of life of group B versus group A (40% vs. 32.6%).

Fig 5. Quality of life in the 2 groups
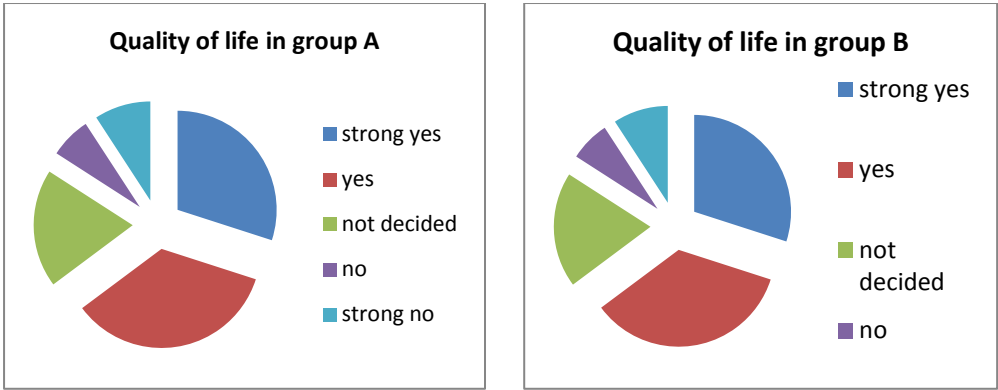
Conclusions

- Between 2014 and 2017, we monitored a group of 165 patients who received oral grafts in the form of bone blocks or bone chips and barrier membranes
- Including criteria were: impossibility of inserting implants due severe bone atrophy or bone defects after tumor resection or labio-maxilo-palatine clefts sequel, and patients eligible for surgery under local anaesthesia, potentiated i.v. or general intubation
- The main group was divided into 2 groups: group A with 95 patients who received bone transplants in the form of intraoral and extraoral blocks and group B with 70 patients receiving grafts in the form of a bone chips grafts
- Objectives: clinical and imaging monitoring of the efficacy of the two reconstruction methods, as well as the analysis of postoperative comfort and quality of life in the 2 groups
- Most patients were female in both groups: 56.8% group A, 61.4% group B
- For age categories the middle aged (36-55 years) was representative in both groups: 43.1% group A, 40% group B
- For group A the most used surgical technique was the iliac crest graft (21.05%) followed by vertical ramus (16.8%) and chin (15.8%)
- At group B the most used membrane was the collagen (40%), followed by titanium mesh (35.7%),
- Depending on the atrophy type in group A, we had horizontal atrophy in 59.8%, vertical 10.45% and mixed in 29.25% and in group B horizontal atrophy 34.2%, vertical 38.4%, mixed 27 ,4%
- The upper jaw was the most involved in the reconstruction (53.9%), followed by the mandible (36.3%)
- The maxilla was most often rebuilt with iliac crest (10.5%) and titanium membranes (30%)
- The mandible was reconstructed mainly by blocks from external oblique crest (16.8%) and by bone chips and titanium membranes (11.6%).
- The donor site for group B was in decreasing order: posterior mandible (50%), chin (32.9%) and zygomatic-alveolar ridge (17.1%)
- Complications related to the donor site: for group B the most frequent was nerve disturbances (15.71%) followed by secondary haemorrhage (11.4%), and for group A nerve disturbances (15.78%) followed by secondary haemorrhage (8.4%)
- Concerning the discomfort of patients after the first surgical phase, 90% of group A experienced severe and moderate pain compared to 77% of group B in the first 24h and at 21 days 34% of A versus 13% of group B
- Patients' quality of life was slightly improved for patients in group B (38.4-40%) vs. Group A (36.2-45%)
- For group A, the instruments used for bone cutting were rotary instrument, disc or micro saws, and piezosurgery

- Concerning the discomfort of the patients in group A, according to the method chosen for harvesting in the first 24h there were similar results for the 3 groups (64.4% vs. 65.7% vs. 63.8%) but at 21 days, we noticed improved postoperative comfort in the piezosurgery (minimally invasive) group 12.6% moderate and severe pain, compared to 15.7% with discs or 25.3% with classic rotary instrumentation
- Grafts were uncovered at 4-9 months depending on the operative technique: in 15 cases there was a failure due to the infection (No = 9) and resorption of the grafting material (No = 6)
- For group A graft failures were predominantly for iliac crest (37.5% of total failure) and in group B those with collagen membranes were predominant (71.42% of the total failure)
- After the grafts were uncovered, a total of 530 implants were inserted: 134 for group B and 396 for group A
- Bone density was predominantly of good quality D1 + D2 cortical type (77.3%), for group A we recorded D1 (56.3%), and for group B D2 (46.3%),
- The width of the ridge was on average 3.16 mm and the height of 9.22 mm, for group A: 3.03 medium width and 8.96 mm height, and for group B: 3.50 mm average width and 13.11 mm height
- At the time of insertion of the implants for group A, the width and mean height were 8.35 and 12.11 mm respectively, and for the B groups 8.25 mm and 13.1 respectively
- We noticed an increase of 175.57% of width and 28.4% of height for group A, and for group B an increase of 135.1% in width and 24.4% of height
- Of the 530 implants, 519 could be loaded, 3 (0.56%) of group A and 8 (1.5%) of group B were not osteointegrated
- 4 months after insertion, at the time of loading, 3.28% of the A group implants had low resorption (<1mm), 1.76% high resorption of 1-2 mm
- For group B: 5.9% had low resorption, 7.46% high resorption
- At the moment of loading we recorded for group A: medium width of 8.11 mm, average height 11.91 mm, and for group B average width of 8.03 mm, average height of 13 mm
- We noticed a decrease of 2.87% of the width and 1.65% of the height for the group A, and for the B group a decrease of 2.66% in width and by 0.76% in height
- 6 months after insertion of the prosthetic components or 14-18 months after the first surgical phase, clinical and imaging control was performed at 112 patients: 83.16% of group A and 47.14% of group B, radiological examination for 73 patients: 53.68% of group A and 31.42% of group B
- For group A we noticed an average width of 7.94mm and an average height of 11.55mm, and for group B an average width of 7.71mm and an average height of 12.63mm.
- We recorded a decrease of 4.91% in width and 4.62% in for group A, and for group B a decrease of 6.54% in width and 3.58% in height

- Overall, at the end of the monitoring, both treatment methods were a viable option, but at 16 months after grafting, there is a decrease of the bone support at group A below 5% and at the B level of 6.5% the horizontal component
- Statistically for group A the bone level is better than group B
- Concerning the quality of life, we noted from the completed questionnaires at the end of the monitoring, the acceptance of the treatment and the satisfaction for group B was: over 50% being categorically satisfied with the aesthetic result and 50% would be willing to resume the treatment
- For group A, the feedback is positive but significantly lower than group B (27.3-33.6%), in terms of resuming the first surgery 12.6% categorically agreed, and 11.5% opposed firmly
- Interventions requiring bone chips by scraping or milling from various sites seem to have a proper result in time and are better tolerated postoperatively by patients
- Techniques that use bone block transplantation are more laborious, reflecting patient comfort, but lead to more stable results over time

CLINICAL CASES

Reconstruction with Ti mesh

A 57 years old female patient had presented in our department, accusing masticatory and aesthetic dysfunction as a result of edentulous spaces. The patient wanted a fixed prosthetic rehabilitation. General medical history highlighted hypertension and ischemic heart disease under treatment with specific diuretic medication and platelet antiaggregants without other associated pathologies.

The exooral examination revealed a decrease of the lower floor of the face following the old edentations. From the lateral norm we noticed a concave profile determined by the frontal maxillary bone atrophy and the decrease of the lower level. The lower lip was everted; the labial mental fold was protruding. The facial appearance was conclusive with a class III Angle dentofacial disharmony.

Intraoral examination revealed first class Kennedy edentulism for the maxilla. The mandible had a class II Kennedy edentulism with a removable prosthesis anchored by a frontal partially uncemented ceramic fused to metal restoration that had mobility on palpation. The teeth had marginal percolation. Radiological examination revealed horizontal and vertical bone resorption in the upper jaw and slight horizontal atrophy in the mandible. The inferior teeth had severe chronic periodontitis and many chronic periapical processes. The remaining mandible teeth were endodontically and prosthetic irrecoverable.
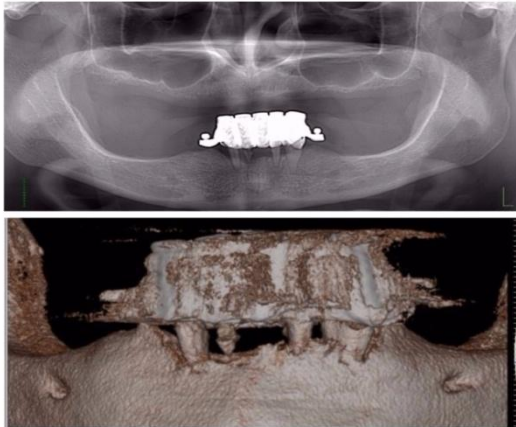
Fig. 6 CBCT showing severe upper jaw bone atrophy

Clinical and radiological analysis revealed the impossibility of applying implants to the upper jaw, requiring bone augmentation surgery by extraoral graft under general anaesthesia to achieve fixed implant-prosthesis rehabilitation. The patient refused the surgery and intraoral bone grafting in the maxilla was planned and insertion of the post extraction implants into the mandible. The prosthetic reconstruction consisted of 2 implant overdentures. This solution involved the insertion of a small number of dental implants (maxillary 4-6, mandible 2-4).

After the dental extraction, 4 dental implants were placed in the anterior mandible without the need for bone grafting.Simultaneously with the insertion of the mandible implants, autologous bone from the chin was harvested using scrapers and special bone chip milling drills. The bone was mixed with xenograft 50-50% and placed in the maxillary defects and stabilized with titanium meshes fixed with titanium osteosynthesis microscrews.

The patient did not returned for check up for about 18 months, and had an incorrect acrylic removable prosthesis that triggered excessive force on the graft, particularly in the left maxilla. For this reason, a dehiscence of titanium mesh was visible on the left side.

Fig. 7. Clinic photo with Ti mesh expose after 18 months
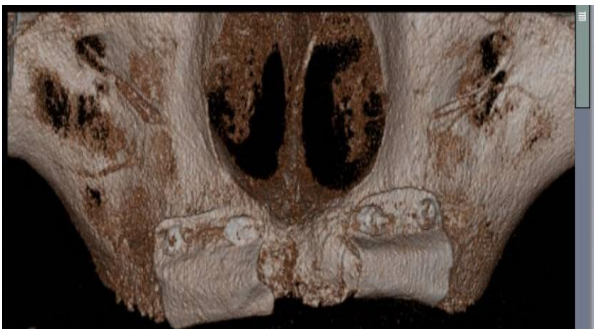
Fig. 8 CBCT 3D after 18 months

A CBCT exam was performed. With the help of the machining software, the 3D image of the bone substrate was obtained. Integration of the graft on the right was good and the bone bed was suitable for implantation, there was a resorption of the grafting material on the left, but a dental implant of the 2 proposed could be inserted. The screws and the titanium mesh were suppressed and 3 dental implants were applied.
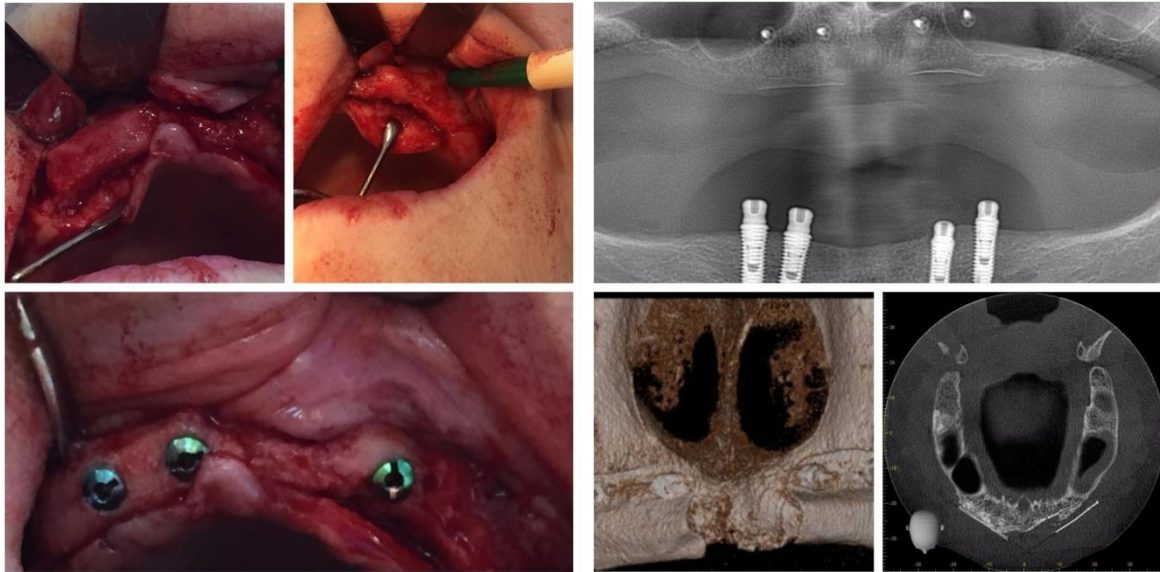
Fig 9. Graft healed after 18 months and dentl implanst inserted in the maxilla

Fig 10. CBCT 3D after 18 months

After a waiting period of another 4 months, the prosthetic reconstruction was fitted. 2 implant overdentures are delivered with locators.

The patient is periodically dispensed from 6 to 6 months.

Clinical and radiological control was performed at 1 year postopertive, with adequate maintenance of the bone support around the implants inserted into the reconstructed bone. Also soft tissue does not show signs of inflammation without bleeding or loss of perimplantary epithelium.
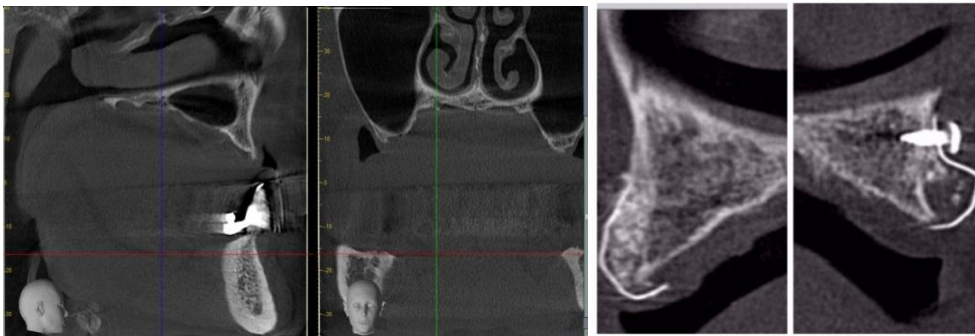
Fig 11. CT showing bone volume before and after bone grafting

Fig 12. Oral photo after 1 year

Fig 13. Oral photo after 34 months from grafting and 12 months from prosthetic delivery

Reconstructions with intraoral bone blocks

A 46 year old female patient presented to our department, accusing masticatory dysfunction and pain in the left temporomandibular region due to edentulism. The patient desired a fixed prosthetic rehabilitation.

From the general medical history no other associated pathologies are revealed. The patient had an implant-prosthetic rehabilitation in the left mandibular region that was suppressed.

Exooral examination did not reveal facial asymmetries or disproportion between the facial floors. The opening of the mouth was slightly antalgic due to arthritis of the temporo-mandibular joint.. The intraoral examination revealed a second class Kennedy mandibular left edentate. On the controlateral site a fixed metal-ceramic implant prostehsis with decreased bone support and mucositis was present. At the maxilla there was functional metallic ceramic fixed restoration. Oclusion was functional.

Radiological examination revealed horizontal and vertical bone resorption in the left mandible and chronic marginal periodontitis at the medial tooth limiting the edentulous space. On the upper jaw there were no signs of apical or marginal infectious processes. The mandible bone atrophy was 5th Atwood class. Controlateral advanced bone resorption phenomena are observed at the medial implant.

Clinical and radiological analysis revealed the impossibility of applying implants in left mandible that required surgical augmentation of the bone bed by intraoral graft transplantation under local anesthesia to achieve a fixed implant-prosthetic rehabilitation. It was recommended to remove the prosthetic component of the implant 46 and perform bone regeneration.
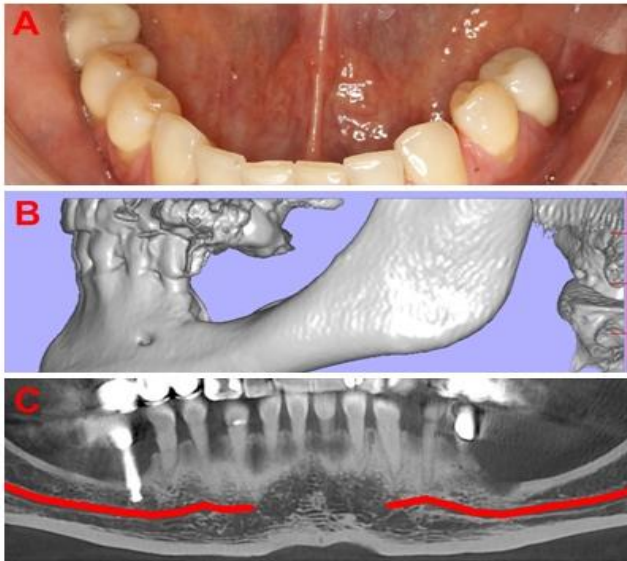
Fig 14. Intraoral photo (A) and CT reconstruction showing severe left mandible atrophy (B,C).

Preoperative physiotherapy sessions are performed at the left temporomandibular and an occlusal splint is made. After the end of the acute articular phenomena, the surgical stage was planned.After the second mandibular premolar was extracted a healing period of about 10 weeks followed, in order to provide a sufficient volume of soft tissue to cover the later graft.

Under local anesthesia a bone block from the external oblique crest region was transplanted at the 35-36 deficient site. The bone block is 12 x 8 mm in size and is cortical. The graft is cut into 2 segments to be able to conform to the receptor site to restablish the three-dimensional bone bed, both vertically and horizontally. The block was fixed with 2 osteosynthesis screws. The gaps are filled with autologous bone chips. In order to prevent the physiological resorption of the bone block during the healing period, the graft was covered with a resorbable xenograft chips. After 4 months, a CBCT exam is performed. With the help of the processing software, the 3D image of the bone substrate was obtained, the position of the lower alveolar nerve and mental foramen was visualised and the bone bed was analysed for implantation.

Fig 15. Bone harvest from the oblique ridge fixed at the recipient site.

Fig 16. CBCT after 4 months healing

At 4 months, the graft integration was good and the bone defect had been reconstructed three-dimensionally. The screws are suppressed and 2 dental implants are insrted. After a waiting period of 4 months, a porcelain fused to metal screwed restoration was delivered.
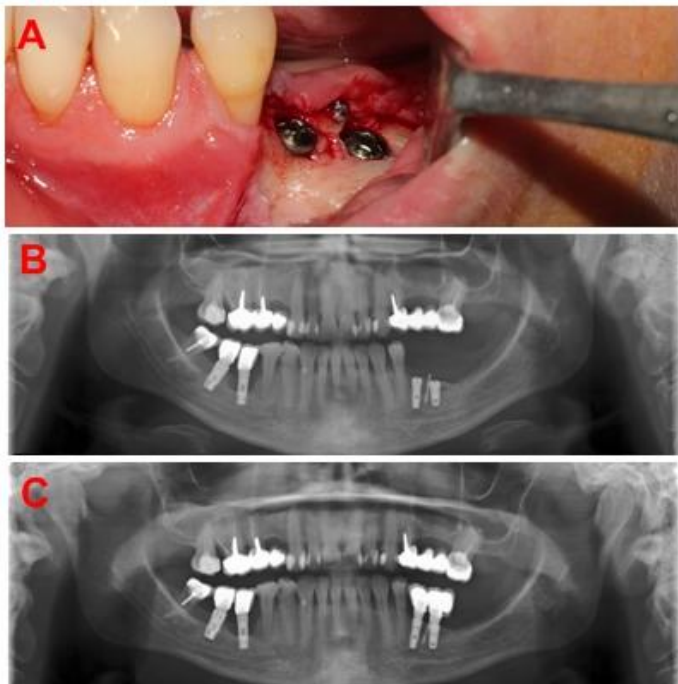

Fig 17. Implants fixed in the graft intraoperative photo (A) and RX after implant placement(B) and after prosthetic delivery (C).

The patient is periodically seen at 6 months checkups .At 12 months, proper bone support was observed around the implants, also soft tissue did not show signs of inflammation , bleeding or loss of perimplant epithelium.

Fig 18. 12 months check up: RX (A) and oral photo (B).
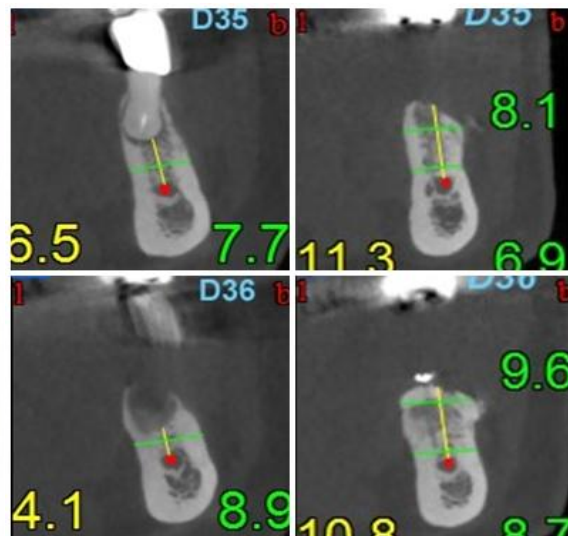
Fig 19. CBCT showing bone volume before (left) and after graft (right).

Reconstructions with extraoral bone blocks

A 61-year-old female presented to our department, accusing severe masticatory and aesthetic dysfunction due to edentulism. The patient wanted fixed prosthetic rehabilitation.

From the general medical history, a hypertension was noted (under treatment with specific diuretic medication), ischemic cardiopathy under platelet antiaggregants treatment and chronic lower vein insufficiency under Detralex treatment.

The exooral examination revealed a decrease of the lower floor of the face, a concave facial profile due to the marked atrophy of the upper jaw through centripetal maxillary resorption and mandibular centrifuge atrophy. The nasal-labial grooves and folds were accentuated; the nasal-labial angle was enlarged.

Intraoral examination revealed bimaxilar edentulism. In the mandible there were 2 dental implants in the incisive region with severe bone resorption and an overdenture. The upper jaw had a total acrylic prosthesis. The patient was dissatisfied with the functional and aesthetic result and the instability of the maxilla denture, desiring a new implant-prosthetic rehabilitation.

The radiological examination revealed resorption of horizontal and vertical bone resorption both in the jaw and in the mandible, Class D Misch. At the level of the lateral areas there was infra-Schneiderian bone grafting material, resulted from a previous sinus lifting intervention. CT analysis revealed that there was no horizontal or vertical support for the regular implant insertion (minimum 10 mm height with a diameter of 3.6 mm). In mandibular incisors there were 2 dental implants with a high resorption degree, with 3 mm implantation in the bone bed.
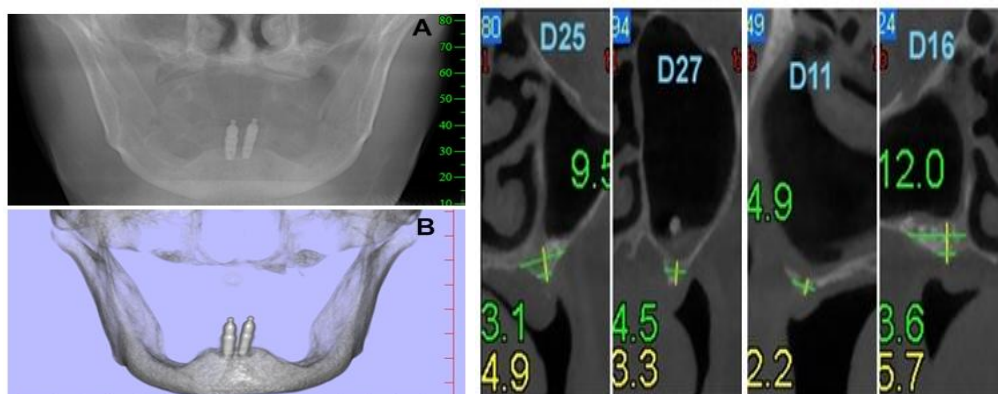

Fig 20. CBCT showing severe maxilla atrophy: 3D (left)and sagital (right)

Clinical and radiological analysis revealed the impossibility of inserting implants especially in the lateral areas, requiring surgical augmentation by extraoral graft under general anesthesia to achieve an implant prosthetic rehabilitation. In the mandible, the bone substrate can accommodate the insertion of implants in the interforaminal area after explantation. The prosthetic phase involved 2 implant driven overdentures. This solution involved the application of a small number of dental implants (maxillary 4-6, mandible 2-4).

It was decided to transplant bone blocks from the parietal calvaria.

Under general anesthesia a total mucoprostal vestibular flap was performed from one tuberosity to the other, exposing the entire severe resorbed ridge.

The patient was placed in dorsal decubitus, with the head turned on the left side, preparing the parietal donor bed.

The donor area has the following limits:

- 2-3 cm lateral to the median line so as not to interfere with the sagittal sinus

- At distance from the temporal line

- Anterior from the coronary suture

The incision transected all layers to the periost. The periostal incision was made at an angle for stable suture. With surgical disks, 5/2 cm thick blocks of 2-3 mm thickness are harvested. The edges are rounded with a large spherical or bone scraper, thus collecting bone chips. The wound was closed in 3 planes.
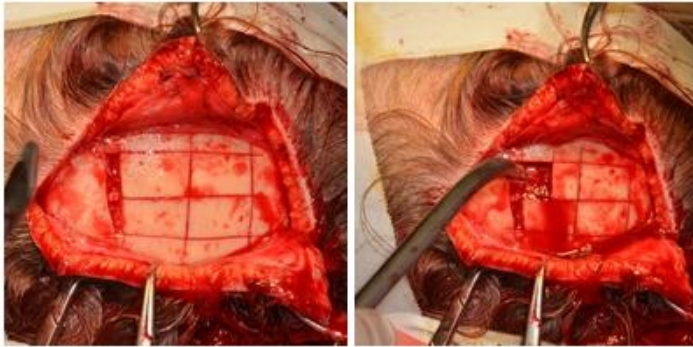

Fig 21. Calvaria bone harvest

The blocks are trimmed with the discs to be able to conform to the receptor site and fixed with 2 osteosynthesis screws. 3 blocks are inserted for each side in the area of future implants, canine-premolar. The gaps are filled with autologous bone chips. In order to prevent the physiological resorption of the bone block during the healing period, the graft was covered with resorbable xenograft chips.

After integration of the maxillary bone graft, a bimaxilar CBCT exam was performed. With the help of the processing software, the 3D image of the bone substrate was obtained, determining the position of the lower alveolar nerve and mental foramen and also the bone dimensions available for implantation.
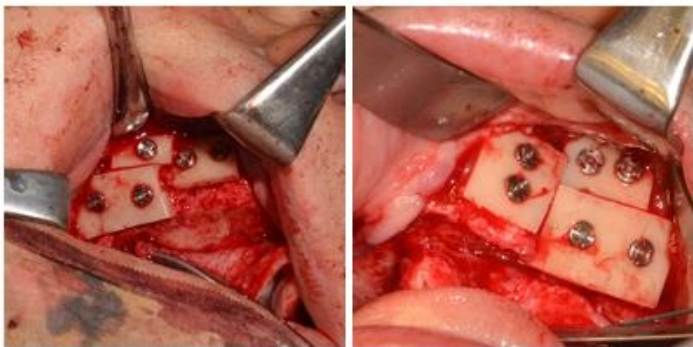

Fig 22. Bone blocks fixed at the recipient site Courtesy dr Petrescu Vlad
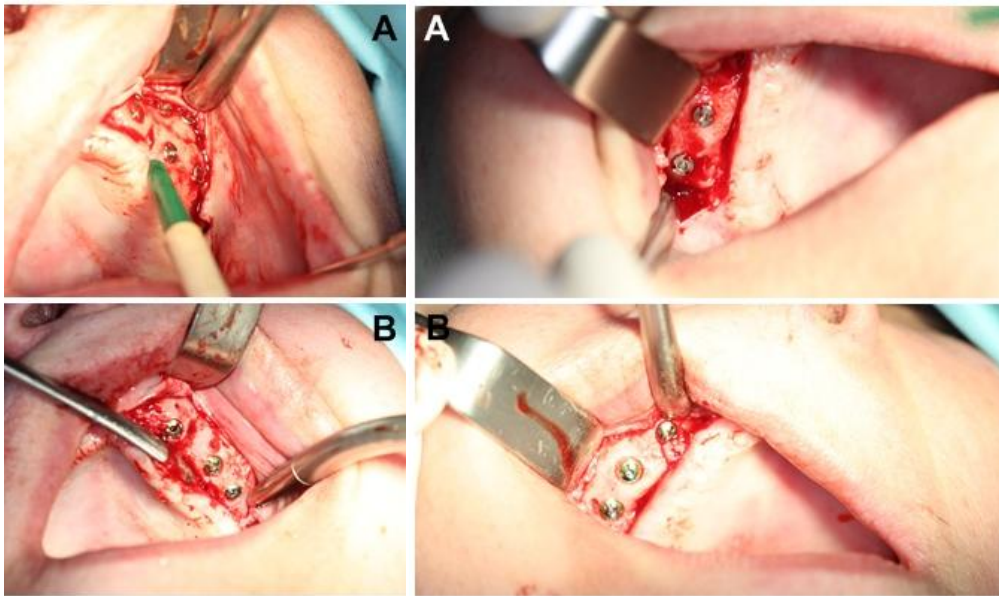
Fig 23. Healed bone graft (A) and implants inserted in the (B) Courtesy dr Petrescu Vlad

After a 4-month healing period, the mandibular dental implants are extracted under local anesthesia, 4 interforamen dental implants are inserted and the graft was exposed at the same sitting. Integration of the graft was good and the bone bed had been reconstructed three-dimensionally. The screws are suppressed and three dental implants for each side are inserted.
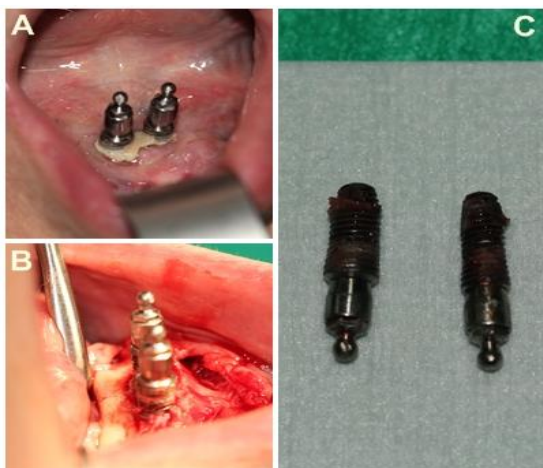

Fig 24. Explantation of the lower implants courtesy of dr Petrescu Vlad

After a healing period of another 4 months, the prosthetic prosthesis was delivered: in the upper jaw a bar overdenture and in the maxilla a 4 locator overdenture

Fig 25. Implant overdentures: bar type in the upper jaw and locator in the lower jaw

The patient is periodically dispensed from 6 to 6 months.

Clinical and radiological control was performed at 2 years with adequate maintenance of the bone support around the implants inserted into the reconstructed bone. Also, soft tissue didnot show signs of inflammation without bleeding or loss of perimplantary epithelium.
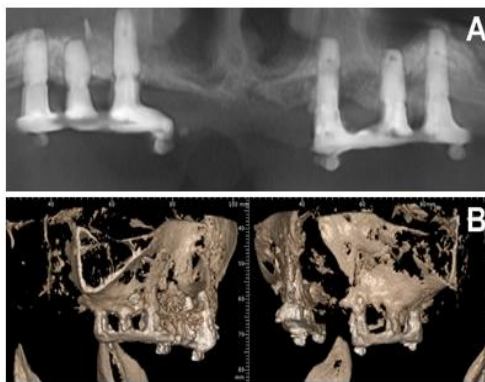

Fig 26. Oral photo at 2 years check up

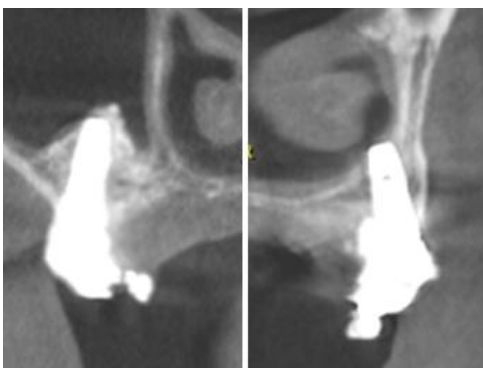Fig 27. CBCT at 2 years check up: A. Frontal view; B. 3D CBCT

Fig 28. Sagital CBCT showing very good bone volume at the graft after 2 years of function

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