GUIDED BONE REGENERATION TECHNIQUES IN ALVEOLAR BONE RECONSTRUCTION

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Abstract
Various alveolar bone augmentation techniques are used in the reconstruction of post-extraction alveolar sites and in the reconstruction of post-cystectomy bone defects. Guided tissue regeneration techniques use grafting materials with osteogenic, osteoinductive, or osteoconductive properties as well as membranes as a barrier to epithelial proliferation and as a stimulating environment for osteogenesis. The sinus lifting technique associated with bone addition is used in the case of implant sites with reduced height and thickness in the posterior areas of the maxillary arch as follows: post-extraction, severe periodontal damage, severe bone resorption, reduced distance between the highest point of the alveolar ridge and the sinus floor, the extension of the sinus in the area initially occupied by the dental roots. S-GBR technique allows to maintain the regenerative bone space due to osteosynthesis screws that support the space of the bone regeneration compartment, while pericardial membrane to protect the area from regeneration from soft tissue invasion). GBR techniques can be performed, in relation to local conditions and pathology, through standard bone addition protocols, in combination with sinus lifting techniques or through specific techniques (S-GBR). The implant-prosthetic treatment plan must pay particular attention to the alveolar bone reconstruction stage through guided bone regeneration techniques that will ensure the optimal positioning of dental implants in the context of restoring biomechanical and functional conditions through fixed or removable prosthetic restorations with implant support.
Key words: alveolar reconstruction, bone grafts, GBR, sinus lifting, S-GBR

Introduction

The long-term success of implant-prosthetic therapy is highly dependent by implant osseointegration (“direct structural and functional connection between surface alveolar bone and the surface of a loadbearing artificial implant”) in alveolar bone with optimal volume and quality (Goto, 2014; Sheikh et al, 2015). Bone reconstruction is requested in patients with bone volume reduced due to tooth loss before implant placement, or due to periodontitis or trauma (Javed et al, 2013). The loss of vertical alveolar bone height conducts to surgical difficulties and anatomical limitations (Rochietta et al, 2008). Alveolar reconstruction techniques solve both the problem of resorption space and the problem of structural stability and the stimulation of bone regeneration processes (Lee et al, 2017). Various alveolar bone augmentation techniques are used in the reconstruction of post-extraction alveolar sites and in the reconstruction of post-cystectomy bone defects. The procedures are based on inserting and maintaining the graft material in position inside the bone cavity. The aim is to increase the graft integration rate by stimulating vascularization and cellular migration phenomena of osteogenic cells among the graft particles. Many techniques have proved success both in horizontal (Elnayef et al, 2015; Gorgis et al, 2021) and vertical (Plonka et al, 2018; Khoury et al, 2019) augmentation of the atrophic maxillary and mandible.

The surgical techniques used for the reconstruction of implant sites are the following (Bucur, 2012): bone augmentation techniques (onlay/inlay bone blocks); guided bone regeneration techniques (GBR); sinus lifting associated with bone addition techniques; apposition grafting (appositional osteoplasty); interposition grafting (interpositional osteoplasty); addition techniques with subperiosteal tunneling; surgical techniques of alveolar bone expansion; surgical techniques of alveolar bone elongation; distraction osteogenesis.

Various algorithms and procedures were proposed to improve the accuracy of decision and execution process in alveolar reconstruction techniques. In vertical alveolar ridge augmentation, the height of alveolar bone (< 4, 4-6, > 6 mm) is a factor that influence the decision tree that include sections where clinician must consider anatomical, clinical, and patient-related factors influencing for guidance in the optimal treatment modality and sequence for predictable management of resorbed alveolar ridge (Plonka et al, 2018). In horizontal augmentation clinician must consider both the bone width available at the site of implant placement ($\geqslant$ 3.5 mm, < 3.5 mm, 4-5 mm) as well as bone thickness, implant site position, availability of autogenous bone to choose the most predictable horizontal ridge augmentation procedure (Fu & Wang, 2011).

Guided tissue regeneration techniques use grafting materials with an osteogenic, osteoinductive or osteoconductive role that allow restoration of resorbed implant sites. Sealing the alveolar bone addition materials as rigorously as possible and ensuring the closure of the flap with tension-free sutures are requested conditions for the formation of a very good quality bone (Urban et al, 2019). GBR technique involves the use of membranes as a barrier to epithelial proliferation and as a stimulating environment for osteogenesis allowing tissues to regenerate the bone defect by blocking invasion with unwanted cells (Khojasteh et al, 2017). Non-resorbable titanium, zirconium or titanium-reinforced membranes (with potential for wound infection after exposure of e-PTFE membranes) or resorbable membranes (reduced ability to create and maintain bone regeneration compartment space, rapid degradation) are highlighted in a systematic review of GBR techniques used in pro-implant stage (Liu & Kerns, 2014). Regarding the reconstruction of the implant sites, the influencing factors are the following (Plonka et al, 2018):

• type of graft material;
• local biological factors (quality of vascularization);
• local infectious factors;
• local mechanical factors (stability and biomechanical load);
• systemic factors (medication, systemic diseases, smoking).

The success of guided bone regeneration techniques is ensured by compliance with the following operatory conditions during surgical procedures (Ehrenfest et al., 2015):

-sterile operating field;
-flaps with uniform thickness and adequate vascularization;
-minimal salivary contamination of the membrane;
-exceeding by 2 - 3 mm of the edges of the defect by the membrane;
-the insertion of grafting materials under the space provided by the membrane,

within the guided bone regeneration techniques;
-adapting the edges of the membrane to the implant site;
-primary closure and the absence of tension at the level of the flap.

Sinus lifting technique associated with bone addition is used in the case of implant sites with reduced height and thickness in the posterior areas of the maxillary arch as follows: post-extraction, severe periodontal damage, severe bone resorption, reduced distance between the highest point of the alveolar ridge and the sinus floor, the extension of the sinus in the area initially occupied by the dental roots (Esposito et al, 2010; 2014). Sinus lifting is recommended for edentulous patients in the posterior maxillary area unilaterally or bilaterally, who want a fixed implant-prosthetic prosthetic work. Volumetric analysis by digital techniques of the residual bone allows the assessment of the primary stability of the dental implants. In situations where the sinus floor is > 7 mm thick, the use of short implants is required. In moderate atrophy of the upper jaw without changes at the level of its base, a sinus lift can be performed without association with the augmentation of the alveolar ridge. The mucosa can be lifted through the osteotomy at the level of the alveolar ridge or through a lateral approach, through sinus lifting by internal (internal osteotomy of the alveolar ridge; elevation of the mucosa of the sinus floor; introduction of a granular bone substitute; insertion of the dental implant) or external (lateral approach to the sinus cavity through a bone flap; elevation of the sinus mucosa; introduction of one or more types of bone substitutes; immediate or subsequent insertion of one or more dental implants) approach (Sennerby & Becker, 2009). The sinus lifting technique has the following advantages: obtaining a sufficient bone volume; stability and mechanical resistance of the graft; implants have minimal exposure; reducing the rate of postoperative complications; stability of dental implants) (Hansen et al, 2011). However, according to Kang et al (2019), sinus lifting, bone grafting, and vertical ridge augmentation performed simultaneously increase the postoperative complications rate and decreases the implant survival. This research group recommends delayed implant placement when alveolar augmentation must be combined with sinus lifting.

S-GBR technique ("Screw-Guided Bone Regeneration") allows excellent results for mandibular edentulous patients with moderate or severe atrophy of the alveolar bone (Toeroek et al, 2013 a,b). S-GBR technique uses a membrane delimiting the regenerative bone compartment supported by osteosynthesis screws or dental implants. S-GBR technique is mainly recommended for horizontal augmentation of mandibular alveolar bone with moderate or severe horizontal resorption, using a combination of autologous bone, xenografts, resorbable or non-resorbable membranes. S-GBR technique allows to maintain the regenerative bone space due to osteosynthesis screws that support the space of the bone regeneration compartment, while pericardial membrane to protect the area from regeneration from soft tissue invasion). Excellent results were recorded at 24 month post-operatory by research groups assessing implant-prosthetic therapy with alveolar bone reconstruction by S-GBR technique (Török et al, 2021; Agop-Forna et al, 2021; Toeroek et al, 2013 a, b).

The protocol stages of S-GBR technique are exposed in Table I (Török et al, 2021) and figures 3.a-g.

Table I. S-GBR technique

No.	Procedure	Instruments and Materials	Role
1.	Local anesthesia	Ultracain DS-Forte (Sanofi, Paris, France)	Comfort of patient and operator
2.	Full-thickness flaps in the resorption bone area	DeveMed GmbH, (Tuttlingen, Germany)	Opening of the surgical field
3.	Immediate implants insertion (3.5–4.5 mm diameter, 10–13 mm length)	BioSTI implants (Tafers, Switzerland) Dentium implants (Seoul, South Korea)	
4.	Periosteal incisions on the flaps	AesculapAG (Tuttlingen, Germany)	Promotion of tension-free closure of the flaps
5.	Insertion of the osteosynthesis screws (1.5 mm diameter, 8 mm length) on the buccal face of the alveolar bone (45° angle to the alveolar crest)	Implantology kits Synthes GmbH, (Zuchwil, Switzerland) DeveMed GmbH, (Tuttlingen,Germany)	Maintenance of the space for the grafted area
6.	Covering of the exposed implant bone surface area with a small layer of autologous bone, followed by the placement of xenograft adjacent to the head of osteosynthesis screws. Covering of the grafted area with a resorbable collagen membrane	Xenograft CompactBone, (Dentegris GmbH, Rheinberg, Germany) Porcine pericardial tissue membrane BoneProtect Membrane (Dentegris GmbH)	Isolation and protection of the graft from the gingival tissue. Stimulation of the gingival healing. Protection of the surgical site from gingival dehiscence during the next 3–4 months and Reconstruction of the lateral resorbed bone area
7.	Suture of the surgical site	Non-resorbable sutures (polypropylene 5.0, Hu-Friedy, Chicago, IL, USA)	Protection of grafted bone and peri-implant tissues
8.	Post-operative care (7 days): antibiotherapy, analgesics, rinse of oral cavity with chlorhexidine 0.5%	Augmentin 625 mg, GlaxoSmithKline Pharma, Vienna, Austria) and analgesics (Ibuflam 600, Zentiva, Lichtenstein)	Control of post-operative pain and inflammatory processes
9.	Removal of sutures at 9–11 days after the surgical intervention		

Prosthetic loading was performed 14-16 weeks after the insertion of the implants. Each patient was included in a dispensary program that included education on performing oral hygiene procedures, non-specific and specific oral hygiene procedures (removal of bacterial plaque on implant surfaces) performed by the patient and recall sessions (evaluation, brushing professional) every 6 months.

Clinical Case 1: L.C., age 69 (GBR technique)

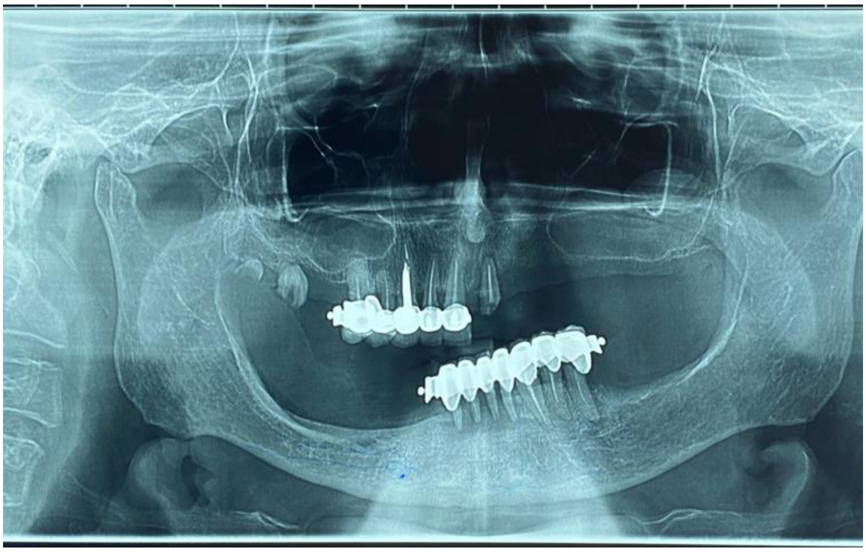

Fig. 1.a. Preoperatory radiographic examen.

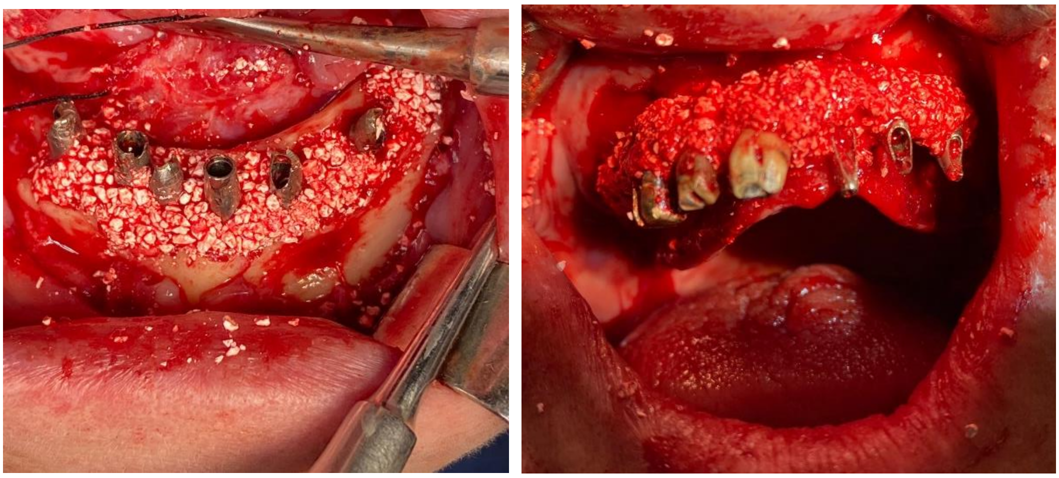

Fig.1.b-c. Insertion of implants and xenograft materials in maxillary and mandible alveolar bone reconstruction

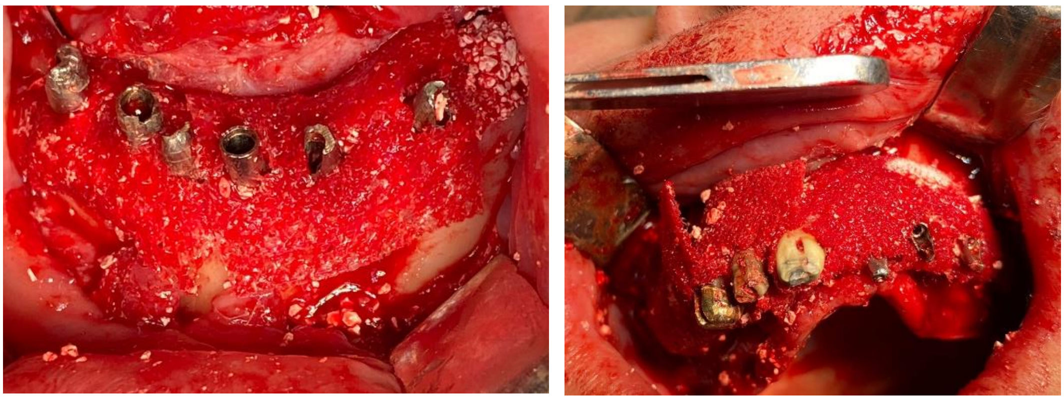

Fig.1.d-e. Placement of xenograft and collagen membrane in maxillary and mandible alveolar bone reconstruction

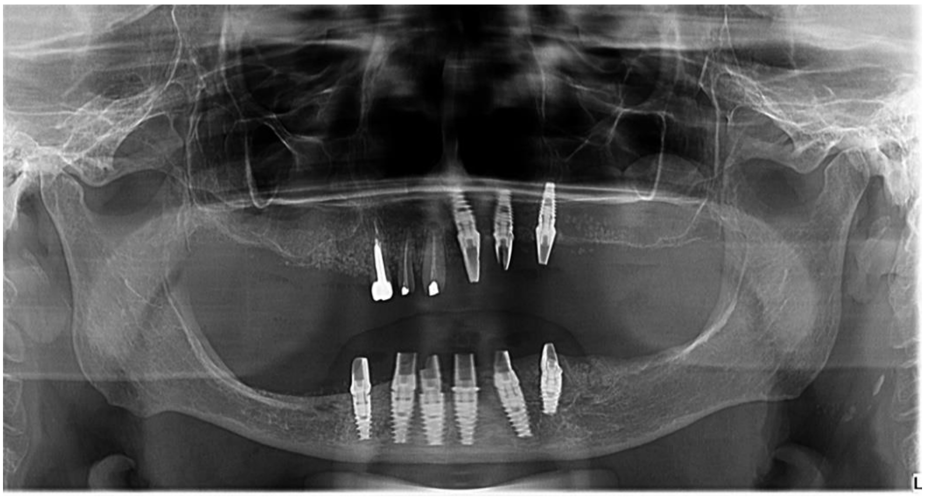

Fig.1.f. Radiographic aspect at 3-months postoperative

Clinical Case 2: N.C., age 50 (Sinus lifting + GBR technique)

Fig. 2.a. Preoperatory radiographic examen

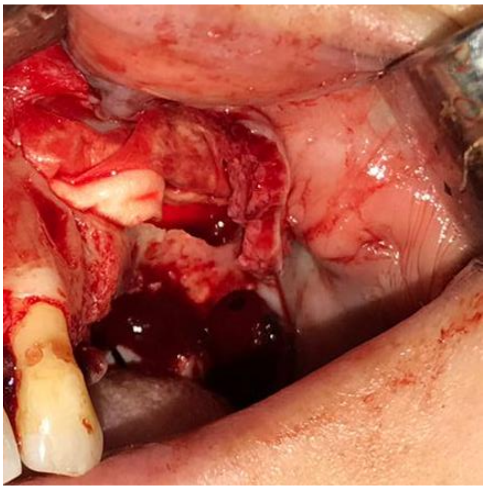

Fig.2.b. Sinus lateral window

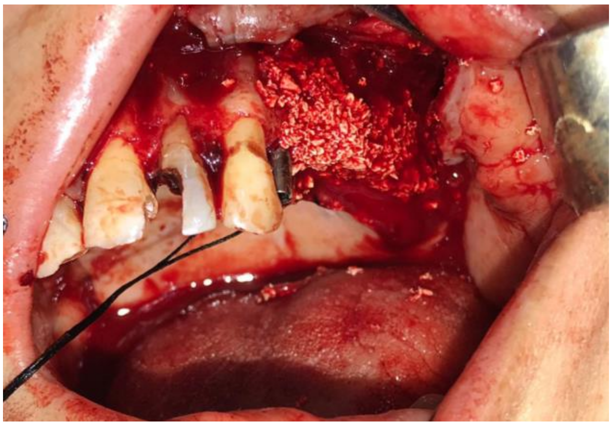

Fig.2.c. Xenograft grafting of posterior maxillary bone

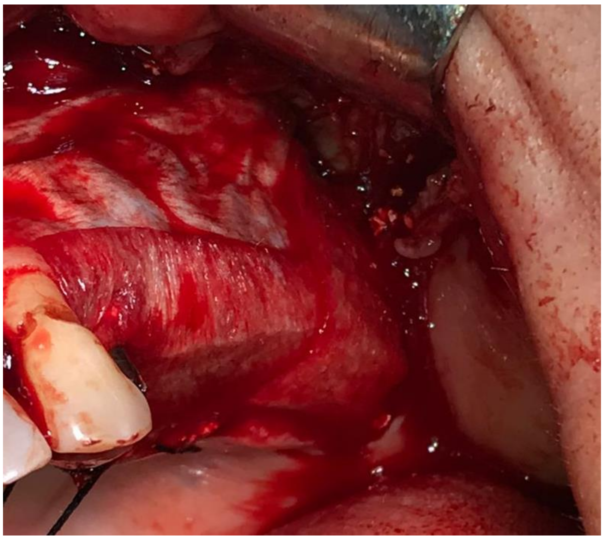

Fig.2.d. Placement of xenograft and collagen membrane

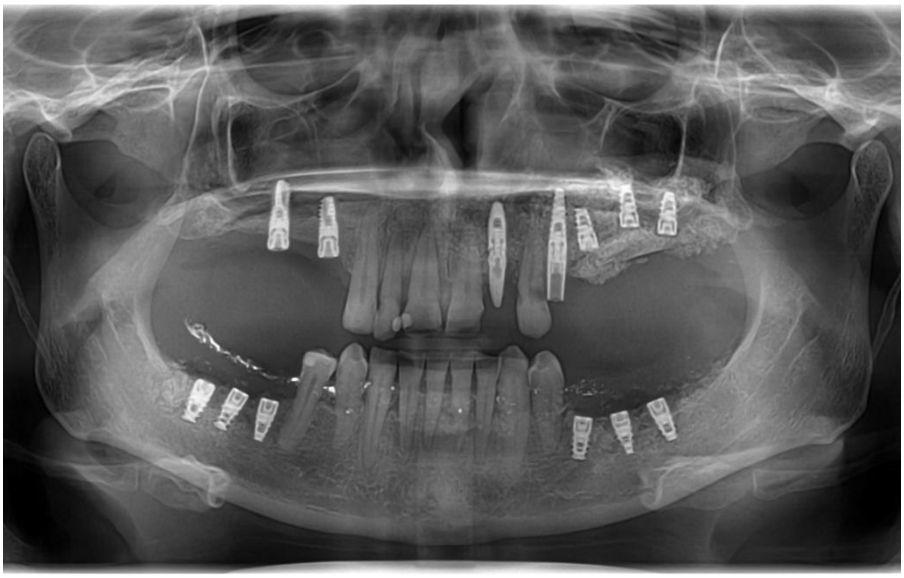

Fig. 2.h-l. Radiographic aspect at 3-months postoperative

Clinical Case 3 (S-GBR Technique)

Fig. 3.a. Preoperatory radiographic examen.

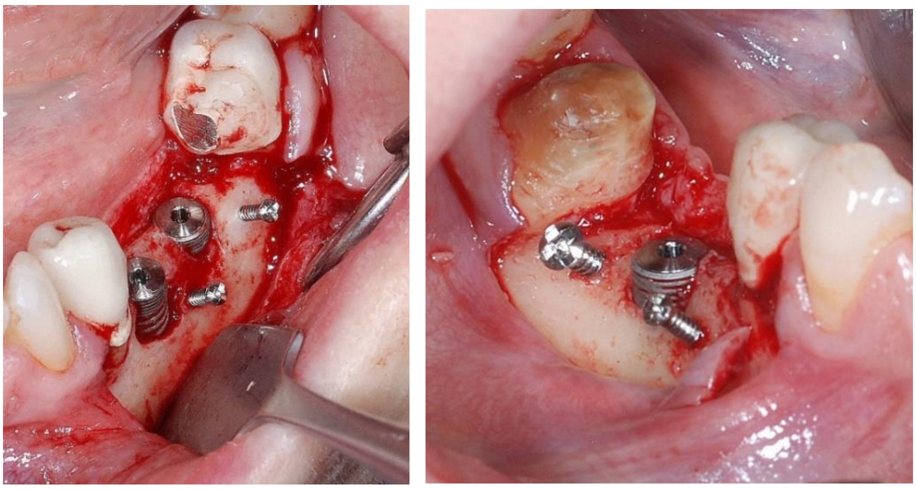

Fig.3.b-c. Insertion of implants and osteosynthesis screws

in S-GBR technique

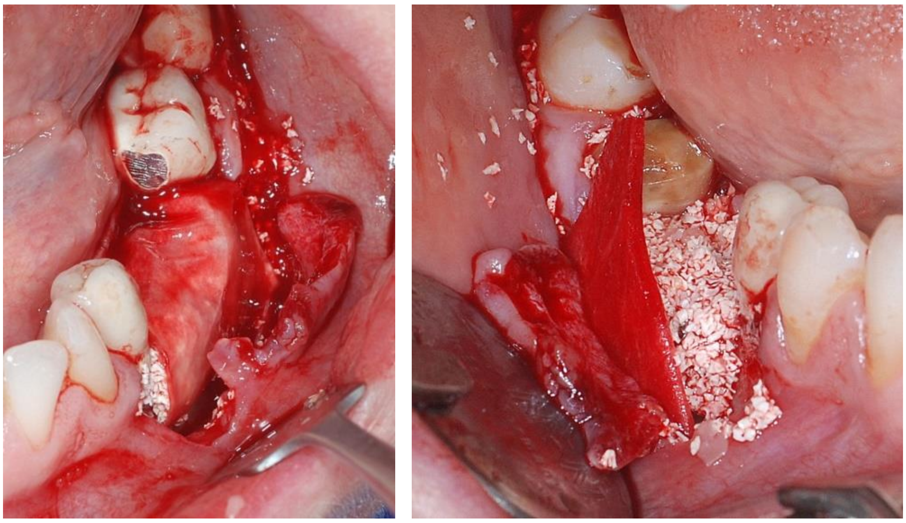

Fig.3.d-e. Placement of xenograft and collagen membrane in S-GBR technique

Fig.3.f-g. Clinical aspect at 24 months postoperative

Fig. 3.h-l. Excellent implants osseointegration shown by radiography and CBCT at 24-month postoperative

CONCLUSIONS

- Patients with complications of partial edentation (masticatory and physiognomic disorders, dental migration, periodontal disorders, occlusal imbalances) represent a challenge for specialists in prosthetics, implantology and oral surgery.
- Guided bone regeneration techniques use a wide range of grafting materials (autologous bone, allografts, xenografts, alloplastic materials) and resorbable and non-resorbable membranes.
- GBR techniques can be performed, in relation to local conditions and pathology, through standard bone addition protocols, in combination with sinus lifting techniques or through specific techniques (S-GBR).
- The implant-prosthetic treatment plan must pay particular attention to the alveolar bone reconstruction stage through guided bone regeneration techniques that will ensure the optimal positioning of dental implants in the context of restoring biomechanical and functional conditions through fixed or removable prosthetic restorations with implant support.

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