

Ridge Augmentation Vol 2.

Horizontal Augmentation – Guided bone regeneration

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 2. **ES** Wang HL "PASS" principles for predictable bone regeneration *Implant Dent*. 2006 Mar;15(1):8-17.
 3. **BT** Park SH, Lee KW, Oh TJ, Misch CE, Shotwell J, Wang HL. Effect of absorbable membranes on sandwich bone augmentation. *Clin Oral Implants Res*. 2008;19(1):32-41.
 4. **AK** Sbrickoli L. Selection of Collagen Membranes for Bone Regeneration: A Literature Review. *Materials (Basel)*. 2020 Feb 9;13(3):786.
 5. **TV** Urban IA, Nagursky H, Lozada JL, Nagy K. Horizontal ridge augmentation with a collagen membrane and a combination of particulated autogenous bone and anorganic bovine bone-derived mineral: a prospective case series in 25 patients. *Int J Periodontics Restorative Dent*. 2013;33(3):299-307.
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Horizontal Augmentation – Guided bone regeneration

Topic: Horizontal Augmentation – GBR

Authors: Benic GI, Hämmerle CH

Title: Horizontal bone augmentation by means of guided bone regeneration.

Source: Periodontol 2000. 2014 Oct;66(1):13-40.

DOI: 10.1111/prd.12039.

Type: Review

Reviewer: Trisha Nguyen-Luu

Keywords: Horizontal bone augmentation, guided bone regeneration, membrane, implants

Purpose: To review guided bone regeneration

Discussion:

Membrane:

- Criteria required to select appropriate barrier membrane:
 - o Biocompatibility
 - o Integration by host tissue
 - o Cell occlusiveness
 - o Space-making ability
 - o Adequate clinical manageability
- Non-resorbable membrane:
 - o ADV: Ti- reinforcement with ePTFE membrane increase mechanical stability + allows membrane to be individually shaped
 - for defects that lack support from adjacent bone wall
 - o DIS: Increased rate of soft tissue complications after premature membrane exposure
 - Porous surface of ePTFE is rapidly colonized by oral microbes leading to infection of adjacent tissue, early membrane removal, impaired bone regeneration
 - Need for re-entry + membrane removal – increase risk of tissue damage + morbidity
- Resorbable membrane:
 - o ADV: no need for membrane removal/ need to expose regenerated bone
 - Many techniques possible
 - Better cost-effectiveness + Decrease patient morbidity
 - o DIS: difficulty maintaining barrier function for an appropriate length of time
 - Resorption process of membrane may interfere with wound healing and bone formation
 - Lack of stability
 - o Native collagen membrane:
 - ADV: Good tissue integration, fast vascularization + biodegradation without foreign-body reaction, spontaneous healing in the presence of mucosal dehiscence
 - DIS: poor resistance to collapse + fast degradation resulting in early loss of barrier function
 - o Cross linked membrane:
 - ADV: Increase cross linking directly related to prolonged biodegradation time
 - DIS: decreased tissue integration, foreign body reaction, Increased frequency of mucosal dehiscence + impaired soft tissue healing + wound infection
 - o Synthetic resorbable membranes: polylactic acid, polyglycolic acid, trimethylcarbonate + copolymer
 - DIS: inflammatory foreign-body reaction associated with degradation products
 - Reduced peri-implantitis vertical defect fill with PGLA (81%) vs e-PTFE (96%) membrane

Table 1. Membranes used for guided bone regeneration procedures

Nonresorbable	Resorbable	
	Natural	Synthetic
e-PTFE	Native collagen	Polyglactin
d-PTFE	Cross-linked collagen	Polyurethane
Titanium foil	Freeze-dried fascia lata	Polylactic acid
Micro titanium mesh	Freeze-dried dura mater	Polyglycolic acid
		Poly(lactic acid)/poly(glycolic acid) copolymers
		Polyethylene glycol

e-PTFE, expanded polytetrafluoroethylene; d-PTFE, dense polytetrafluoroethylene.

Bone Grafts + Bone graft substitute:

- Bone grafts / graft substitute need to be:
 - o Biocompatible, osteoconductive, adequate mechanical support of membrane to provide volume for regenerated bone, biodegradable, replaced with patients own bone
 - o Slow substitution is better for maintenance of augmented volume
- Autogenous bone is the ideal grafting material for bone augmentation
 - o ADV: osteogenic + osteoinductive
 - o DIS: morbidity of donor site, limited graft availability + unpredictable graft resorption
- Deproteinized Bovine Derived Bone Mineral (DBBM) is the gold standard of bone substitute
 - o Osteoconductive but controversial bioresorbability
 - o Studies show DBBM block were embedded in CT + only a moderate amount of new bone formation in peripheral part of graft
 - o Still suitable for implant placement

Table 2. Grafting materials used for guided bone regeneration procedures

Graft material	Origin	Examples
Autograft	Patient's own tissue	Intra-orally or extra-orally harvested
Allograft	Tissue from individuals of the same species	Fresh-frozen bone, freeze-dried bone, demineralized freeze-dried bone
Xenograft	Tissue from other species	Bovine-, porcine-, equine-derived bone mineral
Alloplast	Synthetically produced material	Tricalcium phosphate, hydroxyapatite, hydroxyapatite/tricalcium phosphate composite, calcium phosphate cement, calcium sulfate, bioactive glass, polymers

Choice of Material:

- Dehiscence + Fenestration Defects around implants: Deproteinized granular xenograft + particulate autograft covered with native collagen or e-PTFE membrane is best documented
 - o e-PTFE:
 - 75.7% defect fill
 - 75.7% complete defect fill
 - **26.3% mucosal dehiscence – sig reduces new bone formation**
 - 96.5% mean implant survival rate
 - **High risk of complications + increased surgical trauma -> only justified when the volume stability of region to be augmented is not provided by adjacent bone walls**
 - o Resorbable membrane:
 - 87% defect fill
 - 75.4% complete defect fill
 - 14.5% mucosal dehiscence
 - 95.4% mean implant survival rate
- Horizontal Ridge augmentation before implant placement: autogenous bone block alone or in combination with particulate bone substitutes and or membrane is the most reliable method

Case Evaluation + Treatment Planning:

- Intact and well –dimensioned soft tissue allowing for tension free coverage of augmented region is a prerequisite for successful bone regenerate
- Evaluating soft tissue conditions:
 - o The presence and extent of soft tissue defect

- Gingival biotype
- Level of soft tissue at the teeth neighboring the gap
- The amount of keratinized mucosa
- Presence of invaginations
- Scars
- Discolorations
- Pathologies
- Evaluating hard tissue conditions:
 - Bone defect morphology – determines the selection of materials
 - M-D size of edentulous area
 - Bone level at the teeth adjacent to the gap

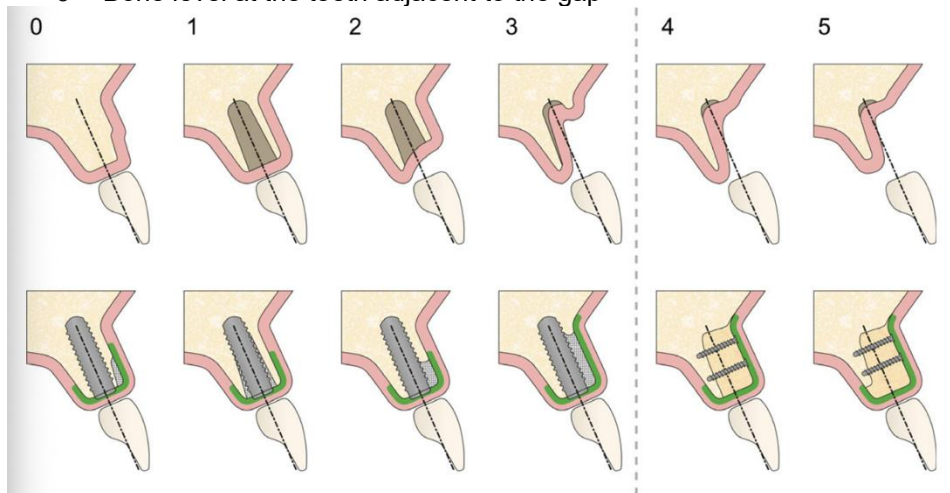


Fig. 3. Schema displaying bone defect Classes 0-5 and the corresponding bone augmentation procedures.

Table 3. Classification of bone defects

Bone defect	Description
Class 0	Site with a ridge contour deficit and sufficient bone volume for standard implant placement
Class 1	Intra-alveolar defect between the implant surface and intact bone walls
Class 2	Peri-implant dehiscence, in which the volume stability of the area to be augmented is provided by the adjacent bone walls
Class 3	Peri-implant dehiscence, in which the volume stability of the area to be augmented is not provided by the adjacent bone walls
Class 4	Horizontal ridge defect requiring bone augmentation before implant placement
Class 5	Vertical ridge defect requiring bone augmentation before implant placement

Ridge Preservation:

- First 6 months post EXT the mean width reduction of alveolar ridge is 3.8 mm + mean height reduction is 1.2 mm
- Ridge preservation to:
 - Maintain ridge profile
 - Enlarge ridge profile
- Ridge preservation cannot prevent physiological bone resorption after EXT but may aid in reducing bone dimensional changes
 - ~1.4 mm less ridge width reduction and 1.8 mm less ridge height reduction after ridge preservation compared to untreated control sites
- DIS:
 - Post-pone implant placement
 - Cost of tx
 - Flap raised to enlarge ridge contour makes it difficult to get primary wound closure
- Technique to achieve optimal soft tissue conditions with ridge preservation:
 - EXT tooth, add bone substitute into socket and harvest a soft tissue graft from the palate and suture against the margins of the ext socket to cover the graft material

Contour Deficit: Class 0

- Implant can be placed in prosthetically correct position within bony envelope but bone augmentation required to improve ridge contour
- Usually with type 4 implant placement (Delayed) + Class 2 dehiscence defect
 - o Tx: GBR (resorbable membrane) particulate bone substitute

Intra-alveolar defect: Class I

- Gap btw implant surface + intact bone walls
- Usually with Type I (immediate) or type 2 (early) implant placement
- Tx: depends on the horizontal dimension of intra-alveolar defect
 - o Posterior site: GBR aims to resolve peri-implant osseous defect
 - o Gap < 1-2 mm: GBR is not needed
 - o Gap > 1-2 mm: Bone substitute in the infrabony defect + covering with resorbable membrane
- Anterior/ esthetic site: GBR also aims to increase buccal contour for esthetic peri-implant soft tissue

Table 4. Guided bone regeneration for Class I defects

Site	Guided bone regeneration procedure
Esthetically non-sensitive site	
HDD < 1-2 mm	No guided bone regeneration
HDD > 1-2 mm	Application of bone substitute into the intra-alveolar defect and coverage with resorbable membrane
Esthetically sensitive site	Application of bone substitute into the intra-alveolar defect and over the buccal bone wall and coverage with resorbable membrane

HDD, horizontal defect dimension.

- Wider gaps btw bone + implants led to less favorable histological outcome
- Spontaneous bone fill without the use of bone graft occurs in peri-implant marginal defects when horizontal defect size is 2 mm or less
- Use of bone graft material results in a more complete resolution of defect + preservation of alveolar process
- Submerged implants placed in fresh extraction sockets had 1 mm more loss of width of KM vs transmucosal implants b/c flap was coronally repositioned to reach primary wound closure in the submerged group

Dehiscence-type defect: Class 2

- Peri-implant dehiscence in which volume stability of the area to be augmented is provided by the adjacent bone walls
- Tx: bioresorbable membrane + particulate bone substitute
 - o Perforate cortical bone around implant to allow earlier vascularization
 - o Membrane to extend 2 mm beyond grafted margins
- Submerged and transmucosal healing can achieve similar outcomes in implant survival

Dehiscence type defect: Class 3

- Peri-implant dehiscences in which volume stability of the area to be augmented is not provided by adjacent bone walls
- Tx: Ti-reinforced e-PTFE membrane + particulate bone substitute + Ti tacks
 - o Additional resorbable membrane can be placed on top to facilitate spontaneous wound healing in cases of soft tissue dehiscence
 - o Submerged healing

Horizontal Defect: Class 4:

- Reduced ridge width precluding the primary stability of the implant in the prosthodontically correct position
- Tx: Autogenous bone block alone or in combo with bone substitute + collagen membrane
 - o Harvest from chin (larger volume) or retromolar mandibular ramus (preferable due to lower risk of complications)
 - o Particulate bone substitute + resorbable collagen membrane reduces resorption of bone block

- Heal for 4-6 months before implant placement
- Tx: ePTFE membrane + particulate DBBM
 - Less gain in ridge width + increased need for additional grafting + higher complication rate
 - Healing time of 7-10 months for DBBM without autogenous bone

Vertical defect: Class 5:

- Reduce ridge height
- Tx: autogenous bone block alone or in combo with bone substitute and or collagen membrane
 - Sig higher rate of soft tissue complications for vertical ridge augmentation – tension free primary wound closure is more difficult to achieve
- Growth factor + Carrier system:
- Bone morphogenetic proteins (BMP2): increasing effect for higher doses
- Growth + differentiation factor (GDF-5): dependent on carrier material as a delivery system + scaffold for cellular growth – ideally should provide space for bone regeneration , allow cell ingrowth + provide controlled release of bioactive molecules (collagen, HA, DBBM, Tricalcium phosphate, allografts, polyglycolic acid, polyethylene glycol)
- Platelet derived growth factor
- Vascular endothelial growth factor
- Insulin like growth factor
- Peptides of the parathyroid hormone
- Enamel matrix derivative

Topic: GBR principles

Authors: Wang HL

Title: "PASS" principles for predictable bone regeneration

Source: Implant Dent. 2006 Mar;15(1):8-17

DOI: 10.1097/01.id.0000204762.39826.0f

Type: discussion

Reviewer: Erin Schwoegl

Keywords: guided bone regeneration, bone grafts, horizontal bone augmentation, implants

Purpose: To outline the 4 major principles of GBR: primary wound closure, angiogenesis, space maintenance, and stability of initial blood clot and implant (PASS)

Discussion:

Primary closure

- Passive closure of wound edges enables healing w less reepithelialization, collagen formation/remodeling, wound contraction, and overall tissue remodeling
- Sig negative effects of memb exposure
 - Machtei meta-analysis: exposed membranes had 0.47mm less attachment gain vs unexposed
 - Unexposed membranes: 3.01mm new bone vs 0.56mm w exposed membranes
 - Simion: 99.6% bone regeneration obtained around DIs w/o membrane exposure for 6-8mo post-DI placement vs 48.6% when membrane exposure occurred earlier.
 - If a membrane remains covered for up to 6-8 months, bone regeneration is predictable
- Factors that impede healing: foreign materials, necrotic tissue, compromised blood supply, wound tension.
- Other possible reasons: contamination of the membrane from an open wound.
- More rapid resorption of bone grafting materials in areas of membrane exposure
- Majority of membrane exposure data is from nonresorbable membranes
- Absorbable collagen membranes may circumvent this problem.
 - Advantages: hemostatic function by platelet aggregation (facilitates clot formation/wound stabilization), chemotactic function for fibroblasts, inhibits epi migration and promotes CT attachment

- Techniques for primary healing: lateral incision technique, buccal rotational flap, coronally positioned palatal sliding flap, split palatal rotated flap, palatal advanced flap

Angiogenesis

- DI surface provides platform for blood clot to form.
- First 24 hours characterized by blood clot forming around DI
- Initial blood clot removed by neutrophils and macrophages
- Initial granulation tissue forms in next days-weeks. Granulation tissue rich in blood vessels
- Primarily deposited woven bone is converted to mature lamellar bone by secondary remodeling
- 6-9 mo needed to fill wound space completely
- Buser: cortical perforations allowed migration of cells- angiogenic and osteogenic potential (regional acceleratory phenomenon)
 - o Others showed bone regeneration occurs even from non-injured cortical layer
- Potential advantages: communication w marrow spaces may enhance revascularization. Growth factors can be released, osteogenic cells from 3 sources: periosteum, endosteum, and undifferentiated pluripotential mesenchymal cells.
 - o Perforations provide mechanical interlock w new bone.
- Larger perforations associated w shorter time for bone fill w/o differences in amount of new bone
- Misch: advocated f both buccal and lingual decortication to enhance healing 2-10x
- To date, no consensus has been established on the beneficial effect of cortical perforation

Space maintenance

- Oh compared 2 collagen membranes (BioGide and Bio-Mend Extend): memb exposure occurred at 9/15 sites and associated w less regeneration; space maintenance and memb coverage were 2 most important factors for GBR success w absorbable collagen membranes
- Jovanovic: sig gain in bone volume, esp supracrestal regeneration, noted w expanded PTFE groups (1.82-1.9mm) vs 0.53mm w control.
- Can be concluded that when sig bone volume is required, reinforced membranes or additional bone grafts more beneficial

Stability

- Barrier membrane: excludes epi cells and stabilized the blood clot
- Initial clot: rich source of cytokines (IL-1, IL-8, TNF), growth factors (PDGF, insulin-like growth factor, fibroblast growth factor), and signaling molecules (recruit clearing cells to site)
 - o PDGF: potent mitogen and chemoattractant for neutrophils and monocytes.
- The clot is precursor to highly vascular granulation tissue, which is site of intramembranous bone formation and remodeling
- Primary stability of DI: key to regeneration and long-term survival.
 - o Lack of primary stability: micromotion and fibrous encapsulation of the implant
 - o Some investigators advocate engaging 2 cortical layers if possible

Postop care

- Antibiotic i.e amoxicillin 2 g/day 10 days
- Warm saltwater rinses for first 2-3 weeks; promotes flap healing w/o disturbing migrating cells.
- CHX gluconate 0.12% next 3 weeks for plaque control.
- Sutures removed at 10-14 days.
- Site checked every 2 weeks for 2 months
- Uncovering 4-6 months later

Topic: Absorbable Membranes

Authors: Park SH, Lee KW, Oh TJ, Misch CE, Shotwell J, Wang HL.

Title: Effect of absorbable membranes on sandwich bone augmentation.

Source: Clin Oral Implants Res. 2008;19(1):32-41.

DOI: 10.1111/jcpe.13665

Type: Pre-clinical study

Reviewer: Brook Thibodeaux

Keywords: animal study, fixation, guided bone regeneration, lateral bone augmentation, non-crosslinked collagen membrane

Purpose: To test the effect of membrane fixation on ridge volume stability and new bone formation histologically post GBR via a pre-clinical study

Materials and Methods:

- In vivo study
- ARRIVE (animal research: reporting of in vivo experiments) guidelines followed
- 8 beagle dogs participated
- 2 types of 0.5mm thick, non-cross linked collagen membranes used:
 - o CM1: Bio-Gide (type I/III collaged derived from porcine peritoneum- bilayer: dense outer layer and spongy inner layer)
 - o CM2: Biocover (type I collagen derived from porcine tendon, uniformly structured)
- Membranes were fixated on both sides for one side of the arch and only fixated on one side on the contralateral side of the arch.
 - o Biogide-Fixed
 - o Biogide- Unfixed
 - o Biocover-Fixed
 - o Biocover- Unfixed
- Randomly assigned to group based on split mouth design and blinded to the surgeon until time of membrane application
- 8 weeks post extraction, GBR took place, animals euthanized 8 weeks post healing and block samples taken

Results:

- All sites healed uneventfully without adverse events- no membrane exposure/wound dehiscence observed
- Membrane fixation versus non membrane fixation had NSSD in total augmented volume for either group
 - o New percentage of bone, residual graft, and non-mineralized tissue not effected either
- Type of membrane was a SS factor for new bone volume and residual graft- more for Bio-Gide vs Biocover.
 - o Greater bone volume for Biogide-Fixed vs Biocover-Fixed and Biogide-Unfixed vs Biocover-Unfixed
- Histo analysis
 - o At crest ridge augmented tissue width amount
 - Biogide-Fixed: 2.4mm
 - Biogide- Unfixed: 2.4mm
 - Biocover-Fixed: 2.3mm
 - Biocover- Unfixed: 1.57mm
 - SS between Biocover- fixed vs Biocover- Unfixed
 - o At ridge crest- regenerated bone width
 - Increased when membrane was fixed
 - Biogide-Fixed: 1.1mm
 - Biogide-Unfixed: 0.82mm
 - Biocover- fixed: 1.0mm
 - Biocover- Unfixed: 0.1mm
 - o NSSD between fixation groups, but when not fixated Biogide-Unfixed had SS incr in augmented tissue width and regenerated bone vs Biocover-Fixed
 - o Remnants of Biogide were detected around periphery of defect at 8wks, membrane integrated with surrounding tissue, with visible divide between areas above and beneath membrane. Directly above- highly vascularized some of loose CT w/ overlaying dense fibrous tissue. Beneath- bone substitute material and interstitial matrix of densely populated fibroblasts. Newly formed bone had not reached outermost zone of augmented area yet.
 - o Biocover mostly resorbed post 8wks, presented as dense layer of fibers running parallel to outline of defect. Space surrounding membrane- loosely arranged interstitial matrix, bone substitute particles sparsely distributed inside defect. Newly formed bone had not reached outermost area in this group, either.

Conclusion: Width of ridge augmented at coronal portion may be dependent on the type of membrane and may be enhanced with fixation, but fixation failed to improve ridge volume stability irrespective of type of membrane.

Topic: collagen membranes

Authors: Sbrickoli L.

Title: Selection of Collagen Membranes for Bone Regeneration: A Literature Review

Source: Materials (Basel). 2020 Feb 9;13(3):786

DOI: 10.3390/ma13030786

Reviewer: Amber Kreko

Type: review

Keywords: collagen membrane; guided bone regeneration; bone augmentation; biocompatible materials; dental implants

Purpose: To provide a review on main features, application, outcomes, and clinical employment of different types of collagen membranes.

Discussion:

- Literature review up to December 2019. 68 articles fulfilled inclusion criteria
- Introduction:
 - o Collagen type I is major component of collagen membranes for regenerative purposes.
 - o Principal of GTR based on ability of membrane to exclude epithelial and connective cells to increase ability of damaged periodontal tissue to regenerate with new bone, PDL, and cementum formation.
 - o Non-resorbable membranes cannot be left exposed and could have complication if they become exposed. They also required a second surgery.
 - o Ideal barrier membrane: biocompatibility, tissue integration, dimensional stability, handling, selective permeability, space making function,
- Collagen membranes vs. non-resorbable membranes
 - o Main disadvantage of non-resorbable was higher rate of wound dehiscence leading to high occurrence of infections
 - o Main disadvantage of resorbable are lack of space maintenance and shorter degradation time.
 - o Advantages of resorbable are single step surgical procedure, decreasing patient morbidity and risk to newly regenerated tissues, good tissue integration, with lower risk of membrane exposure, radiolucency that allows imaging of regenerated bone during healing.
- Native vs. Cross-linked collagen
 - o Natural CM are native materials which means the natural collagen structure of original tissue and natural properties are preserved.
 - o Natural membranes have rapid in vivo degradation.
 - o Cross-linked CM results in a barrier of increased area and thickness. Can reduce bone graft resorption.
 - o NSD found between cross linked and non-cross linked membranes for volumetric bone gains.
 - o Tissue integration and post op complications suggest non-cross-linked had better results.
 - o Degree of cross-linking affects rate of degradation. More cross-linking leads to slower degradation
 - o Suggested that 1-month barrier function time for each millimeter of bone regeneration is needed.
- Collagen membranes in conjunction with graft
 - o CM frequently combined with grafts due to limitations in space maintenance.
 - o Autogenous – osteoconductive, osteogenicity, osteoinductive; increased pt morbidity and fast degradation

- Bone block with fixation pins was superior to particulate bone substitute for vertical gain
- Horizontal – particulate with resorbable membranes; bone substitutes can be mixed with autogenous
- CM without bone grafts showed less vertical and horizontal bone loss and greater bone fill in ridge preservation
- Single layer vs. double layer
 - Double layer for GBR proposed for reduction of micro-movements and the best stabilization of graft, optimizing the sheltering in the area to be regenerated
 - Some authors reported better results and some authors found no statistically significant difference.
- Fixation vs. non-fixation
 - Micromotion of membrane or contained graft can influence volume of the augmented site during healing period.
 - Groups with membrane stabilization always showed better outcomes, preventing graft migration and membrane collapse. Displacement of particulate grafting material still occurs during flap suturing and during subsequent healing period.

Table 2. Non-exhaustive list of available collagen membranes for clinical use (n.d. = not declared).

Commercial Name	Produced By/For	Origin	Cross-Link	Barrier Effect (Weeks)
Biomend	Collagen Matrix Inc.	Bovine Tendon	Yes	8
Biomend Extend	Collagen Matrix Inc.	Bovine Tendon	Yes	18
Copios Extend	Collagen Matrix Inc.	Porcine Dermis	No	24–36
Osseoguard	Collagen Matrix Inc.	Bovine Tendon	Yes	26–38
Bio Gide	Geistlich Pharma Ag	Porcine Dermis	No	24
Mem-Lok RCM	Collagen Matrix Inc.	Bovine Tendon	Yes	26–38
Mem-Lok Pliable	Collagen Matrix Inc.	Porcine Peritoneum	Yes	12–16
Ossix Plus	Datum Dental Ltd.	Porcine Tendon	Yes	16–24
Creos Xenoprotect	Nobel Biocare	Porcine	No	12–16
Biocollagen	Bioteck S.P.A.	Equine Tendon Type I Collagen	No	4–6
Heart	Bioteck S.P.A.	Equine Pericardium	No	12–16
Cytoplast	Collagen Matrix Inc.	Bovine Tendon Type I	Yes	26–38
Collatape	Zimmer -Biomet	Bovine Collagen	No	1–2
Jason	MBP GmbH -Botiss Biomaterials	Porcine Pericardium	No	8–12
Collprotect	Botiss Biomaterials	Porcine Dermis	Yes	4–8
Dynamatrix	Keystone Dental	Porcine Submucosa	No	n.d.
Ez Cure	Biomatlante	Purified Porcine-Based Type I And III Collagen	Yes	12
Conform	Ace Surgical Supply Company	Bovine Type I Collagen	Yes	12–16

Conclusions: Membranes should be chosen for each clinical case according to desired biodegradation characteristics. Collagen membranes show advantageous biological and clinical features compared to both non-resorbable and other resorbable membranes but are not free from complications.

Topic: Ridge Augmentation

Authors: Urban IA, Nagursky H, Lozada JL, Nagy K

Title: Horizontal ridge augmentation with a collagen membrane and a combination of particulated autogenous bone and anorganic bovine bone-derived mineral: a prospective case series in 25 patients

Source: Int J Periodontics Restorative Dent.2013;33(3):299-307

DOI:10.11607/prd.1407

Reviewer: Tam Vu

Type: Case series

Keywords: guided bone regeneration, horizontal ridge augmentation, bovine bone, autogenous bone, dental implant

Purpose: to evaluate rapidly resorbing natural collagen membrane in combination with anorganic bovine bone-derived mineral (ABBM) and autogenous particulate bone in horizontal ridge augmentation of knife edge ridges, clinically and histologically

Material and methods:

- Case series on patients who need horizontal ridge aug in posterior jaw for implants
- GBR with
 - bilayer resorbable membrane from natural collagen (Bio-Gide)
 - combo of autogenous bone + ABBM (Bio-Oss)
- Ridge width measured at time of grafting and at implant placement
- PA taken at abutment and every year
- 9 biopsies taken from implant osteotomies

Results:

- 76 implants placed in 25 pts w/31 knife-edged ridges (anodized TiUnite surface, Nobel)
- Avg residual bone width: 2.19 mm
- Horizontal aug:
 - Mean healing: 8.9 mo
 - Mean ridge: 7.87 mm (5.68 mm gain)
- NSD btn Mx and Mn
- One site with complication (3.2%) – developed abscess – tx with graft removal, irrigation, and abx; pt was successfully retreated
- 100% survival rate
- Histology
 - 8.4 mo graft healing
 - Autogenous/regenerated bone represented 31.0%
 - ABBM: 25.8% (ABBM was connected w/dense network of newly formed bone)
 - Marrow space: 43.2%

Conclusion: GBR with collagen membrane w/ABBM + autogenous bone to treat horizontal ridge defects is successful and leads to implant survival.

Topic: Horizontal Augmentation-Membrane exposure

Authors: Garcia J, Dodge A, Luepke P, Wang HL, Kapila Y, Lin GH.

Title: Effect of membrane exposure on guided bone regeneration: A systematic review and meta-analysis

Source: Clin Oral Implants Res. 2018 Mar;29(3):328-338.

DOI: 10.1111/clr.13121

Reviewer: Daeoo Lee

Type: Sys/meta

Keywords: exposure, complication, alveolar ridge augmentation, bone regeneration, evidence-based dentistry, meta-analysis, review, surgical wound dehiscence

Purpose: To compare the amount of bone gain after GBR procedures between sites with and without membrane exposure.

Material and methods:

- Electronic literature search.

- The primary outcome was the percentage of horizontal bone gain at edentulous ridges.
- The secondary outcome was the percentage of peri-implant bone dehiscence reduction at peri-implant sites.

Results:

- 3 RCT, 4 prospective, 1 retrospective study included.
 - only studies reporting the percentage of bone defect reduction were pooled for comparable comparisons.
- Membranes in the various study: e-PTFE, absorbable membranes, acellular dermal matrix, bovine pericardium membrane
- Bone graft: autogenous, DFDBA, mineralized allograft, autogenous+DFDBA/xenograft
- Main outcomes:
 - SSD Result favoring group without membrane exposure
 - Machtei 2001: 6x greater bone gain if the healing period did not have early membrane exposure.
 - Annibali 2012: Comparable percentages of defect reduction, 90.82% for sites without membrane exposure, and 87.50% for sites with exposure.
 - GBR at edentulous sites
 - Annibali 2012; Nowzari & Slots, 1995 (e-PTFE): without membrane exposure achieved 74% more horizontal bone gain than those with exposure
 - Peri-implant dehiscence defects
 - Annibali 2012; Fu 2014; Nowzari & Slots, 1995; Park 2008; Tawil 2001: 27% more defect reduction at sites without membrane exposure compared to those with exposures

Conclusions:

Membrane exposure after GBR procedures has a significant detrimental influence on the amount of bone augmentation.

Topic: Tenting screws

Authors: César Neto JB., Cavalcanti MC., Sapata VM., Pannuti CM., Hämmerle CHF., Naenni N., Thoma DS., Romito GA.

Title: The positive effect of tenting screws for primary horizontal guided bone regeneration: A retrospective study based on cone-beam computed tomography data

Source: Clin Oral Impl Res. 2020;31:846–855.

DOI: 10.1111/clr.13630

Reviewer: Cyrus J Mansouri

Type: Retrospective study

Keywords: bone regeneration, alveolar ridge augmentation, cone-beam computed tomography, dental implants

Purpose:

To radiographically evaluate the effect of tenting screws (TS) in horizontal guided bone regeneration.

Material and methods:

28 patients in need of stage bone augmentation were consecutively treated in private practice.

- Xenogeneic particulate bone (DBBM) and a collagen membrane was used in all patients.

Subjects were allocated to:

- Control: n = 22; conventional GBR.
- Test: n = 22; GBR in conjunction with TS.

CBCT images were obtained before augmentation and 6-8 months after healing.

- CBCTs were superimposed and linear horizontal measurements were made.

- Ridge width (RW) and ridge width change (RWchange) were assessed at 1-, 3- 5-, and 7-mm below the bone crest.

Surgical protocol:

- Trapezoidal flap design was used, and soft tissue remnants were removed.
- Decortication perforations were made in the buccal plate of bone.
- Both groups were grafted with the same biomaterials (Bio-Oss mixed with autogenous chips harvested from adjacent sites).
- Lingual sites were also grafted when necessary.
- Tenting screws in the test sites were 8 or 10 mm in length with a diameter of 1.5 mm and a head diameter of 3.5 mm.
 - o Inserted buccally at the center of the horizontal defect.
 - o Coronal portion of the screw head 1 mm apical the the ridge crest and 4 mm away from buccal bone.
- Periosteal releases were performed for tension-free wound closure and sites were closed with simple interrupted and horizontal mattress sutures.

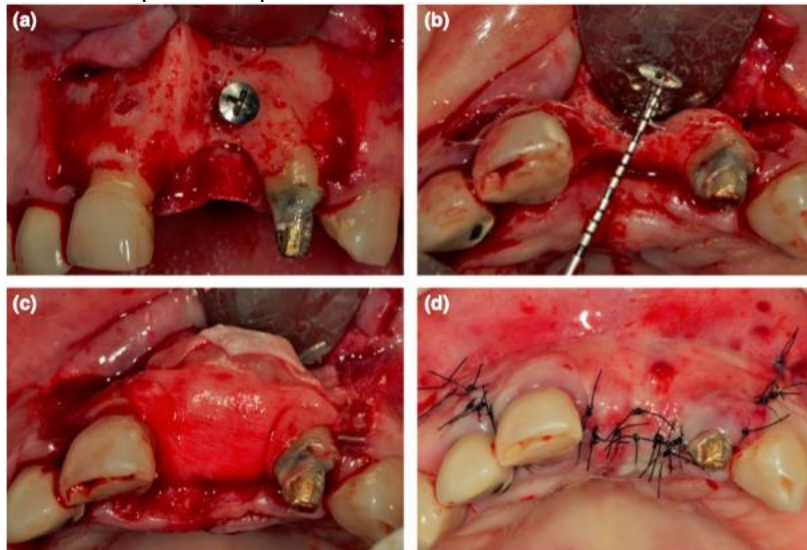


FIGURE 1 Photographs illustrating a clinical case of TS group. Full-thickness trapezoidal flap with a linear incision at the mid-crest and two releasing incisions one-tooth apart of bone defect and decorticalization (a) were performed. The screw was inserted at the center of horizontal defect, with the coronal portion of the screw head about 1 mm below the top of the ridge and 4 mm out of buccal bone (a, b). Bone defects were grafted with DBBM and covered with a collagen membrane (c). Simple interrupted sutures were placed in the releasing incisions and in the horizontal incision, horizontal mattress sutures were placed only in the horizontal incision (d)

Results:

44 sites in 28 patients were evaluated in the study.

RW were statistically similar at baseline.

RWchange was statistically superior with adjunct use of TS.

- At 1-mm below the crest, RWchange was 2.47 mm higher with addition of TS (3.72 mm for TS and 1.25 mm for control).
- At 3-mm below the crest RW change was 1.48 mm higher with addition of TS (3.98 for TS and 2.50 for control).

Conclusion:

The use of tenting screws exerted a positive effect on staged GBR, with greater dimensional gain in RW.

Topic: Vertical Mattress Suture in GBR

Author: Urban IA, Lozada JL, Wessing B, Suárez-López del Amo F, Wang HL.

Title: Vertical Bone Grafting and Periosteal Vertical Mattress Suture for the Fixation of Resorbable Membranes and Stabilization of Particulate Grafts in Horizontal Guided Bone Regeneration to Achieve More Predictable Results: A Technical Report.

Source: Int J Periodontics Restorative Dent. 2016 Mar-Apr;36(2):153-9.

DOI: 10.11607/prd.2627.

Type: Technical Report

Reviewer: Veronica Xia

Keywords: guided bone regeneration, vertical bone grafting, suturing, vertical mattress

Purpose:

- Introduce a new technique for fixation of resorbable membranes onto the underlying bone, potentially immobilizing particulate grafts using resorbable sutures in horizontal GBR procedures

Technique:

- Periosteal vertical mattress suture (PVMS) technique
- Remote flap (crestal and vertical releasing incisions) used for membrane fixation
 - Divergent vertical releasing incisions one tooth away from surgical site
- Decortication holes can be made using 1mm round bur
- Graft placed with/without simultaneous implant placement
 - Sandwich augmentation
 - Autologous bone chips on surface of dental implant with buccal dehiscence and anorganic bovine bone mineral (Bio-Oss) on top (slower resorption)
 - Goal of vertical bone grafting to achieve more space in occlusobuccal corner of implant
- Membrane rehydrated with sterile saline and placed (this study used Bio-Guide)
- Periosteal release incisions made 3-4mm apical to graft/overlapping resorbable membrane
- Suturing
 - First periosteal suture (thin ie 6-0 and small needle ie 10-13m 3/8 circle) placed apical to periosteal release incision mesially/distally
 - Suture periosteum apical to horizontal release incision to ensure tension of vertical periosteal suture is kept
 - Suture laid over distal extension of membrane and continued as mattress on palatal/lingual
 - Tightened until palatal/lingual fixed to underlying bone
 - Same thing performed on the mesial aspect of the bone graft
- Membrane can be stretched until bone graft completely immobilized
- Two internal vertical mattress sutures added to prevent movement/graft migration
- Closure of flap
 - Horizontal mattress 4mm from incision and single interrupted sutures to close edges
 - Flap margin averted (4mm wide inner CT layers)
 - Remain 2-3 weeks
 - Vertical incisions closed with single interrupted (removed at 10-14 days)

Conclusion:

- PVMS technique primarily recommended for single implant sites as an alternative to pin fixation
- Limitation due to the tensile strength of the suture

Topic: Horizontal Augmentation – GBR

Authors: Mertens C

Title: The influence of wound closure on graft stability: An in vitro comparison of different bone grafting techniques for the treatment of one-wall horizontal bone defects

Source: Clin Implant Dent Relat Res 2019 Apr;21(2):284-291

DOI: 10.1111/cid.12728.

Type: Comparative study

Reviewer: Trisha Nguyen-Luu

Keywords: block grafts, bone defects, bone grafting, graft fixation, graft stability, guided bone regeneration, wound closure

Background:

- Ideal defect for GBR is single tooth gap with 3 wall bone defect for bone grafting inside the bone

- contour --> adjacent bone walls graft provides stability + predictable results
- 1 wall defects is not self containing + grafted area is exposed to micromovement leading to fibrous incorporation of particulate bone graft instead of bone regeneration of alveolar ridge
 - o Usually due to mucosal pressure
 - o Reason why block grafts have better regenerative potential in 1 wall defects
- Wound closure is critical factor influencing final bone dimension – excessive pressure from flap covering the particulate graft (which are less resistant to collapse) lead to apical displacement of graft and a reduce crestal dimension

Purpose: To examine the influence of wound closure on graft stability outside the bone contours in 1 wall horizontal bone defects and to compare the volume stability after wound closure with different grafting techniques

- Hypothesis: micromovement of particulate graft is not the sole factor in reducing the initial graft dimensions but prior wound closure might have a negative impact on the volume of the grafted site

Material and methods:

- 10 pig mandibles were received Astra Osseospeed EV 4.2 x 11 mm implants
 - o All implants had a buccal dehiscence defect + implants were randomly assigned to 4 different grafting procedures to achieve min of 2 mm of horizontal graft dimension at the crest of the bone.
- Group 1: GBR + collagen membrane + particulate xenograft
- Group 2: GBR + collagen membrane + particulate xenograft + pins
- Group 3: GBR with Ti-reinforced membrane + particulate xenograft + pins
- Group 4: Autogenous block graft + particulate xenograft + collagen membrane
- CBCT scans were taken before and after wound closure
- Horizontal bone dimensions were measured at 0-5 mm apical from implant shoulder to determine stability
 - o H0: implant shoulder
 - o H1 – 5: 1-5 mm

Results:

- Horizontal Volume Reduction due to wound closure:
 - o Group 1: SSD btw H0-H5
 - o Group 2: SSD btw H0-H5
 - o Group 3: SSD only at H0
 - o Group 4: SSD btw H2 + H4
 - o Group 2, 3, 4 always had better outcomes than group 1 at all levels
 - Any form of stabilization of 1 wall horizontal bone augmentation results in better horizontal graft stability
 - o Group 3 + 4 had better outcomes due to better graft stabilization than group 2
 - o Group 3 had sig better outcome at levels H0 + H1 than Group 2
 - Ti-reinforced membranes produced better graft stabilization in the crestal portion of the grafted area
 - o Group 4 had sig better results at H0 than group 2
 - o NSSD btw Group 3 + 4 – both techniques produce similar results

Conclusions

- Group 1: Only particulate bone graft material was responsible for graft stability
- Group 2: use of pin fixation leads to better stabilization of graft vs no stabilization
- Group 3: Ti-reinforced non resorbable membrane with stabilization pins led to even better stabilization esp in the coronal portion of alveolar ridge
 - o Wound closure only led to minimal graft dislocation in group + non-sig.
 - o May be indicated in for anterior maxilla where crestal bone is essential for good esthetic results
 - o Associated with biological complications (83% higher risk)
- Group 4: recommended for larger defects with unfavorable defect geometry
 - o Wound closure induced only min. Non-significant Dislocation of grafted area – comparable to Group 3
 - o Autogenous block had better results than GBR procedures for bone gain with lower biologic complications rates

- **Overall, nonresorbable, ti-reinforced or bone blocked are recommended for 1 wall defects**
 - **Higher volume stability compared to GBR esp at implant shoulder**
 - **With 1 wall defect type, graft stabilization is of greater importance than self-contained defect**

Discussion:

- 3 wall bone defects (self contained) have better graft stability vs 1 wall defects outside the bone envelope – influence selection of tx + type of graft used
- Particulate grafts are more prone to dislocation by wound closure vs block grafts are more stable from the pressure of surrounding soft tissue
- Results show wound closure leads to statically significant dislocation of graft material at all levels H0-H5
 - GBR without stabilization should be restricted to self-contained defects
- 1 wall defects that are not self contained the dimensions of graft esp in the crestal ridge – dimensions will be severely reduced + bone gain at crest is unpredictable
 - Limited space maintaining capacity of resorbable collagen membrane
 - Sufficient graft immobilization cannot be achieved with 1 wall defects
- Micromovement can lead to further volume reduction + fibrous incorporation of graft

Topic: GBR + collagen membrane

Authors: Park JY, Song YW, Ko KA, Strauss FJ, Thoma DS, Lee JS

Title: Effect of collagen membrane fixation on ridge volume stability and new bone formation following guided bone regeneration

Source: J Clin Periodontol. 2022 Jul;49(7):684-693

DOI: 10.1111/jcpe.13665

Type: beagle study

Reviewer: Erin Schwoegl

Keywords: animal study, fixation, guided bone regeneration, lateral bone augmentation, non-crosslinked collagen membrane

Purpose: To evaluate bone formation w GBR using collagen membranes w and w/o fixation

Material and methods:

- Included 8 beagle dogs
- Collagen membranes: BioGide (type I and III; porcine) and Biocover (type I; porcine)
- Box-shaped defect created on each side of arch in dogs
- 4 dogs: deproteinized porcine bone, BioGide (CM1), and tacks while opposite was unfixed
- 4 dogs: porcine bone + Biocover (CM2); fixed on one side and unfixed on other
 - 4 tx groups: CM1-F (fixed), CM1-U (unfixed), CM2-F, CM2-U
- Block samples taken after 8 weeks

Results:

- Uneventful healing; no wound opening or membrane exposure noted
- NISSD in total augmented volume
- % new bone, residual graft, and non-mineralized tissue were unaffected by fixation
- Type of membrane was sig factor for new bone volume and residual graft, which were
 - Sig more for CM1 vs CM2
 - CM1-F had greater new bone volume vs CM2-F (27.4% vs. 20.4%);
 - CM1-UF had greater new bone volume vs CM2-UF (27.5% vs. 20.6%)

Conclusions:

- Fixation of collagen membrane had no sig difference on volume of augmentation.
- Differences in outcome existed, depending on the collagen membranes.

Topic: Sausage GBR

Authors: Arnal HM, Angioni CD, Gaultier F, Urbinelli R, Urban IA.

Title: Horizontal guided bone regeneration on knife-edge ridges: A retrospective case-control pilot study comparing two surgical techniques.

Source: Clin Implant Dent Relat Res. 2022 Apr;24(2):211-221.

DOI: 10.1111/cid.13073

Type: Retrospective Study

Reviewer: Brook Thibodeaux

Keywords: biomaterials, bone gain, bone resorption, guided bone regeneration, horizontal ridge augmentation, resorbable membrane, sausage technique

Purpose: To compare horizontal bone gain via conventional technique for GBR and sausage technique developed by Urban and colleagues.

Materials and Methods:

- Retrospective study
- 31 pts with horizontal bone defects and a thin ridge of <4mm wide at top of ridge participated
- 8 days of antibiotics: 2g of amoxicillin+ clauvanic acid/d or if allergic 600mg clindamycin+1.5g metronidazole/d
- Control
 - o Conventional GBR- full thickness lap w/ vertical vestibular incisions, cortical perforations, reticulated resorbable membrane(OsseoGuard) fixed with lingual/palatal pins (Geistlick Titan- fix set), 1:1 autograft: Bio-Oss, fixed with pins on buccal, Buccal flap advanced with classical periosteal releasing incision connecting 2 vertices, horizontal & single interrupted sutures.
- Test
 - o Surgical technique described above, but a resorbable collagen membrane (Bio-Gide) was stretched over graft and Master=Pin-Control used instead. Elasticity of membrane was the key in successfully immobilizing the bone graft. Once all pins secured, blunt periosteal instrument used to evaluate the compaction- should feel as dense as possible. Periosteal incision connecting the vertical incisions as described above was completed, then elastic fiber separation was completed using a blunt periosteal instrument in a coronal pushing motion. Horizontal mattress sutures were placed 5mm from the crestal incision and then every 5mm in order to create 5mm CT barrier. Single interrupted sutures then placed to finalize closure.

Results:

- Control group:
 - o Average healing time= 9.2mo
 - o Osseointegration of TSV DI tested at least 2mo after insertion
 - o Some pts experienced little post op discomfort, none lasting longer than 2wks
 - o 1 pt had wound dehiscence after 1mo
 - o 2 DIS failed
 - o Horizontal bone gain after healing= 2.7mm
 - o Mean bone loss between day of surgery and post healing= 0.9mm
 - o Rate of bone resorption= 27.9%
- Test group:
 - o Average healing time= 8.1mo
 - o Osseointegration of TSV DI tested at least 2mo after insertion
 - o Some pts experienced little post op discomfort, none lasting longer than 2wks
 - o 1 pt presented with paresthesia that lasted 6mo.
 - o Horizontal bone gain after healing= 5.3mm
 - o Mean bone loss between day of surgery and post healing= 2.1mm
 - o Rate of bone resorption= 29.4%

Conclusion: The new technique resulted in increased gain of bone compared to conventional GBR. Rate of graft resorption was stable, irrespective of amount of grafted material. This technique does not require space-maintaining defects or form- stable devices.

Topic: xenograft+autograft vs. xenograft

Authors: Temmerman, A., Cortellini, S., Van Dessel, J., De Greef, A., Jacobs, R., Dhondt, R., Teughels, W., & Quirynen, M.

Title: Bovine-derived xenograft in combination with autogenous bone chips versus xenograft alone for the augmentation of bony dehiscences around oral implants: A randomized, controlled, split-mouth clinical trial.

Source: Journal of Clinical Periodontology, 2020, 47(1), 110–119

DOI: 10.1111/jcpe.13209

Reviewer: Amber Kreko

Type: RCT

Keywords: bone chips, bone graft, DBBM, dental implants, GBR

Purpose: To evaluate whether the use of a xenograft is not inferior to the use of xenograft and autogenous bone chips in treating dehiscences at implant placement

Material and methods:

- Randomized, controlled, clinical trial with split-mouth design.
- 14 patients needing GBR to treat a bony dehiscence and bilateral solitary implant in quad 1 and 2 or quad 3 and 4.
- Surgery:
 - o Crestal incision with vertical releasing incisions were used. Osteotomy prepared for Straumann bone level. Autogenous bone chips were collected on surrounding bone. Cover screw placed. Cortical perforations done. Bony dehiscence was measured
 - Control site – autogenous bone chips placed on implant surface and DBBM (Bio-Oss) was placed
 - Test site – DBBM was placed on implant surface
 - o Resorbable collagen membrane (Bio-Gide) was placed. Periosteal incisions done for primary intention healing. Second-stage surgery occurred 4 months after implant placement.
- After implant installation and at abutment surgery, different parameters of bony defect were measured.
- CBCT was taken immediately after implant placement and after 4 months

Results:

- Change in vertical defect height was 2.07mm (46.7%) in test group and 2.28mm (50.9%) in control group
- Change in horizontal defect width at implant shoulder was 1.85mm (40.5%) in test group and 1.75mm (40.9%) in control group
- Loss in augmentation thickness (based on CBCT) of 0.45mm (68.9%) in test group and 0.64mm (55.5%) in control group between implant placement and abutment surgery. NSD between groups
- NSD found between test and control for marginal bone level alterations or weighted amounts of graft material.

Conclusions: The use of autogenous bone chips as an adjunct to DBBM in treatment of solitary bony dehiscencies during implant placement may be questionable. At implant shoulder level, augmentation thickness seems to partially disappear after suturing and healing phase.

Topic: guided bone regeneration

Authors: Mir-Mari J, Wui H, Jung RE, Hämmerle CH, Benic GI

Title: Influence of blinded wound closure on the volume stability of different GBR materials: an in vitro cone-beam computed tomographic examination.

Source: Clin Oral Implants Res. 2016 Feb;27(2):258-65

DOI: 10.1111/clr.12590

Reviewer: Tam Vu

Type: Clinical

Keywords: guided bone regeneration, suture, stability, bone graft, bone block, tack, pins, fixation, membrane

Purpose:

1. To test if there is displacement of graft materials when suturing flaps after GBR (xenograft + collagen membrane)
2. Compare volume stability of augmentation of
 - a. Bone graft + collagen membrane
 - b. Bone graft + collagen membrane + fixation pins
 - c. Bone blocks + collagen membrane

Material and methods:

- 10 pig mandibles, 20 box shaped bone defects (8 x 3 x 6 mm) were prepared with carbide drills
 - 4 x 8 mm Astra tech implant placed
- Bone graft soaked in radiopaque contrast medium prior to GBR
- GBR procedures tested:
 - Granulate: demineralized bovine bone mineral (DBBM, Bio-Oss) + collagen membrane (Bio-Gide)
 - Granulate + Pins: DBBM + collagen membrane + 2 titanium fixation pins (Frios, DENTSPLY)
 - Block: block DBBM + collagen membrane
- Suture method: not mentioned
- CBCT was taken immediately prior and after flap suturing
 - Analyzed horizontal thickness (HT) of augmented bone in direction perpendicular to implant surface at implant shoulder HT0, 1,2,3,4, and 5 mm apical to implant shoulder (HT1-5 mm)

Results:

- NSD between HT before suturing among the 3 tx procedures
- Suturing/wound closure produced SS change in HT
- HT changes of Granulate was sig diff from Granulate + Pins and Block
- NSSD between HT changes btn Granulate + Pins and Block

	Granulate (%)	Granulate + Pins (%)	Block (%)
HT0	-42.8	-22.9	20.2
HT1mm	-23.4	-6.9	-10.8
HT2mm	-13.1	-0.9	-5.3
HT3mm	-7.8	3.3	-0.0
HT4mm	-6.6	2.2	3.2
HT5mm	-2.0	1.6	27.2

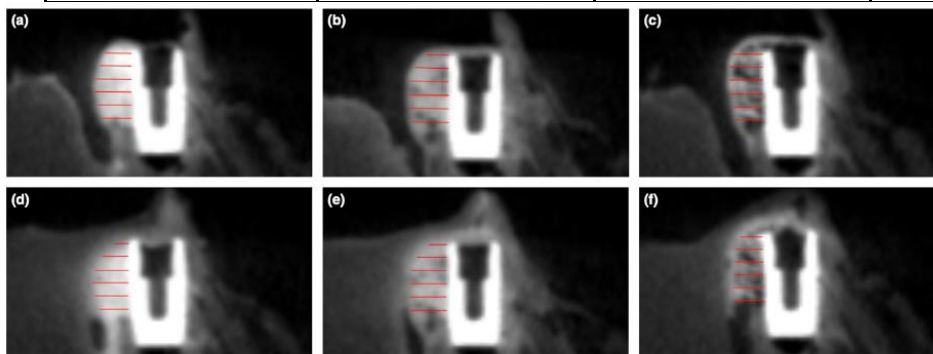


Fig. 3. Bucco-oral CBCT reconstructions with the measurements of the dimensions of the augmented regions [HT0 mm- HT5 mm]. (a) Granulate, (b) Granulate + Pins, and (c) Block treatment procedures before suturing. (d) Granulate, (e) Granulate + Pins, and (f) Block treatment procedures after suturing.

Discussion:

- Even with tension-free flap closure, there are compressive forces on the coronal portion which displaces the graft material and cannot be avoided
- DBBM block has complications, such as block fracturing [have to prepare new block]
- Histologically, DBBM blocks were mainly embedded in connective tissue, with moderate amounts of new bone formation in peripheral portion of graft
- Expect partial collapse of membrane/material --- overaugment defect to compensate for material displacement

Conclusion:

- Flap manipulation during suturing displaces bone material and causes partial collapse of membrane in the coronal portion of augmented site
- Primary stability is enhanced with fixation pins
- Bone blocks in combo with collagen membrane sig better for dimensional stability during flap suturing (vs particulated bone graft covered with collagen membrane)