

Ridge Augmentation Vol. 4

Ridge Expansion – Ridge Split

1. **TN** Jong-Jin Suh 1, Avi Shelemay, Seong-Ho Choi, Jung-Kui Chai Alveolar ridge splitting: a new microsaw technique Int J Periodontics Restorative Dent. 2005 Apr;25(2):165-71.
2. **ES** Dong-Seok Sohn, Hyun-Jin Lee, Jeung-Uk Heo, Jee-Won Moon, In-Suk Park, Georgios E Romanos. Immediate and delayed lateral ridge expansion technique in the atrophic posterior mandibular ridge. J Oral Maxillofac Surg 2010 Sep;68(9):2283-90. doi: 10.1016/j.joms.2010.04.009.
3. **BT** J Garcez-Filho 1, L Tolentino, F Sukekava, M Seabra, J B Cesar-Neto, M G Araújo Long-term outcomes from implants installed by using split-crest technique in posterior maxillae: 10 years of follow-up. Clin Oral Implants Res 2015 Mar;26(3):326-31. doi: 10.1111/clr.12330.

Bone blocks (Onlay)

4. **AK** C M Misch Comparison of intraoral donor sites for onlay grafting prior to implant placement Int J Oral Maxillofac Implants. 1997 Nov-Dec;12(6):767-76.
5. **TV** Thomas von Arx 1, Daniel Buser Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: a clinical study with 42 patients Clin Oral Implants Res. 2006 Aug;17(4):359-66.
6. **DL** Ilara R Zerbo 1, Gert L de Lange, Manon Joldersma, Antonius L J J Bronckers, Elisabeth H Burger. Fate of monocortical bone blocks grafted in the human maxilla: a histological and histomorphometric study Clin Oral Implants Res. 2003 Dec;14(6):759-66.
7. **CM** Maoxia Wang 1, Yazhen Li 2, Zhenya Su 3, Anchun Mo 3 Clinical and radiographic outcomes of customized allogeneic bone block versus autogenous bone block for ridge augmentation: 6 Month results of a randomized controlled clinical trial J Clin Periodontol. 2023 Jan;50(1):22-35. doi: 10.1111/jcpe.13714.

Khoury Plates

8. **VX** Fouad Khoury, Thomas Hanser Mandibular bone block harvesting from the retromolar region: a 10-year prospective clinical study Int J Oral Maxillofac Implants. 2015 May-Jun;30(3):688-97 doi: 10.11607/jomi.4117.
9. **TN** Luca De Stavola 1, Jochen Tunkel Results of vertical bone augmentation with autogenous bone block grafts and the tunnel technique: a clinical prospective study of 10 consecutively treated patients Int J Periodontics Restorative Dent.2013 Sep-Oct;33(5):651-9. doi: 10.11607/prd.0932.
10. **ES** Fouad Khoury, Thomas Hanser Three-Dimensional Vertical Alveolar Ridge Augmentation in the Posterior Maxilla: A 10-year Clinical Study Int J Oral Maxillofac Impl 2019 Mar/Apr;34(2):471-480. doi: 10.11607/jomi.6869.
11. **BT** Luca De Stavola, Andrea Fincato, Eriberto Bressan, Luca Gobbato Results of Computer-Guided Bone Block Harvesting from the Mandible: A Case Series Int J Periodontics Restorative Dent .2017 Jan/Feb;37(1):e111-e119. doi: 10.11607/prd.2721.

Distraction osteogenesis- Interpositional grafts (inlay)

12. **AK** Ole T Jensen, Lee Kuhlke, Jean-Francois Bedard, Dawn White Alveolar segmental sandwich osteotomy for anterior maxillary vertical augmentation prior to implant placement. J Oral Maxillofac Surg 2006 Feb;64(2):290-6.
 13. **TV** Pietro Felice 1, Claudio Marchetti, Giovanna Iezzi, Adriano Piattelli, Helen Worthington, Gerardo Pellegrino, Marco Esposito Vertical ridge augmentation of the atrophic posterior mandible with interpositional bloc grafts: bone from the iliac crest vs. bovine anorganic bone. Clinical and histological results up to one year after loading from a randomized-controlled clinical trial Clin Oral Implants Res 2009 Dec;20(12):1386-93.
 14. **DL** Bradley S McAllister 1, Thomas E Gaffaney Distraction osteogenesis for vertical bone augmentation prior to oral implant reconstruction Periodontol 2000 . 2003;33:54-66.
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Ridge Expansion – Ridge Split

Topic: Ridge Expansion – Ridge split

Authors: Jong-Jin Suh et al

Title: Alveolar ridge splitting: a new microsaw technique

Source: Int J Periodontics Restorative Dent. 2005 Apr;25(2):165-71.

DOI: none

Type: Case Series

Reviewer: Trisha Nguyen-Luu

Keywords: Alveolar ridge splitting, periodontics, microsaw

Background:

Minimum 6 mm ridge dimension required

- 1 – 1.5 mm min thickness of bone on buccal + lingual plate needed for successful outcome
- Different techniques for horizontal augmentation:
 - o GBR , block graft, soft tissue
 - o Summers Ridge expansion: using hand osteotomes to create localized expansion of osteotomy
 - o Sciponi Bone flap: use hand chisel to expand ridge
- Problems with ridge expansion + bone flap:
 - o Requires 3- 4 mm of ridge width
 - o Does not work if ridge is made of primarily cortical bone
 - o Risk of fracturing the expanding plate of bone + unable to stabilize the implant sufficiently to ensure predictable osseointegration

Purpose: To review cases of using the microsaw technique for alveolar ridge splitting

Material and methods:

- 10 patients were included with 3 types of implants placed
 - o 9 patients had implants placed simultaneously with ridge splitting using microsaw blades
 - o 1 patients whose ridge was < 2.5 mm had ridge splitting completed first and implants placed 1 month after
- Maxilla Anterior site:
 - o Initial incision made on the crest of ridge towards the palatate
 - o Partial thickness flap on the buccal + vertical incisions
- Mandible Anterior site:
 - o Horizontal incision on in the labial mucosa apical to the MGJ
 - o Partial thickness flap to crest of ridge + then full thickness flap from crest to the lingual
 - o May be necessary to create shallow horizontal cuts 2-3 mm deep to joint the apical extents of vertical grooves for more flexibility
- Both Maxilla + Mandible:
 - o No. 330 straight fissure bur used to create 1 mm deep perforations along crest of ridge 1 mm apart + at least 1.5 mm from the buccal cortical plate
 - o Microsaw (Friadent) used to create horizontal cut in bone connecting the perforations at its max depth/ radius of cutting diamond disk (4 mm)
 - o No 15 surgical blade inserted into cut + using light tapping with a surgical mallet advanced to desired implant placement depth
 - Blade is much thinner than chisel allowing for more gentle expansion + less risk of fracture
 - o Small buccolingual motions are used to expand ridge when blade is advanced into ridge
 - With increasing depth the bone is likely to become more cancellous compared to crest of ridge --> gives it elasticity for ridge expansion
 - o Eliminate sharp edges exposed during expansion to avoid flap perforations
 - o 1 or 2 vertical grooves 2 mm deep can be placed through the periosteum of buccal plate with microsaw to allow buccal plate to move more freely

- Once full depth + some expansion with No 15 blade is completed, use series of flat chisels with increasing widths to expand ridge
- After ridge has been expanded, use implant burs to create osteotomies
- Preferred tapered endosseous implants to minimize stress on expanded bone after implant placement (Friarent or Endospore)
- Bone chips harvested from surgical site are used to fill gaps btw implants + ridge
- Flap is replaced +. sutured tension free
- 5 months healing period in the maxilla for 2 stage surgery
- 3 month reentry in mandible for 1 stage surgery

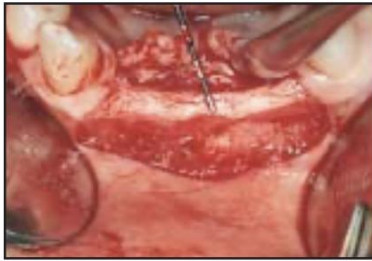


Fig 1a Vertical and horizontal incisions below mucogingival junction. Partial-thickness flap dissection to crest and full-thickness flap reflection past crest, lingually. Crest is less than 2.5 mm wide, and 1-mm undercut is present apical to it.

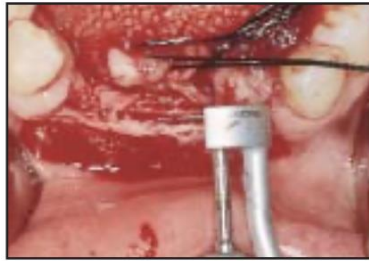


Fig 1b Microsaw is used to connect perforations at full depth.

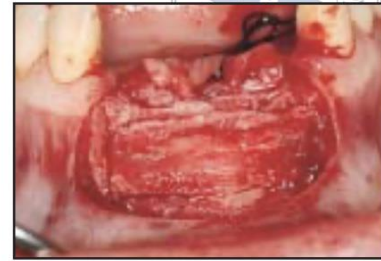


Fig 1c Buccal vertical cuts a minimum of 2 mm from teeth. Additional horizontal microsaw cuts join the two vertical cuts at their apical extents.



Fig 1d Expanded ridge. Autogenous bone graft is used to fill space between buccal and lingual plates.



Fig 1e Expanded ridge following 1 month of healing, at time of implant placement.



Fig 1f Conventional implant placement in two stages.



Fig 2a Use of microsaw to make horizontal cut at crest of maxillary ridge. Initial width at crest is 2.5 mm.



Fig 2b Simultaneous implant placement with ridge expansion. Sharp edges at vertical cuts are rounded.



Fig 2c Stage-two reentry after 5 months of healing in the maxilla.



Fig 2d (left) Normal resorptive pattern of the maxillary ridge; crest of anterior maxilla has been displaced palatally relative to anterior mandibular teeth.

Fig 2e (right) Proper maxillomandibular relation is restored in anterior dentition.

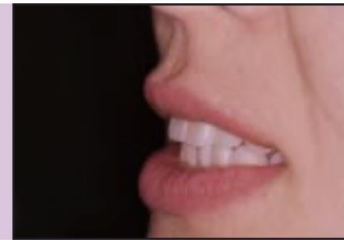


Fig 2f Radiographic view of implants placed simultaneously with ridge expansion in anterior maxilla (26 months postoperative).

Results:

- 27 implants placed + All implants osteointegration + were in function for 1-4 years
- No post-op complications
- Radiograph of anterior maxilla of implants placed simultaneously with ridge splitting revealed stable bone levels

Conclusions:

- Microsaws is an effective tool for ridge expansion over previous techniques
- Main advantage:
 - o Microsaw blades are 0.25 mm thick + less bone is removed from narrow ridge + less trauma + better control
 - o Allows ridge expansion for 2.5 mm narrow alveolar ridges
- Preserving periosteum on buccal plate of bone via partial thickness flap is critical
 - o Allows rapid revascularization of expanded bone even with vertical+ horizontal releasing cuts

- Min buccal bone thickness of 1 – 1.5 mm retained under periosteum is a pre-requisite for success

Topic: ridge split

Authors: Sohn DS, Lee HJ, Heo JU, Moon JW, Park IS, Romanos GE.

Title: Immediate and delayed lateral ridge expansion technique in the atrophic posterior mandibular ridge

Source: J Oral Maxillofac Surg. 2010 Sep;68(9):2283-90

DOI: 10.1016/j.joms.2010.04.009

Type: clinical

Reviewer: Erin Schwoegl

Purpose: To present results of implant placement in narrow mandibular ridges undergoing expansion

Background:

- Lateral ridge split/expansion: buccal cortex repositioned laterally via greenstick fx
- Space btwn B and L plates filled w autologous, allogenic, or alloplastic graft, or w/o any graft added
- Usually simultaneous w DI placement
- More suitable in maxilla due to thinner cortex and softer medullary bone.
- Higher risk of malfracture of B segment in mand due to lower flexibility and thicker cortex
 - o Staged approach to may be beneficial

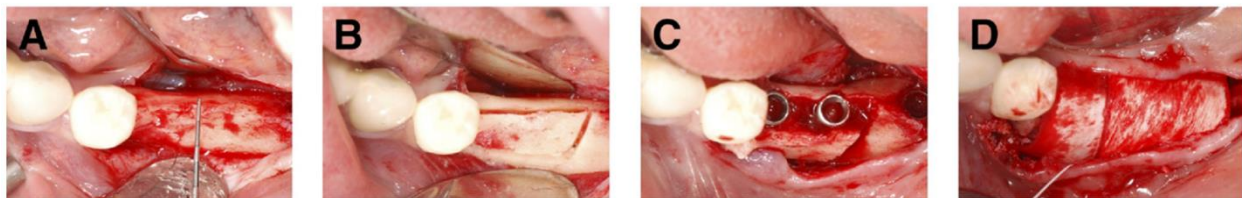
Material and methods:

- Included 32 pts and 84 DIs
 - o 23 pts with immediate and 9 w delayed approaches
- Mand BL ridge widths ranged 2-4mm; adequate height

Technique

Immediate:

- Crestal incision offset lingually
- Lingual flap raised minimally to preserve blood supply
- Corticotomies made on buccal w piezo saw or erbium: yttrium- aluminum-garnet laser (power 6W, frequency 20Hz)
- 1 horizontal and 2 vertical corticotomies made to depth of L plate
- Small chisel and mallet to expand B segment and make greenstick fx and dislocate buccally
- DI sites prepared; each site received 2 or 4 DIs
- Bone grafts of varying placed into gap btwn expanded B plate and L plate
 - o Graft material not used in all cases
- Resorbable barriers placed over top
- Tension-free closure
- DIs exposed after 4-5mo



Delayed:

- Applied to ridges w dense/thick cortex due to incr risk of fx of the expanded B segment.
- First surgery: rectangular corticotomies made w piezo saw or laser,
 - o Greenstick fx created in B segments and repositioned; flap sutured.
- After 3-4 weeks, crestal incision made expose crestal cut, but minimally reflecting B flap to preserve blood supply
- Small chisel to separate and mobilize segmented bone, creating a greenstick fx.
- Blood supply on B aspect of displaced maintained.
- DIs placed and bone graft placed; graft not used in all cases.

- Tension-free closure
- After 3-4mo, healing abutments placed.

Results:

- 84 DIs: 63 w immediate lateral expansion and 21 w delayed.
- 5/23 pts w immediate technique had malfracture of thin B plate
 - o 1 fixed w microscrews and 4 repositioned in place after placing DIs.
- No malfractures in 9 pts who underwent delayed expansion technique
- After 4-5mo, all 83/43 DIs were stable, surrounded by bone, w ossification of osteotomy line
 - o This 1 pt underwent immediate expansion; B bone resorption at second sx; secondary bone grafting performed.
- Prostheses successful in all cases; adjacent DIs were splinted.
 - o Avg time to loading: 17 months

Conclusions:

- Lateral ridge expansion was successful in horizontal ridge aug of severely atrophic post mand.
- Delayed technique safer and more predictable in pts w thick cortex and narrower ridge

Topic: Split- Crest Technique

Authors: Garcez-Filho 1, L Tolentino, F Sukekava, M Seabra, J B Cesar-Neto, M G Araújo

Title: Long-term outcomes from implants installed by using split-crest technique in posterior maxillae: 10 years of follow-up.

Source: Clin Oral Implants Res 2015 Mar;26(3):326-31.

DOI: 10.1111/clr.12330

Type: retrospective study

Reviewer: Brook Thibodeaux

Keywords: biomaterials, bone implant interactions, surgical techniques, split- crest technique

Purpose: To analyze the survival and success rates of narrow diameter implants (3.3mm) using the split-crest technique.

Material and methods:

- Retrospective study, 10y f/u
- 21 pts, 26 procedures, 40 NDIs
- Narrow diameter implants placed in atrophic maxillary posterior area post and at the time of split crest procedure
- Ridge width >3mm but less than 5mm
- Flap reflection to allow for visibility of the most coronal 5mm of alveolar bone on the B and P, On the B, split thickness periosteal releasing incision 5mm below crest of bone. Blood supply was not interrupted to the B aspect of bone by allowing periosteum to remain intact. Horizontal osteotomy and two vertical osteotomies created using comic ogival end diamond drill. If neighboring dentition- vertical osteotomies placed at least 1mm from adjacent teeth. Crest of the alveolar ridge split w/ bone chisel. Immediately post crest split- NDI (3.3 SLActive- 4.8mm platform) placed following Straumann protocol. Healing caps placed. All implants were 8-10mm in length and placed in at least 5mm of native bone. Bio-Oss small granule (0.25-1mm) graft placed between inner bone wall of split crest and DI surface. Flap repositioned and stabilized.
- Potassium diclofenac (50mg), Amoxicillin (500mg), and peridex rx to pt
- Primary & secondary measurements recorded, statistical analysis

Results:

- Healing uneventful in all pts
- Factors that did not show any impact on DI/prosthesis survival/success rates: gender, age, tobacco addiction (>10cig/d)
- During the 1st year- 6 pts dropped out after moving to another city- 2 fixed partial dentures and 4 single crowns lost
- 1 DI had early failure 2mo post installation
- 1 DI had late failure after 3y of loading
- 20 DIs were single crowns, 19 DIs were fixed partial dentures

- End of study (10y f/u) included 14 pts, 19 split crest ridges, 34 NDIs- 16 single crowns and 17 fixed partial dentures
- Survival: T1= 97.5% T2= 97%
- Success rates: T1= 97.5% T2= 95%
- Bone Loss: T1= 0.47mm T2= 1.93mm
- Annual Bone Loss Progression Rate during 10y f/u= 1.46mm
- Maximum bone loss was during the first 6mo after loading
- Survival prosthetic rate: T1= 100% T2= 97%
- Success prosthetic rate: T1= 100% T2= 79%
 - o NSSD between fixed partial dentures vs single crowns

Conclusions: Split-crest technique is potentially an alternative for bone augmentation, showing similar clinical results to those observed from implants placed under ideal conditions. After a long time interval, narrow diameter implants placed post-split crest procedure may successfully support prosthetic rehabilitation.

Bone blocks (Onlay)

Topic: intraoral donor sites

Authors: Misch, C M

Title: Comparison of intraoral donor sites for onlay grafting prior to implant placement

Source: Int J Oral Maxillofac Implants. 1997 Nov-Dec;12(6):767-76.

DOI: N/A

Reviewer: Amber Kreko

Type: clinical study

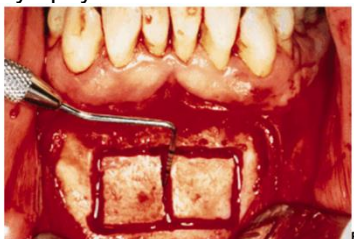
Keywords: autogenous bone grafts, mandibular bone grafts, ramus, symphysis

Purpose: To present clinical evaluation and comparison of intraoral harvest sites for grafting prior to implant placement

Material and methods:

- 50 patients with inadequate bone volume for implant placement were included.
- Donor sites were either symphysis or ramus and chosen based on defect morphology and recipient site location. Teeth were extracted at least 8 weeks before grafting.

- Symphysis:



- Ramus:



- Clinical evaluation included graft size and morphology at bone procurement, post op complication

with harvest, incorporation, and resorption, bone quality of healed graft, and implant placement in graft sites.

Results:

- Volume for symphysis was largest
- Symphysis was corticocancellous and ramus was more cortical
- Symphysis – incision dehiscence in 10.7%, two patients had developed infection of grafted donor site; No dehiscence or infection occurred in ramus group
- Temporary mental nerve paresthesia in symphysis graft patients 9.6%; none in ramus graft group
- 29% of symphysis patients described altered sensation of incisor teeth; no changes noted in ramus group
- All 50 grafts incorporated with no significant clinical difference noted in resorption between groups.
- Bone quality in ramus was more often graded as one and quality two for the symphysis. None were noted as 3 or 4.

Conclusions: The ramus offers some advantages over the mandibular symphysis as an autogenous donor site including minimal patient concern for altered facial contour, lower incidence of incision dehiscence, decreased complaints of post op sensory disturbance, and proximity to posterior mandible recipient sites. Surgical access in some patients is more difficult and there are limitations to size and shape of the graft. The symphysis offers the potential for thicker grafts with an increased cancellous component.

Topic: Ridge Augmentation

Authors: von Arx T, Buser D

Title: Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: a clinical study with 42 patients

Source: Clin Oral Implants Res. 2006;17(4):359-366

DOI: 10.1111/j.1600-0501.2005.01234.x

Reviewer: Tam Vu

Type: Clinical

Keywords: horizontal ridge augmentation, autogenous, bone block, bovine, collagen membrane, success

Purpose: to analyze the clinical outcome of horizontal ridge aug using autogenous block grafts covered with anorganic bovine bone mineral (ABBM, BioOss) and a resorbable collagen membrane (BioGide)

Material and methods:

- 42 pts with severe ridge atrophy
- Block grafts harvested from symphysis or retromolar area
- One or two screws to stabilize block graft
- Voids around block graft filled with bone chips harvested from donor site
- ABBM mixed with blood applied to cover block graft and covered with collagen membrane
- Sutures removed at 7-10 days
- Follow up at 3 and 5 mo

Results:

- 58 sites augmented
- Mean measurements:
 - Pre-aug width: 3.06 mm
 - Post-aug width: 8.02 mm

- Re-entry width: 7.66 mm
- Ridge width gain: 4.59 mm
- Amount of surface resorption: 0.36 mm

Discussion:

- ABBM was used for graft protection – at re-entry, the ABBM particles had fibrous encapsulation, which deflected from block graft when flaps were raised
- ABBM particles were incorporated into newly formed bone at the periphery of block graft

Conclusion:

- Combo of autogenous block graft and ABBM particles covered with collagen membrane results in successful horizontal ridge augmentation, with high efficacy and predictability

Topic: Bone block (Onlay)

Authors: Zerbo IR, de Lange GL, Joldersma M, Bronckers AL, Burger EH

Title: Fate of monocortical bone blocks grafted in the human maxilla: a histological and histomorphometric study

Source: Clin Oral Implants Res. 2003 Dec;14(6):759-66

DOI: 10.1046/j.0905-7161.2003.00967.x

Reviewer: Daeoo Lee

Type: Histological

Keywords: histology, histomorphometry, mandibular symphysis, maxillary defects, monocortical bone graft

Purpose: To gain insight into the fate of bone grafts into the human jaw with emphasis on the survival of the osteocytes and graft vitality.

Material and methods:

- 19 pts (15M 4F), 17-57 yo, severe defect in the anterior maxilla, with complete loss of the buccal plate that required regeneration with a bone block
- 8 pts agreed to use tetracycline for bone labelling
- Bone harvest:
 - A partial thickness incision was made 10 mm apically of the margin between attached and loose gingiva of the lower incisors.
 - Incision extended apically until approximately 0.5–1.0 cm below the apex of the lower incisors where a full-thickness flap was made
 - Symphyseal bone visualized and bone block was cut
 - Site filled with bioactive glass particles (Biograns, 3i Implant Innovations Inc)
- Defect site:
 - Full thickness flap
 - Thoroughly cleaned.
 - Bone block reshaped to fit defect and then fixed with two screws.
 - Grafts covered with resorbable membrane (Biogide, Geistlich); in two cases PTFE (GORE)membrane was used.
 - Flap closed over bone graft and suture placed.
 - Suture removed 1 wk later.
- Implant placed 2.5-7 mo later

- At the time of implant placement, biopsy performed.
- Histological and histomorphometry analysis performed.
- Statistical analysis performed.

Results:

- All 19 graft successfully integrated; 1 membrane exposure, 1 allergic reaction to suture
- Histology
 - The amounts of vital and NVB varied considerably between individuals
 - Very little qualitative difference could be found between biopsies of different healing times by description of the histology alone.
 - Amount of osteoid also varied between biopsies
 - Tetracycline labeling varied in length from short to long. Overall distribution of labels was similar in all cases.
- Histomorphometry
 - Total mean bone volume: 41% (27%-57%)
 - Average NVB 11% (1%-34%)
 - Average vital bone volume: 30%
 - The NVB significantly decreased with increasing time of healing
 - Resorption surface varied among patients from 0.2% to 1.8% of the BS
 - Average mineral apposition rate (MAR) of all patients was 1.5 ± 0.4 mm/day. All patients who received the tetracycline bone labelling had a short healing period (between 3 and 4 months).
 - NVB fully replaced by new VB in approximately 7 mo.

Conclusions: Present study suggests that osteocytes in monocortical bone blocks of the human chin are for the greater part unable to survive grafting. However, the remodeling that follows grafting is relatively quick and free of complications. Within approximately 7 months after grafting the bone is fully remodeled, vital and in principle able to adapt fully to the functional loads it must endure.

Topic: Bone blocks

Authors: Wang M., Li Y., Su Z., Mo A.

Title: Clinical and radiographic outcomes of customized allogeneic bone block versus autogenous bone block for ridge augmentation: 6 Month results of a randomized controlled clinical trial

Source: J Clin Periodontol. 2023;50:22–35.

DOI: 10.1111/jcpe.13714

Reviewer: Cyrus J Mansouri

Type: RCT

Keywords: alveolar ridge augmentation, autogenous bone block, customized allogeneic bone block, graft remodelling, randomized controlled clinical trial

Purpose:

To compare the efficacy of allogeneic bone block (CABB) to autogenous bone block (ABB) for ridge augmentation.

Material and methods:

24 pts in need of ridge augmentation were recruited and randomly assigned to tx groups.

- CABB: CAD/CAM bone blocks: designed from DICOM files obtained from CBCT scans and milled from cortico-cancellous components of a donor iliac crest.

- ABB: Obtained from the pts external oblique line of the mandible.
 - o In both groups, the void surrounding the bone blocks was filled with particulate bone allograft and were covered with a collagen membrane.

Radiographic evaluation:

- CBCT scan obtained at baseline, immediately after closure, and after 6 months.

The primary outcome of interest was the horizontal bone gain (HBG₁) 1 mm apical to the alveolar ridge crest.

- Secondary outcomes of interest included bone gain at other levels, bone resorption rates, ridge width, operative time, pain score, and histological results.

FIGURE 1 (a, b) Customized allogeneic bone blocks were virtually designed based on the pre-operative cone-beam computed tomography (CBCT). (c) Bone defect could be observed. (d, e) Bone blocks were fixated on the defect area. (f) Occlusal view of the augmented hard tissue at 6 months. (g) Radiographic view of pre-operative CBCT. (h) Radiographic view of CBCT immediately after wound closure. (i) Radiographic view of CBCT at 6 months

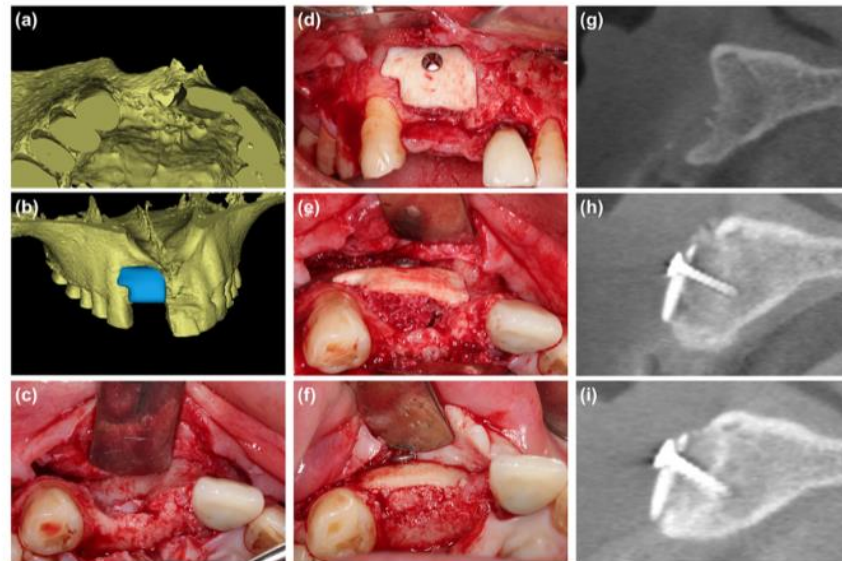
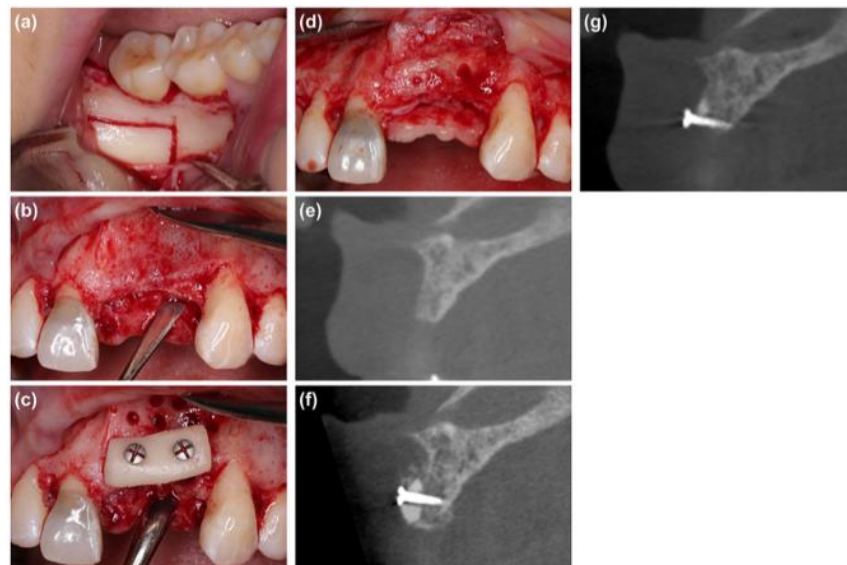


FIGURE 2 (a) Autogenous bone block was harvested from the external oblique line of the mandible. (b) Bone defect could be observed. (c) Bone block was fixated on the defect area. (d) Labial view of the augmented hard tissue at 6 months. (e) Radiographic view of pre-operative cone-beam computed tomography (CBCT). (f) Radiographic view of CBCT immediately after wound closure. (g) Radiographic view of CBCT at 6 months



Results:

24 pts (12 in CABB; 12 in ABB) completed the 6-month follow-up.

- One block exposure was experienced in the CABB group.

CABB experienced significantly more horizontal bone gain 1 mm below the ridge crest compared to ABB.

- 4.29 ± 1.48 mm vs 1.12 ± 3.25 mm bone gain, respectively.

CABB experienced significantly less bone resorption 1 mm below the ridge crest compared to ABB.

- $42.15 \pm 14.03\%$ vs $92.52 \pm 55.78\%$ resorption, respectively.
- 2.97 ± 0.78 mm vs 4.72 ± 2.16 mm, respectively.

Performing ABB took significantly longer compared to CABB.

- 78.50 ± 7.50 min vs 8.75 ± 4.49 min, respectively.

New bone formation was found in both groups.

Conclusion:

The use of CABB resulted in more horizontal bone gain and less resorption 1 mm below the crest at 6 months post-surgery, compared to ABB. Operative time was also reduced substantially with use of the CABB.

Khoury Plates

Topic: Bone Block Harvesting

Author: Khoury F, Hanser T.

Title Mandibular bone block harvesting from the retromolar region: a 10-year prospective clinical study.

Source: Int J Oral Maxillofac Implants. 2015 May-Jun;30(3):688-97.

DOI: 10.11607/jomi.4117. PMID: 26009921.

Type: Clinical Study

Reviewer:

Veronica

Xia

Keywords: bone block, external oblique ridge

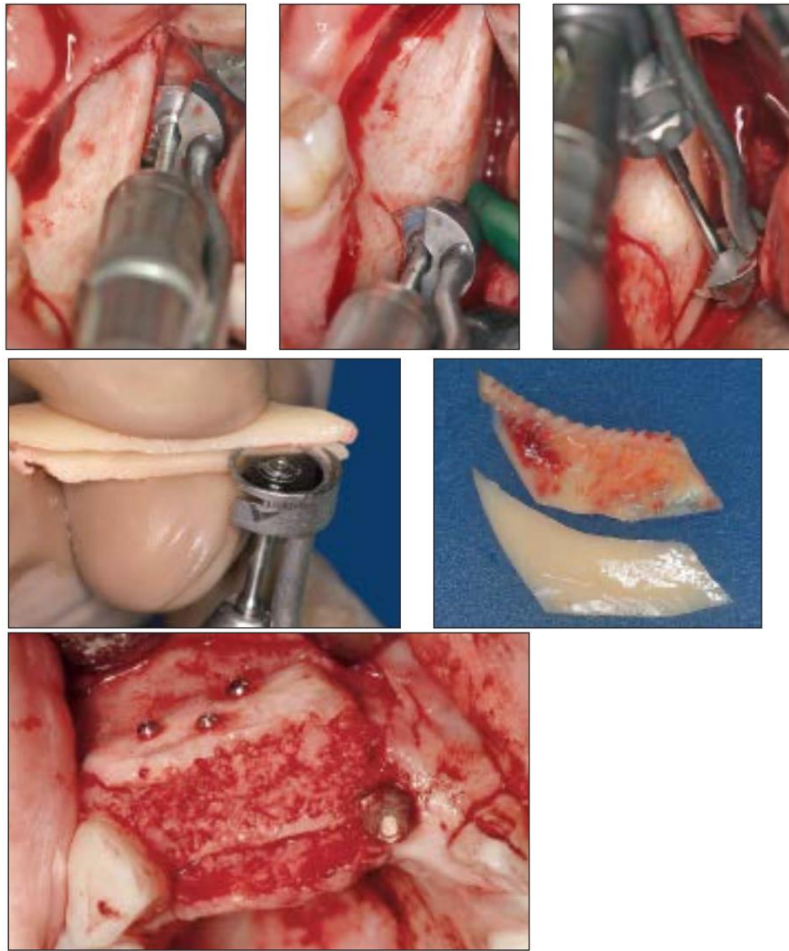
Purpose:

- Evaluate the outcome of bone block harvesting from the external oblique ridge (EOR) with the MicroSaw

Materials and Methods:

- Patients with large bony defects or severe bone atrophy of the maxilla/mandible
- Surgery:
 - Trapeze-like incision (starting distal to second molar with 2cm vestibular incision over the ramus, continuing parallel/lateral to second molar, then going back in the vestibular direction on distal border of the first molar)
 - Exposed EOR (3-4cm x 2cm)
 - Harvesting osteotomy performed with MicroSaw
 - Two proximovertical osteotomies and one apicohorizontally, then on occlusal crestal site parallel to EOR (small perforations connected with chisel)
 - Donor site sealed with collagen fleece
 - Harvested bone split into two thin bone blocks (split bone block technique)
 - Two thin bone blocks with autogenous chips in between
 - Stabilizing with small screw if necessary





Results:

- 3328 patients who underwent bone block harvesting
- Average time require to harvest a bone block: 6.5+/-2.5 minutes
- Mean volume harvested: 1.9 +/- 0.9 cm³ with thickness up to 6.5mm
- 0.5% of cases experienced minor nerve injury:
 - Hypesthesia and paresthesia
- 48.8% of patients experienced minimal pain, and 3.45% experienced severe pain
- Mandibular donor sites were examined postoperatively via panoramic radiographs
 - Surgical scars disappeared within 6-12 months, but external oblique line not reformed

Conclusion:

- EOR favorable to obtain large mandibular bone block grafts, allowing for efficient and safe harvesting
- CBCT recommended to obtain information regarding thickness of bone structures and position of the mandibular nerve
- Repositioning split bone block at donor site is adequate to rebuild donor site

Topic: Khoury Plates

Authors: Luca De Stavola 1, Jochen Tunkel

Title: Results of vertical bone augmentation with autogenous bone block grafts and the tunnel technique: a clinical prospective study of 10 consecutively treated patients

Source: Int J Periodontics Restorative Dent.2013 Sep-Oct;33(5):651-9.

DOI: 10.11607/prd.0932.

Type: Clinical Prospective study

Reviewer: Trisha Nguyen-Luu

Keywords: vertical ridge augmentation, bone block. Tunneling

Background: crestal incision for accessing bone increases the risk for dehiscence during healing

Purpose: To examine the results of a tunneling technique for autogenous intraoral bone block augmentation prior to implant placement

Material and methods:

- 10 partially edentulous patients with a vertical defect in the mandible or maxilla were included in the study
- Bone harvested from external oblique ridge of mandible on same side of defect
 - o Microsaw technique/ protocol
- Harvest bone block was cut along axis into 2 thinner blocks with diamond disk + thinned to be 1 mm using the bone scraper
 - o Bone chips were collected
- Single vertical incision at the distal margin of the mesial tooth to the defect beyond the MGJ
- Full thickness flap raised buccally and lingually via tunneling the mucosa + fixed gingiva over the defect + reaching distal bone peak
- Lateral window was completed when necessary
- 1st bone blocks was adapted to defect area + Stabilized with Ti screws to create a bone bridge btw M + D bone peaks
 - o Space btw bottom of defect + bone block was filled completely with bone chips
- 2nd bone block was fixed lateral with Ti screws to close access to the space + bone chips were packed to fill remaining gap
- Wound closed by sutured single vertical incisions + Removed at 2 weeks
- Implants placed in submerged position via protocol AFTER
- Abutment connection at 4 months post- implant placement
- 4 clinical measurements taken:
 - o VD: Maximal extension of vertical defect
 - residual alveolar crest to line connective M-D bone pea
 - o VBG: Vertical bone graft
 - distance from residual alveolar crest to more coronal portion of graft
 - o BR1: Bone resorption at Time of implant placement
 - Distance btw regenerative alveolar crest + head of Ti screw fixing bone block
 - o BR2: bone resorption during implant healing
 - Distance btw implant shoulder + bone level at time of abutment connection

Results:

- All surgical sites healed uneventfully – no exposure of grafted material + donor site complication

Table 3 Morphology of the vertical bone defects according to linear measurements on preoperative radiographs

Patient	Defect site*	A-P (mm)	Maximum VD (mm)	Minimum VD (mm)
1	16, 17	23	8	4
2	16, 17	21	7	3
3	26, 27	22	6	5
4	26, 27	22	9	3
5	46	12	5	5
6	34, 35, 36	29	6	5
7	36, 37	22	5	4
8	22, 23, 24	22	6	5
9	22, 23	16	8	6
10	25, 26	23	5	4
Mean $\pm$ SD		21.2 $\pm$ 4.49	6.50 $\pm$ 1.43	4.50 $\pm$ 0.80

A-P = anteroposterior dimension of the defect; VD = vertical bone defect; SD = standard deviation.
*FDI tooth-numbering system.

Table 2 Vertical bone augmentation and bone remodeling results

Patient	VD (mm)	VBG (mm)	BR1 (mm)	BR2 (mm)	Total VBG (mm)	Total BR (mm)	No. of implants	Implant type (root-form)
1	8.0	8.0	0.0	0.5	7.5	0.5	2	XiVE, Dentsply Friadent
2	7.0	7.0	0.0	0.0	7.0	0.0	2	XiVE, Dentsply Friadent
3	6.0	6.0	0.0	0.0	6.0	0.0	2	XiVE, Dentsply Friadent
4	9.0	9.0	1.0	0.0	8.0	1.0	2	XiVE, Dentsply Friadent
5	5.0	5.0	0.0	0.0	5.0	0.0	1	XiVE, Dentsply Friadent
6	6.0	6.0	0.0	0.5	5.5	0.5	2	EZ Plus, Megagen
7	5.0	5.0	0.0	0.5	4.5	0.5	2	NanoTite, Biomet 3i
8	6.0	6.0	1.0	0.5	4.5	1.5	2	XiVE, Dentsply Friadent
9	8.0	8.0	1.0	0.0	7.0	1.0	1	OsseoTite, Biomet 3i
10	5.0	5.0	0.0	0.0	5.0	0.0	2	XiVE, Dentsply Friadent
Mean $\pm$ SD	6.50 $\pm$ 1.43	6.50 $\pm$ 1.43	0.30 $\pm$ 0.48	0.25 $\pm$ 0.26	6.00 $\pm$ 1.29	0.55 $\pm$ 0.49		

VD = vertical defect (time 0); VBG = vertical bone graft (time 0); BR1 = bone resorption at implant placement (time 1); BR2 = bone resorption at implant abutment connection (time 2); SD = standard deviation.

Time 0:

- mean VG + VBG = 6.50 mm.
- Mean defect in AP dimension = 21.2 mm

Re-entry Time 1:

- Mean BR1: 0.30 mm
- Mean BR 2: 0.25 mm
- Total BR: 0.55 mm

- Total amount of regenerated bone after 8 months was 6 mm + resorption rate 8.46%
- 100% survival rate

Conclusions

- Jensen + Terheyden reports a 18% complication rate for vertical bone augmentation + a 29.8% complication rate of bone blocks
- This study had no complications which leads the author to believe that avoiding the crestal incision can reduce risk of complications
- Tunneling is more demanding + technique sensitive
 - o Not feasible in every defect (complex anatomy making it difficult to completely elevate the mucoperiosteal flap)
- Several factors responsible for limited bone graft resorption:
 - o Tunneling mucoperiosteal flap over the defect – tissue integrity could provide more blood supply for regeneration
 - o Bone graft is revascularized more easily than the traditional cortical bone block – bone block was sectioned into 2 and then further thinned into 1 mm then the 2 cortical laminae bone block was adapted to defect in a way that creates the occlusal bone plate (new vertical level of crest) + the vestibular plate + then the particulate autogenous bone was used to fill the space btw the plates
 - This results in the major component of graft is composed of spongelike bone + minimal cortical bone
 - Vessels penetrated faster + involved the entire graft compared to simply adapting a bone block into the recipient site where majority of the bone is cortical bone which has slower + incomplete vessel penetration
 - This technique also decreases the correlation btw the thickness + size of bone block + the vertical augmentation results – usually the a 4 mm bone block is harvested which can limit the extent of regeneration

Topic: Khoury plate

Authors: Khoury F, Hanser T

Title: Three-Dimensional Vertical Alveolar Ridge Augmentation in the Posterior Maxilla: A 10-year Clinical Study

Source: Int J Oral Maxillofac Implants. 2019 Mar/Apr;34(2):471-480

DOI: 10.11607/jomi.6869

Type: prospective

Reviewer: Erin Schwoegl

Keywords: autogenous bone block, diamond disk, external oblique line, mandibular bone graft, mandibular bone harvesting, MicroSaw, split bone block

Purpose: To present outcomes of bone block harvesting from external oblique ridge using a MicroSaw

Material and methods:

- Included pts who underwent bone block harvesting from the retromolar area prior or simultaneous to DI placement
- Trapeze-like incision; started D to 2nd molar w a 2cm vestibular incision over the ramus, continuing parallel and lateral to 2nd molar, and then going back in the vestibular direction on the distal border of the first molar
- Bone volume to be harvested depended on size of external oblique ridge and quantity needed
- Osteotomy harvested w the MicroSaw
- Bone blocks split into 2 thin blocks with diamond disk
- If only one block needed, second block used to reconstruct donor site
- If needed, blocks additionally stabilized w small screws
- Remaining half-blocks placed back over collagen fleece, without screw stabilization, within contour of external oblique line

Fig 13 (below) Vertical three-dimensional reconstruction is performed with one-half of the split block, in combination with autogenous particulate bone. No other augmentation material or membranes were used.



Fig 14 (above) The second half of the bone block is reimplanted at its origin and secured with a MicroScrew to reconstruct the external oblique line.

Results:

- Total of 3,328 pts underwent bone block harvesting during 10-yr study.
- Mean volume: $1.9 \pm 0.9 \text{ cm}^3$ (max 4.4cm³)
- Bone quality mostly cortical w little cancellous bone.
- All blocks successfully split; no fractures.
- In 2,285 sites, osteotomy lines were apical to IAN; in 168 (7.35%) of these, nerve was exposed, , leading to transient sensory problems (max of 6mo).
- In 20 cases, minor nerve injury occurred (0.5%): 8 pts (0.2%) w hypesthesia, and 12 (0.31%) w paresthesia that lasted up to 1 year.
- In 4 pts (0.1%), paresthesia present >1 year.
- No permanent anesthesia in any case.
- 61 (1.58%) donor sites had complications in primary healing; 46 (1.19%) were minor (wound dehiscence, superficial infection) and 15 pts (0.39%) had major complications; all were smokers.
 - o Tx: intensive local rinsing and drainage for up to 3 wk.
- Comparison of pre and postop CBCT in 341 pts showed that, after at least 18mo, a certain amount of regeneration occurred, but external oblique line was not re-formed
- In cases where half the block was reimplanted, excellent regeneration of donor site w observed..

Conclusions:

- The surgical protocol allows efficient and safe harvesting from external oblique ridge.
- Repositioning of split block at the donor site seems to improve healing and rebuild donor site almost completely.

Topic: Computer- Guided Bone Block Harvest

Authors: Luca De Stavola, Andrea Fincato, Eriberto Bressan, Luca Gobbato

Title: Results of Computer-Guided Bone Block Harvesting from the Mandible: A Case Series

Source: Int J Periodontics Restorative Dent .2017 Jan/Feb;37(1):e111-e119

DOI: 10.11607/prd.2721

Type: Case Series

Reviewer: Brook Thibodeaux

Keywords: n/a

Purpose: To discuss mandibular computer- guided bone harvesting procedure results.

Material and methods:

- 13 patients participated with partial edentulism and insufficient bone quality with vertical and/or horizontal alveolar ridge deficiency, 16 alveolar defects.
- Sx protocol: Antibiotics for 6 days beginning the day before sx (Amoxicillin 1g q12h). Procedure started with bone harvesting from the mandible.
 - o For external oblique line donor sites- intrasulcular incisions in the molar area or on top of the alveolar crest in cases of edentulism with a M releasing incision. Full thickness flap elevated. Surgical guide screwed to the bone with a 1.3mm diameter screw. Piezoelectric instrument was used for osteotomy cuts facing the flat side of the piezoelectric insert to the internal face of the surgical guide. Cutting direction defined by surgical guide and working depth defined by volumetric image analysis. Cranial and M osteotomies completed w/ B7 inserts. Apical and D with the B2R and/or B2L inserts. Block removed by straight, thin elevator without necessity of hammering

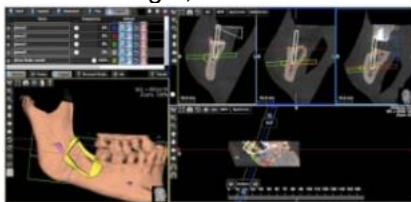


Fig 1 Computer-guided bone harvesting planning. The cutting plane (green and white) projection outside the bone body/surface defined the internal faces of the surgical guide (yellow).

Fig 2 The external oblique ridge after elevation of a full-thickness flap.



Fig 3 (a) The surgical guide screwed in situ. (b) Using a piezoelectric instrument, the osteotomy cuts were made facing the flat side of the piezoelectric insert to the internal face of the surgical guide. The cutting direction was unequivocally defined by the surgical guide. (c) A clinical aspect of the osteotomies done in accordance with the surgical guide.



Fig 4 Harvested bone block from the external oblique ridge.

For chin bone donor sites- incision line was intrasulcular in the frontal teeth area involving bases of papillae and two distal releasing incisions. Flap elevation and guide secured as previously described. Osteotomies completed using B7 inserts. Donor site filled with collagen sponge.



Fig 5 (a) Clinical view of a bone block harvesting procedure from the chin area. The surgical guide is screwed to the bone and tooth supported. The flat face of the surgical tool was placed against the internal face of the surgical guide. (b) Clinical aspect of the osteotomy cuts done in accordance with the surgical guide.



Fig 6 (a) The bone block was luxated with a thin elevator. (b) The harvested bone block from the chin.

All cases the bone blocks were grafted following Khoury and Khoury's bone augmentation approach.

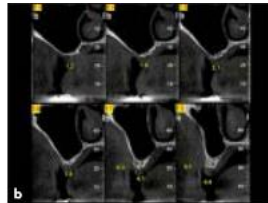
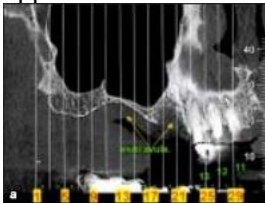


Fig 7 (a) Presurgical situation of a 6-mm vertical defect in the upper right maxilla. (b) Cross-sectional images of the residual bone crest. A vertical autogenous bone augmentation and sinus lifting was planned.



Fig 8 (a) Autogenous bone laminae were screwed to build the vestibular and palatal walls of the alveolar crest. (b) The space between the two bone laminae was filled with autogenous bone particles.

Fig 9 (a) Clinical situation after 4 months healing. Optimal bone reconstruction of the alveolar crest was achieved. (b) Three implants were inserted (XIVE Cell Plus, Dentiply).

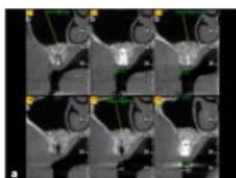


Fig 10 (a) Radiographs of the treated area 4 months after the implantation surgery. (b) Intraoral radiograph of the implants after 12 months of loading. (c) Clinical view of the final restoration.

Results:

- Mean MD defect dimension on the preop volumetric image= 25mm
- 3 cases the single harvested bone graft used for two different quads
- 3 cases the projected bone block length was 37.5mm and grafted into 2 vertical bone augmentations
- In one patient 33.2mm block was harvested and grafted horizontally in a maxillary 9 tooth defect.
- Left external oblique ridge harvested in 6 cases, right external oblique ridge harvested in 5 cases., chin harvested in 2 cases
- 3/12 surgical guides were tooth supported and screwed to the bone.
- Mean block dimensions: height was 8mm. thickness was 4mm and MD was 24.8mm

- Mean bone block volume from the ramus= 0.8cm^3 , from the chin= 0.9cm^3
- Following Khoury and Khoury's bone block management- bone block bisected into two thinner cortical lamina and then grafted in combo w/ autogenous particles bone scrapped from same lamina
- At reentry 4mo post healing- optimal bone reconstruction of alveolar crest had been achieved
- 12mo post loading- intraoral XR showed absolute stability of peri-implant bone with no resorption.
- Horizontal grafting- 7 cases, vertical grafting- 9 cases.
- Healing uneventful in all cases and patients did not experience any alteration in function of neurologic structures or of tooth vitality in long or short term.

Fig 11 Radiograph of a 7-mm vertical defect in the posterior left mandible.

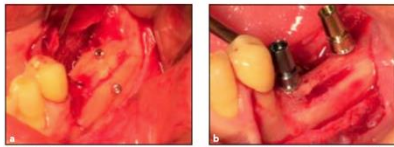
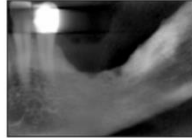


Fig 12 (a) Clinical image of an autogenous vertical bone graft. (b) Clinical situation of the reconstructed alveolar crest 4 months post augmentation surgery, when two implants were inserted.

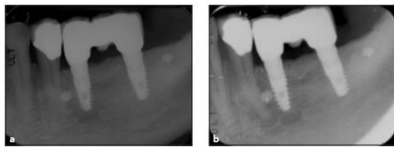


Fig 13 (a) Radiograph of the treated area 12 months postloading. (b) Radiograph of the same site after 3 years of follow-up. The bone level seems to be well maintained.

Conclusions: The method described above combines computer guided procedure in controlling the osteotomy lines advantage with the ability to maximize and relate the harvestable bone block volume to the bone volume necessary for reconstruction of the defect.

Distraction osteogenesis- Interpositional grafts (inlay)

Topic: alveolar segmental sandwich

Authors: Ole T Jensen, Lee Kuhlke, Jean-Francois Bedard, Dawn White

Title: Alveolar segmental sandwich osteotomy for anterior maxillary vertical augmentation prior to implant placement

Source: J Oral Maxillofac Surg 2006 Feb;64(2):290-6.

DOI: 10.1016/j.joms.2005.10.021

Reviewer: Amber Kreko

Type: clinical study

Keywords:

Purpose: To report a study of 10 cases treated over 5 years in which sandwich osteotomy was done as an alternative to block onlay graft or distraction osteogenesis.

Material and methods:

- 10 patients with edentulous sites in anterior maxilla. Vertical deficiencies ranged from 3-7mm.
- Technique:
 - o Vestibular incision made high in vestibule.
 - o With a sagittal saw, alveolar bone was segmentalized through vestibular incision using horizontal cut about 10mm below crest of the ridge and connecting vertical cuts to free the segment.
 - o Segments were 3-6 teeth in length and moved down 5mm crestally.
 - o Cortical wedge of bone harvested from ramus was placed interpositionally to establish desired alveolar height.

- Particulate autograft was used to fill gap.
- After 4 months, implants were placed using a percutaneous approach with a guide stent.
- Pictures in article.

Results:

- Vertical gain ranged from 3-6mm.
- The 10 patients demonstrated very stable and aesthetic results. Implant integration and bone levels remained stable postrestoration.
- Technique provided papillary support interdentally.
- Bone marker xray verification was not done, but there was no significant bone resorption observed prior to implant placement.

Conclusions: Moderately atrophic anterior maxilla can be vertically augmented up to 5mm using segmental osteotomy with interpositional bone graft. Efforts to displace segment greater than 5mm risk potential of detaching periosteal blood supply and excessively rotating the segment palatally, compromising aesthetic gingival projection.

Topic: Vertical ridge augmentation

Authors: Felice P, Marchetti C, Iezzi G, et al

Title: Vertical ridge augmentation of the atrophic posterior mandible with interpositional bloc grafts: bone from the iliac crest vs. bovine anorganic bone. Clinical and histological results up to one year after loading from a randomized-controlled clinical trial.

Source: *Clin Oral Implants Res.* 2009;20(12):1386-1393

DOI: 10.1111/j.1600-0501.2009.01765.x

Reviewer: Tam Vu

Type: Clinical

Keywords: bone block, autogenous, bovine, xenograft, marginal bone loss

Purpose: to compare bone blocs from iliac crest vs anorganic bovine bone blocks for vertical bone augmentation in the posterior mandible

Material and methods:

- 10 bilateral partially edentulous pts (posterior mandible) w/ 5-7 mm of residual crestal height above mandibular canal
 - Each side randomly assigned to each procedure (autogenous bone block or Bio-Oss bone block)
- Post op at 3, 6 weeks, and 3 mo
- At 4 mo, bone biopsy with trephine (histomorphometric analysis) and implant placed
- Provisional prosthesis placed 4 mo after that
- After 4 mo, definitive prosthesis delivered
- Prosthesis failure, implant failure, biological/prosthetic complication, peri-implant marginal bone levels were evaluated

Results:

- SS more residual graft in Bio-Oss group (13%, compared to auto 10%)
- NSSD in failures and complications
- Both group lost SS amount of peri-implant marginal bone (NSSD b/n groups)
 - Autogenous bone: 0.82 mm
 - Bio-Oss: 0.59 mm

Conclusion: Both procedures achieved good results, Bio-Oss was less invasive than autogenous bone blocks, and preferable than harvesting bone from iliac crest.

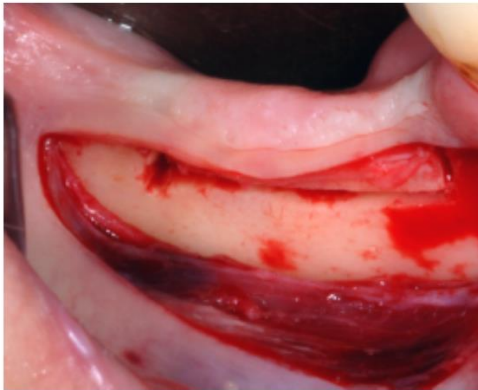


Fig. 1. A paracrestal incision was made on the buccal side, and horizontal and vertical osteotomies were made with a piezo-electric device.

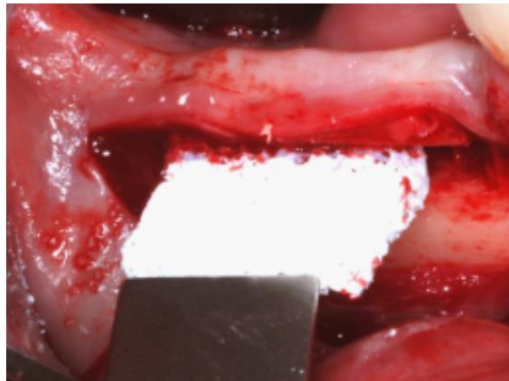


Fig. 2. Placement of a bloc of anorganic bovine bone (Bio-Oss) as an interpositional graft.

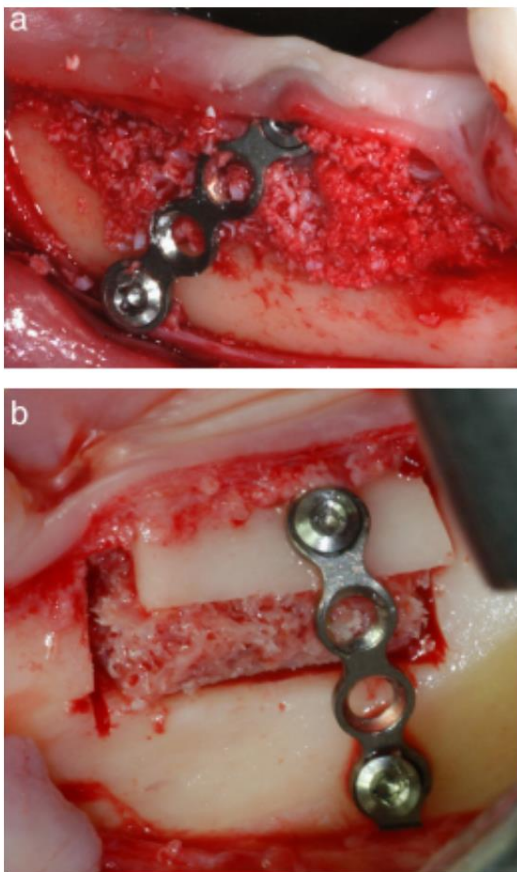


Fig. 3. (a-b) The osteotomized cranial fragment is immobilized with surgical plates and screws with the basal bone: (a) interpositional autogenous bone bloc from the iliac crest; (b) interpositional Bio-Oss bloc.

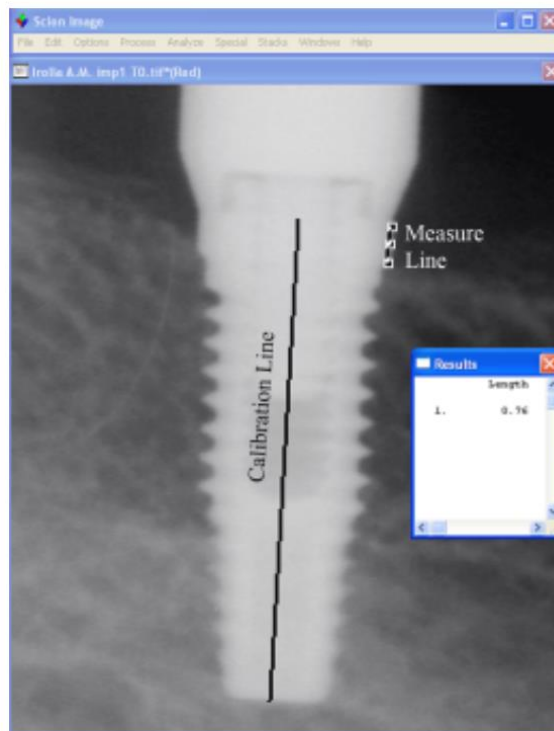


Fig. 6. Methods used to measure marginal bone levels. The known length of the implant was used to calibrate the measurement software.

Topic: Distraction osteogenesis- Interpositional grafts (inlay)

Authors: McAllister BS, Gaffaney TE

Title: Distraction osteogenesis for vertical bone augmentation prior to oral implant reconstruction

Source: Periodontol 2000. 2003;33:54-66

DOI: 10.1046/j.0906-6713.2002.03305.x

Reviewer: Daeoo Lee

Type: Narrative Review

Keywords: distraction osteogenesis, vertical bone, implant, techniques

Purpose: describe different distraction osteogenesis technique/device

Background: the basic principle with three distinct phases:

- A latency phase of approximately 7 days of initial post surgical healing
- The distraction phase, consisting of the gradual incremental separation of two bone pieces at a rate of approximately 1 mm per day.
- Consolidation phase, during which new bone forms in the regenerate zone between the separated bone pieces.

Discussion:

- Surgical technique of distraction osteogenesis
 - Indication: a minimum of 6-7 mm of bone height must remain above vital anatomic structures and at least a 4 mm vertical defect of sufficient length (edentulous zone of three or more missing teeth) must exist when measuring from the height of the adjacent bony walls to the vertical depth of the osseous defect.
 - Latency period: depending on healing capability (young vs. older pts) may shorten or prolong the 1 wk period.
 - Distraction: slower rate of distraction for older pts.
 - While some slight crestal resorption is often found during consolidation, it usually is no further apical than the adjacent bone levels. Therefore, it may be beneficial to overdistract by 2-3 mm.
- ACE surgical distractor
 - See figures 1-10
 - The intraosseous ACE distractor (ACE Surgical Supply, Brockton, MA) is made of titanium alloy and has three main components during active distraction (Fig. 1).
 - The distractor body engages the bony transport segment with external threads that are of the same pattern as that of a conventional 3.75 mm oral implant. Unless anatomic constraints exist, it is advisable to utilize the long body distractor for maximal fixation
- The Leibinger Endosseous Alveolar Distraction (LEAD) system
 - See figures 11-14
 - The intraosseous LEAD system (Stryker Leibinger, Kalamazoo, MI) consists of a 2 mm diameter threaded rod, a threaded transport plate, and a stabilizing unthreaded base plate
- KLS Martin distractor
 - See figure 15-22
 - The extraosseous Track distractors (KLS Martin, Jacksonville, FL) are made of titanium with microplates that have been welded onto the sliding mechanism of the actual distraction screw
- Distractor and oral implant combination devices
 - See fig. 23
 - Prosthetically restorable distractor was introduced by SIS Trade Systems (Klagenfurt, Austria)
- Potential complications with distraction osteogenesis
 - Infection, extensive bleeding, nerve injury, adjacent tooth damage, and ̄ap dehiscence may occur.

- Complications related to the alveolar distraction procedure
 - Fracture of the host bone or transport segment may occur during insertion of the distraction device, or distraction fixation screws.
 - Distractor instability can develop due to poor bone quality, soft tissue dehiscence, transport or host segment fracture, or extensive site preparation for distractor placement
 - Undesirable movement of the transport bone segment may occur, often due to lingual flap or muscle tension
 - Premature consolidation occurs prior to completion of distraction.
 - Delayed consolidation may occur, potentially leading to the development of a nonunion.