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Decision making in GBR protocols for rehabilitation of missing anterior teeth

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Abstract:
Background*: Guided Bone Regeneration (GBR) is a very challenging procedure. This case discusses replacement of missing anterior teeth with implant restorations using guided bone regeneration using two different protocols: single and staged. The proper treatment planning, case selection, implant positioning, final restorations selection is very important for the final outcome of the treatment. The principles for GBR to be followed for different case scenarios are discussed in this article.*
Key Words*: Guided bone regeneration, Implant restorations, Bone graft*

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I. Introduction

Significant anatomical alterations occur following extraction or loss of teeth.[1] In the anterior maxilla, there is a pronounced resorption owing to the loss of bundle bone and the thin labial bone which is connected directly to the periodontal ligament of the extracted tooth.[2,3] This consequently results in an anticipated reduction in the bone dimensions both horizontally and vertically.[4,5,6] The alveolar bone resorption rates ranges from 0.5 to 1% annually.[7]

Bone augmentation become an essential procedure under these circumstances for implant placement to ensure long term stability.[8,9] Bone augmentation evidently not only provides enhanced support for implant placement but also the soft tissue topography.[10] Guided bone regeneration is a procedure in which the bone graft material along with a barrier membrane are used to prevent soft tissue incursion.[11] These barrier membranes provide a space to be occupied by the bone graft thus letting the regeneration of bone and may either be resorbable or non resorbable.[12,13]

Substitutes for bone graft can be from various sources like human, animal or synthetic and are known to initiate osteoblastic action of the bone and surrounding periosteal tissue or osteoconductive scaffolding which secondarily enhances bone augmentation.[14,15]

Over a decade the popularity and success of GBR technique is elaborately reported in literature for rehabilitating bone deficiencies of post-extraction ridges and in implant placement sites.[16,17,18,19] Enhanced soft tissue topography is a well-documented outcome following GBR at the time of implant fixture.[20]
The dimension of the labial bone influences the soft tissue topography and are codependent.[20] The requirement of GBR is decided based on the density and size of the remaining bone walls indicating that, an implant placed in a socket in which all the surrounding bone is intact and need.

II. Case Report

A 33-Year-old male reported to the Department of Prosthodontics of our institute complaining of missing teeth in the upper front tooth region. The cause of tooth loss was a traumatic injury, following which the fractured teeth were extracted one year ago. He was concerned about the esthetics and was seeking a fixed replacement for the same. The medical history was non-contributory. On examination, 11 and 22 were missing. Also,12 and 21 were endodontically treated and had a resin build up on the same teeth. **(Fig. 1)** Intraoral examination of the edentulous sites revealed a marked labiopalatal defect in the region of 11 and 22. **(Fig. 2)** Furthermore, the patient presented with generalized staining due to fluorosis. Periodontal examination revealed, the gingival zeniths were asymmetric with adequate width of attached gingiva. On smiling, unpleasant appearance of missing teeth and a low smile line was observed. **(Fig. 3)**

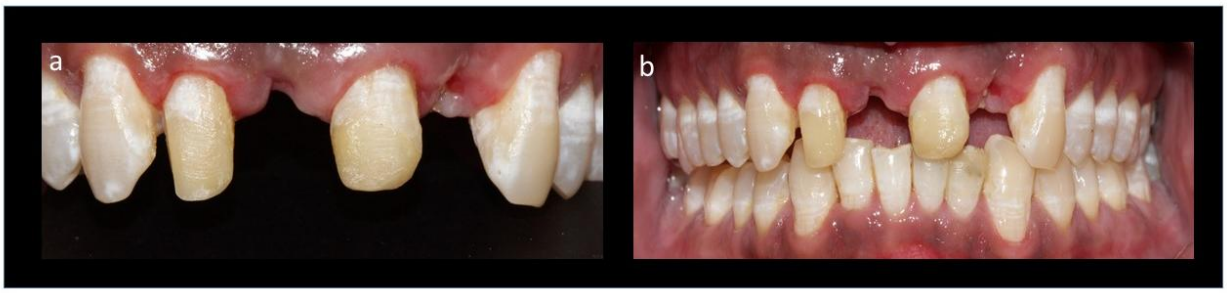

Fig 1. Pre-operative view: a. Frontal, b. Maximum intercuspation

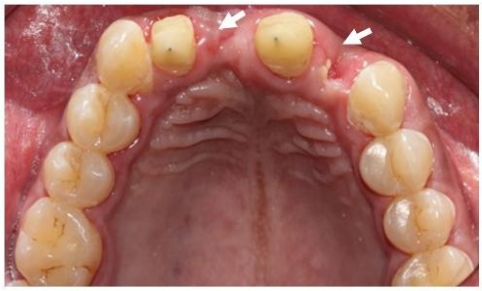

Fig 2. Pre-operative occlusal view: marked labiopalatal defect in the region of 11 and 22

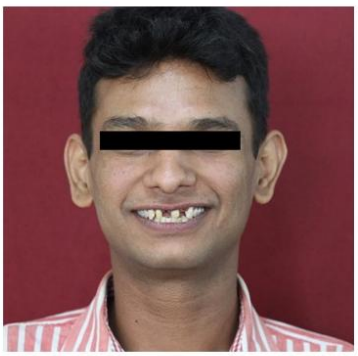

Fig 3. Extra-oral pretreatment: Smiling (low smile line)

A Cone Beam Computed Tomography (CBCT) scan was advised to evaluate the underlying osseous ridge contour and density and dimensions of the residual alveolar bone at the proposed implant site. Clinical and radiographic assessment using CBCT of both the subjects revealed a deficiency of labial plate (Seibert's class III) thereby requiring guided bone regeneration for implant placement. The bone density was D2 (Misch's classification), soft tissue biotype was thick and an adequate mesiodistal width of edentulous span was noted.

The patient was thoroughly explained about the current state, alternative treatment plans and the proposed treatment plan. An informed consent was acquired from the patient. A comprehensive treatment plan was established in four phases:

1) Phase I: Pre- surgical planning
   - Diagnostic wax mockup for anterior teeth
   - Esthetic evaluation using wax mockup
   - Implant planning with 11 and 22

2) Phase II- Surgical phase with implant site development

   – Tooth preparation with 12 and 21

   – Implant placement with 22 with immediate GBR (using a resorbable barrier membrane)

   – GBR for 11 (using a non-resorbable titanium mesh)

3) Phase III- Surgical phase with implant placement

   – Implant placement with 11with GBR (using a resorbable barrier membrane)

4) Phase IV- Restorative Phase

– Provisonalization:

   ▪ Screw retained implant provisional restoration for 8-12 weeks for developing the soft tissue architecture.

– Final restoration:

   ▪ Cement retained lithium disilicate crown on a zirconia abutment with 11 22

   ▪ Lithium disilicate crown on 12 21

Phase I:

A diagnostic wax mockup was made for the anterior teeth on a set of mounted diagnostic stone models. The wax mockup was then transferred intraorally using bis-acrylic material (3M™ ESPE Protemp™, USA) with the help of a silicone index (Zetaplus, Zhermack, Italy). The desired corrections were made and esthetic evaluation was done for analyzing the speech and esthetics. A duplicate model of the wax mockup was used to fabricate a vacuum pressed thermoplastic stent for implant placement.

Further the CBCT scan was used for implant planning in the region of 11 and 22. The dimension of the bone in the region of 11 was 5.9 mm in width and 10.4 mm in length and 3.1 mm in width and 11.1 mm in length in the region of 22 respectively. **(Fig. 4)** An implant of size 3.3 ×10 mm (Adin® Touareg™ S, Alon Tavor, Israel) was planned with 22 and 3.5 × 10 mm (Adin® Touareg™ S, Alon Tavor, Israel) with 11 respectively. The International Team for Implantology (ITI) SAC assessment tool categorized the case as "complex".

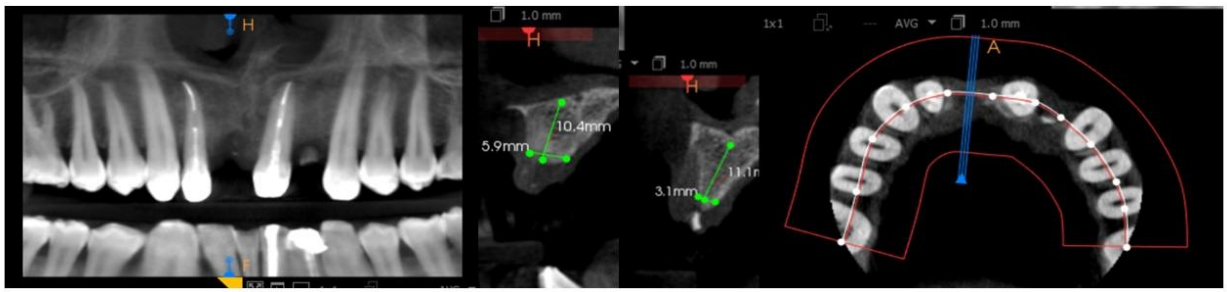

Fig 4.CBCT assessment showing implant planning

Phase II:

A thorough oral prophylaxis was carried out. Tooth preparation for 12 and 21 for full ceramic crowns was done with chamfer equigingival margins. Prior to the surgical appointment, prophylactic antibiotics (Tab Ordent - Ofloxacin 200 mg + Ornidazole 500 mg, BD, Dr Reddy's Laboratories Ltd, India) were started three days prior.

The patient was instructed to have a pre procedural intraoral rinse of chlorhexidine. Perioral skin preparation was done using povidone-iodine solution 5% w/v (Wokadine, Wockhardt Ltd, India). The surgical site was infiltrated with local anaesthesia with 2% lignocaine hydrochloride with adrenaline bitartrate (XICAINE®, ICPA Health Products Ltd, Mumbai, India). A mid crestal incision with bilateral oblique vertical releasing incisions (extending above the mucogingival junction) were given and a full thickness trapezoidal flap was elevated. The size and shape of the defect in both the regions (11,22) was clinically verified. Subsequently, a 3.3 ×10 mm implant (Adin® Touareg™ S, Alon Tavor, Israel) was placed with sequential drilling; the implant shoulder was placed 2 mm sub-crestally and a low collar gingival former (Adin® RS healing abutment Ø3×2 mm length) was placed over the implant. **(Fig. 5)**

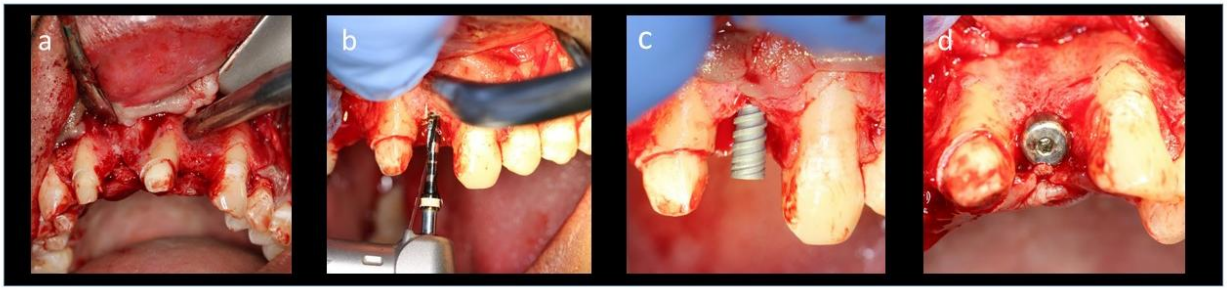

Fig 5.Implant placement with 22- 3.3 ×10 mm implant (Adin® Touareg™ S, Alon Tavor, Israel)

Simultaneously, a titanium mesh was shaped and adapted to the defect in the region of 11 and was secured with a tack screw. Also, autogenous bone was harvested from the mandibular symphysis using a trephine bur and was crushed into small particulate autogenous bone. Bone decortication was performed at the recipient site of 11 and 22 with 0.5-mm round bur to decorticate the implant site. It improves the blood supply to the graft and accelerates revascularization resulting in rapid healing.

A layer of autogenous bone was laid over both the defects. Small particulate xenograft (0.5 – 1.0 mm, Cerabone®, Botiss, Zossen, Germany) bone was layered over the autogenous bone. The graft in the region of 11 was secured with a titanium mesh to contain the larger volume of particulate graft followed by a resorbable membrane (ColoGide™ GTR membrane, Cologenesis Healthcare Pvt. Ltd, India). For 22, only a resorbable membrane was adequate over the residual labial cortex supporting the placed implant. **(Fig. 6)**

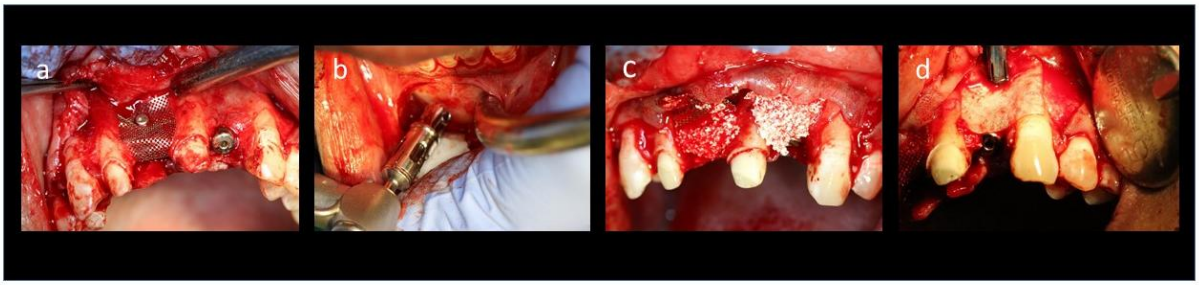

Fig 6. Immediate GBR with 22 (using a resorbable barrier membrane)
& GBR for 11 (using a non-resorbable titanium mesh)

The flap was undermined to ensure a tension free adaptation of the tissue margins prior to the final closure. Interrupted sutures were given for closure of the site using monofilament suture material (Prolene,4-0 reverse cutting, Ethicon US, LLC).

Postoperative instructions and antibiotic therapy with Non-Steroidal Anti-inflammatory drugs (Enzoflam, diclofenac 50mg + paracetamol 325mg + serratiopeptidase 15mg, Alkem Laboratories Ltd, India,) for five days were advised to the patient. The patient was advised to rinse with 0.12% chlorhexidine gluconate

three times a day for a period of two weeks. Oral hygiene instructions were reinforced, the site was allowed to heal for two weeks,
followed by suture removal. The patient was given chairside fabricated well-polished bis acrylic temporary teeth during the healing phase for six months.

Phase III:

After 6 months of healing the 11 region was revisited, the shape and size of the bone was evaluated and was considered to be adequate and then using a similar approach a 3.5 ×10 mm implant (Adin® Touareg™ S, Alon Tavor, Israel) was placed with sequential drilling; the implant shoulder was placed 2 mm subcrestally and a low collar gingival former (Adin® RS healing abutment Ø3×2 mm length) was placed over the implant.

However, a labial dehiscence was seen after implant placement which was then grafted with a mixture of autogenous bone harvested from the adjacent tooth sites and the anterior nasal spine using a bone scrapper (Hu-Friedy Mfg. Co., LLC, Chicago, IL, USA) and small particle xenograft (0.5 – 1.0 mm, Cerabone ®, Botiss, Zossen, Germany) which was secured with a resorbable membrane (ColoGide™ GTR membrane, Cologenesis Healthcare Pvt. Ltd, India). The flap was closed with interrupted sutures using monofilament suture material (Prolene,4-0 reverse cutting, Ethicon US, LLC). **(Fig. 7)**

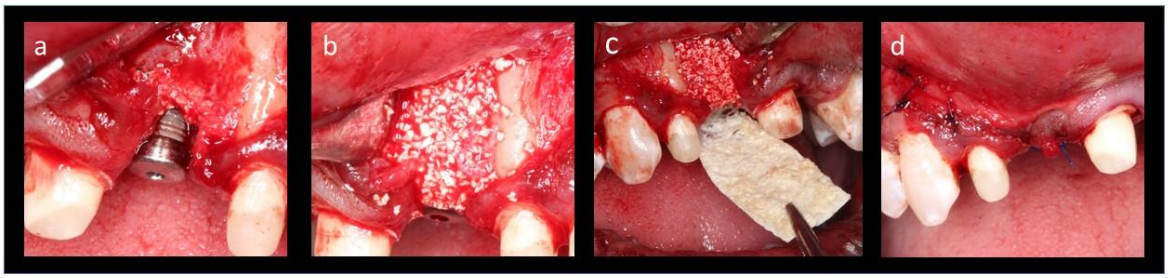

Fig 7. Implant placement with 11 with GBR (using a resorbable barrier membrane)

Phase IV:

A stage II procedure was carried out after four months of healing. A periapical radiograph was taken which presented successful osseointegration of the implants. Consequently, the low collar gingival formers were replaced with high collar gingiva formers (Adin® RS healing abutment Ø3×5mm length) over the osseointegrated implants. **(Fig. 8)** Two weeks after stage II procedure, provisionalization of the implants was done using a screw retained provisional restoration to attain the desired soft tissue contour. After 8-12 weeks of provisionalization the desired soft tissue contour was achieved. **(Fig. 9)**

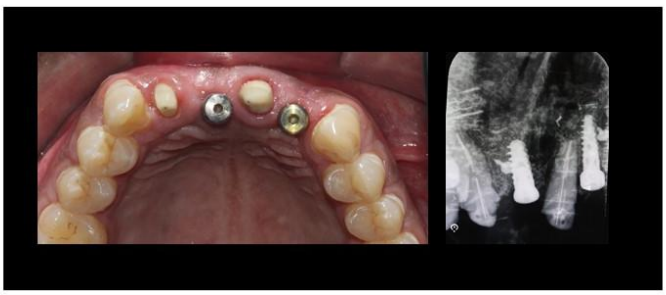

Fig 8.Stage II

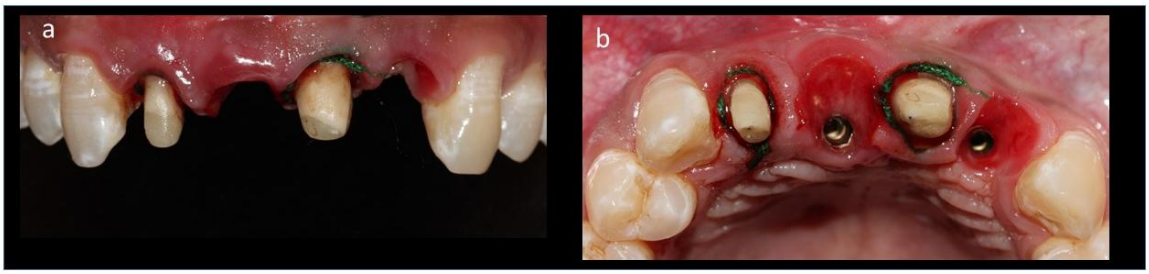

Fig 9. Soft tissue profile view: a. frontal , b. occlusal

Gingival retraction with 12 and 21 was done using gingival retraction cord a final open tray impression was made using polyether impression material (Impregum heavy body, 3MESPE, 3M India Ltd, Bangalore) in a special tray. Customized impression posts were used for recording the achieved soft tissue contour in the final impression. **(Fig. 10)** A customized zirconia abutment was milled over a Co-Cr castable substructure. The zirconia abutment try-in was performed and the appropriate shade was selected for the lithium disilicate crowns in the natural light. Later, a bake trial was done followed by the final glazed lithium disilicate crowns. Prior to the final cementation procedure, the abutments were preloaded with a torque of 20 Ncm. The final cementation was done by pretreating the lithium disilicate crowns with 5% hydrofluoric acid (IPS® Ceramic Etching Gel; Ivoclar Vivadent, Schaan, Liechtenstein) and a silane coupling agent (RelyX™ Ceramic Primer; 3M ESPE, USA) and cemented with a dual cure resin cement (Relyx U200, 3MESPE, 3M India Ltd, Bangalore). **(Fig. 11)** The patient was recalled after one week, three months, and one year.

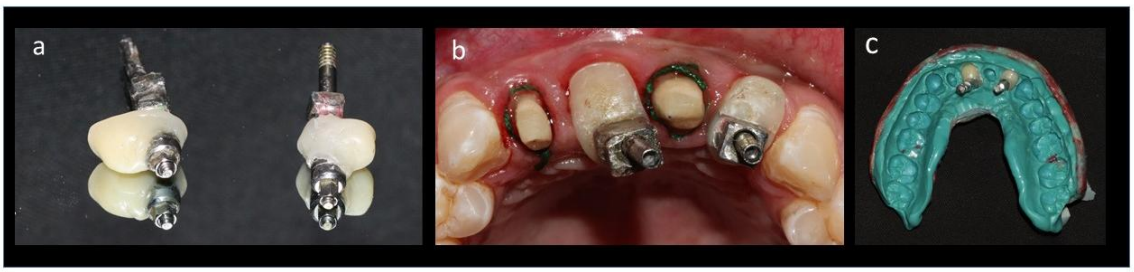

Fig 10. Final impression

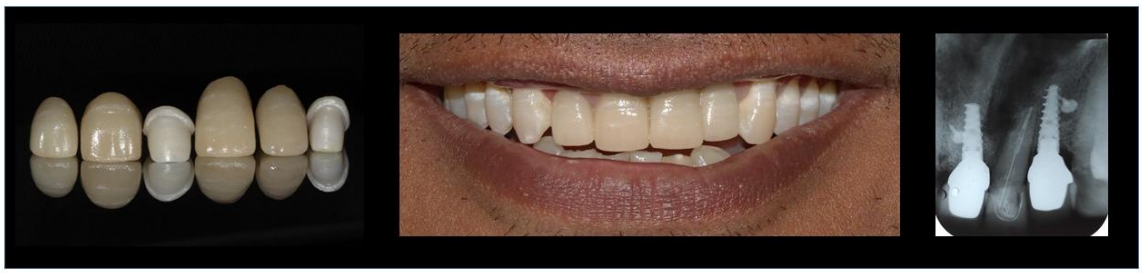

Fig 11. Final prosthesis

III. Discussion

A thorough knowledge of bone contour and soft tissue topography of the implant site provides the beginning for a successful implant planning and placement for the operator. The aesthetic risk assessment tool introduced by the International Team of Implantology (ITI) was given by Levine and Martin and aids in the classification of implant cases as straightforward, advanced and complex. This assessment tool helps in considering all the individual risk factors involved in the esthetic zone and which should be known prior to commencing the treatment.[22,23]

The main objective of bone augmentation in the esthetic zone is to create sufficient height and width of buccal bone for soft tissue. Concomitant GBR has shown to propagate osseous regeneration. [24,25] Currently, with the anatomical limitation in the anterior maxilla, simultaneous GBR with implant placement is a routine procedure. Early or delayed implant placement with simultaneous GBR is a predictable treatment option with

long term clinical and esthetic outcomes.[26,27,28] Also, the PASS principle (P: primary closure, A: angiogenesis, S: space maintenance, S: stability) proposed by Wang and Boyapati is crucial for a successful GBR.[29]

However, prior to any GBR procedure the defect and its configuration, bone graft material selection, barrier membrane selection and single staged or delayed implant placement protocols need to be determined for a successful and anticipated outcome.

I. Defect configuration

i) Width of edentulous span: The esthetic outcome of single tooth defect is considerably better than that with multiple teeth defects, as the graft placed in a wider defect is expected to migrate due to a wider flap elevated. Wider defects require the use of a mesh or membrane with tack screws to maintain the space and stabilize the bone graft.[30]

ii) Number of walls: Osteogenesis depends on the surface area of the visible bone and bone marrow as the angiogenic and osteogenic cells that lead to the formation of new bone are present in the bone marrow.[31] Thus, more the number of bony walls available in the defect area, greater is its influence on the healing and success of the GBR procedure.[32]

II. Bone graft material:

For a successful GBR, the bone substitute selected must be high in demineralized bone matrix content and should show good mechanical stability along with a suitable barrier membrane placement.[33,34,35]

Previously, autogenous bone graft material was the sole preference for GBR procedures, but its invasive techniques often result in donor site morbidity, increases the post-operative complications and also shows a rapid rate of resorption.[36,37]

Consequently, xenografts and alloplastic particulate or block bone substitutes with deproteinized bovine bone (DBB) have been widely used for such indications.

Xenograft bone materials contain hydroxyapatite and have shown properties similar to that of human bone. They have osteoconductive healing potential, show a slower rate of resorption and provide excellent stability and space maintenance.[38,39,40]

Currently, a mixture of autogenous bone and xenograft bone substitutes have shown exceptional bone healing capacity and also aids in faster bone amalgamation and healing of bone substitutes.[41,42,43]

Thus, for a predictable outcome of a bone dehiscence around an implant, a layer of autogenous bone graft should be placed to cover the implant followed by a layer of xenograft bone substitute above it and later covering it with a suitable barrier membrane.[44,45]

III. Barrier membrane

The section of the barrier membrane should be made as per the requisites of the clinical situation. Among the two types of membranes (resorbable and non-resorabable) both have their own benefits and limitations.[11]

The resorbable membrane is advantageous in resisting infection after a wound dehiscence and in space maintenance supported by the graft.[46,47] It usually biodegrades within 8-12 weeks and is known to protect the regenerated region from migration during the initial stages of healing.[48]

Non-resorbable membranes have shown an ability of bone formation and an excellent space maintenance property, but also have a high risk of infection with wound dehiscence.[49] Titanium mesh owing to their excellent stability and infection resistant property are broadly used in vertical and horizontal GBR procedures. To enhance the bone formation and compensate for the large holes in the mesh a resorbable membrane is frequently used over it.[17,50] Also, to prevent the migration of bone graft substitute additional membrane fixation can be done using tack screws, sutures or pins.[51-53]

IV. Bone decortication

Bone decortication concept is recommended to enhance bone healing by increasing the vascular supply to the graft material.[54] Danesh-Sani et al stated that enlarging the cortical bone perforation results in newer bone formation at the grafted site.[55]

V. Staged implant placement v/s single stage

The primary stability of the implant is a crucial factor that governs osseointergration. If the anticipated primary stability of the implant is poor, it is safer to provide an adequate healing period between the GBR procedure and implant placement.[56,57]

i) Staged implant placement:

Staged approach in when a traditional GBR procedure requires a second surgical intervention for implant placement. GBR procedure done prior to implant placement will aid in ideal implant placement position and also enhance the soft tissue architecture. Screws can be used along with GBR to migrate the graft apically towards the crest to support the labial ridge.[58] There is an anticipated amount of bone resorption which happens inherently due to the secondary remodeling following GBR, so over contouring the defect with 2-3 mm of graft material is recommended to achieve and maintain the required labial contour after long term remodeling.[59]

ii) Single stage:

Proper case selection makes single stage implant placement with simultaneous GBR a possible treatment modality with mild and moderate bone defects immediately after tooth extraction or in a healed ridge.

In this technique, the implant is submerged and a healing abutment aids in non-submerged healing.[60,61] This technique aids in minimizing the compression and migration of the bone graft and permits healing and development of the bone and soft tissue around the healing abutment. It provides some tenting to soft tissue around the implant and reduces the apical migration of the graft material.

Several authors have assessed the outcomes of single stage, non-submerged implant placement with simultaneous GBR and have shown 100% and 79.3% bone regeneration in small and medium sized bone defects respectively.[62]

VI. Flap closure

A tension free adaptation of the flap margins during closure is critical for predictable esthetic outcomes. It can be done by undermining the periosteum of the flap prior to repositioning it. Undermining of the periosteum stimulates angiogenesis by generating bleeding to the graft material.[29]

IV. Conclusion

Correcting the labial defect is among the many factors leading to an excellent esthetic outcome. Treatment planning, case selection, ideal implant position and angulation, ideal provisional restoration design and esthetic fabrication of the final restorations are prerequisites for the success of implant treatment.

However, to achieve a successful GBR the following ten principles should be considered,

1) Evaluation of defect configuration.
2) Selection of bone graft material, mixture with autogenous bone enhances the bone formation quality and reduces the healing period.
3) Maintaining excellent vascular supply.
4) Stability of membrane fixation.
5) Tension-free flap closure.
6) Adequate healing period: 6-9 months depending on the size of the defect.
7) Staged approach for larger ridge defects.
8) Avoidance of infection using suitable antibiotic prior and following the surgical procedure.
9) Operator skill and experience.
10) Patient compliance and maintenance.

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