Maintaining space in localized ridge augmentation using guided bone regeneration with tenting screw technology

Evdokia Chasioti, DDS1/Tat Fai Chiang, DMD2/Howard J. Drew, DMD3

Prosthetic guided implant surgery requires adequate ridge dimensions for proper implant placement. Various surgical procedures can be used to augment deficient alveolar ridges. Studies have examined new bone formation on deficient ridges, utilizing numerous surgical techniques and biomaterials. The goal is to develop time efficient techniques, which have low morbidity. A crucial factor for successful bone grafting procedures is space maintenance. The article discusses space maintenance tenting screws, used in conjunction with bone allografts and resorbable barrier membranes, to ensure uneventful guided bone regeneration (GBR) enabling optimal implant positioning. The technique utilized has been described in the literature to treat severely resorbed alveolar ridges and additionally can be considered in restoring the vertical and horizontal component of deficient extraction sites. Three cases are presented to illustrate the utilization and effectiveness of tenting screw technology in the treatment of atrophic extraction sockets and for deficient ridges. (Quintessence Int 2013;10:763–771; doi: 10.3290/j.qi.a30178)

Key words: alveolar ridge deficiency, augmentation, GBR, site development, tenting screw technology

The concept of restorative-driven implant dentistry is currently well accepted among clinicians. Implants support prosthetic devices and consequently need to be placed in a three-dimensionally accurate location.1 Treatment planning with definitive prosthetic and periodontal objectives aids in achieving optimal function and esthetics.2 Extraction of teeth is followed by loss in height and width of the alveolar process, resulting in a narrowing and shortening of the residual ridge.3 Previously, the consequential ridge deformities would not allow for favorable placement of endosseous implants, which could lead to biomechanical and esthetic problems.4

Reconstruction of alveolar bone can be achieved through many regenerative surgical procedures including guided bone regeneration (GBR), onlay grafting (OG), and combinations of onlay, veneer, and interpositional inlay grafting (COG), distraction osteogenesis (DO), ridge splitting (RS), as well as a multidisciplinary approach utilizing forced eruption.5,6 The implant survival rate is reported as 95.5% for GBR, 90.4% for OG, 94.7% for DO, and 83.8% for COG.6,7 There are alternatives to these “gold standard” surgical procedures that are as effective in promoting new bone formation, are localized to the site, time efficient, cost effective, and have less morbidity.8 The techniques are based on the principle of GBR utilizing barrier membranes, to achieve a predictable success rate. This article illustrates an alternative technique, tenting screw technology (TST), to facilitate GBR in atrophic extraction sockets and alveolar ridges.

METHOD AND MATERIALS

TST allows efficient space maintenance. During the healing period the system maintains the volume and the geometry of the
space. This allows for the stabilization of the blood clot and undisturbed healing. Titanium tenting screws are available in 6, 8, 10, and 12 mm lengths and in 1.4 to 2.0 mm diameter widths. Funato et al described a Class IV defect as an extraction socket with a buccal/lingual wall severely compromised, where implant placement in the remaining palatal wall results in nonfavorable three-dimensional implant positioning. Bone and soft tissue reconstruction, with delayed implant placement, should be performed when treating Class IV defects. The tenting screw osteotomy is prepared prior to screw placement with a mini drill. By appropriately placing titanium tenting screws surrounded by allografts and covered by barrier membranes, it is possible to augment large ridge defects without harvesting autogenous bone. The result can be the restoration of vertical height to the surrounding proximal osseous levels. Insufficient interproximal bone height may jeopardize the vertical increase in the bone volume. In such cases, orthodontic eruption could be advantageous. For ridge reconstruction, the tenting screw is engaged into the buccal cortical plate pointing coronally, and into the palatal/lingual cortex if further stability is necessary. If additional palatal/lingual augmentation is required, the tenting screw can protrude through the palatal/lingual cortex to tent up this portion of the graft and membrane. If bicortical stabilization is used, the tenting screw tip is smoothed to avoid any soft tissue penetration. The primary goal is the engagement of the cortical plate(s), to ensure initial stability of the tenting screws.

For extraction sites, the screw should engage the apical bone and angle coronally towards the deficient cortical plate. The height of the screw should be positioned at the level of the proximal bone. If both the buccal and the palatal/lingual bone are missing, two tenting screws can engage the apical bone and create scaffolding for buccal-palatal and apicocoronal three-dimensional bone regeneration.

When engaging the apical bone in severely resorbed posterior maxillary extraction sockets, avoiding sinus membrane perforation is crucial. Cone beam computed tomography (CBCT) can confirm the presence of at least 3 mm of vertical bone height to allow for tenting screw primary stability and minimize the risk of sinus perforation. If the residual bone height allows for an internal sinus lift and immediate implant placement with primary stability and intact buccal bone, the use of a tenting screw is not indicated. In the posterior mandible, the inferior alveolar and mental nerves should be considered when placing screws.

TST includes decortication of the bone to allow for cell proliferation and angiogen-

![Fig 1 Schematic for space maintenance in tenting screw technology.](image)
The addition of growth factors may increase maturation. Addition of the bone allograft and placement of the barrier membrane maximize the space-maintenance effect. The necessity for tacking down the membrane is based on the clinician’s judgment. Passive positioning of the flap and tension-free primary wound closure complete the procedure (Fig 1).

The tenting effect facilitates successful bone augmentation with high predictability, low risk of complications, and reduced healing period. This technique involves expanding the soft tissue volume using screws as “tents” for the surrounding graft. This helps prevent the soft tissues from contracting around the graft material and subsequently displacing it or causing physiologic resorption. In addition to restoring the hard tissue defect, the bone grafting material helps to restore the soft tissue architecture that is lost during ridge alterations, since soft tissue contour typically follows underlying bony architecture.

The cases presented had inadequate alveolar ridges or extraction sockets with deformities that required augmentation to allow the proper placement of endosseous implants. They illustrate that ridge reconstruction can be achieved with TST and traditional GBR procedures, not only for ridge augmentation, but also for severely deficient extraction sites. The FDI numbering system has been adopted to refer to particular teeth.

**Case 1 (Figs 2 to 6)**

A 50-year-old man presented with a nonsignificant medical history, requiring a fixed partial denture. A complete periodontal-restorative work up was completed. The treatment plan included extractions of teeth 16, 14, 12, 21, 22, and 26 with GBR, due to the extent of the attachment loss (Fig 2). In the maxillary incisor area, a fixed partial denture was planned with implant abutments in the lateral incisor area. The patient was premedicated with 2 g amoxicillin. Upon full thickness flap reflection, extraction of the lateral incisors, and degranulation, the lateral incisor areas presented with severe vertical and horizontal bone loss, precluding immediate implant placement. Tenting screws 1.4 × 12 mm were placed engaging the apical bone, pointing coronally and extending 5 mm into the extraction site. Note that the head of the screw was placed slightly above the residual interproximal bone peak. Mineralized crushed cortical bone (RegenerOss Allograft, Biomet 3i) was placed around the screws and a resorbable collagen membrane (OsseoGuard Flex, Biomet 3i) was then placed over the area (Fig 3). Primary closure with horizontal mattress and single interrupted vicryl 4-0 sutures was achieved for optimal healing. The patient was prescribed amoxicillin 500 mg every 8 hours for 7 days, chlorhexidine gluconate rinse twice a day.
and nonsteroidal anti-inflammatory medication (ibuprofen 600 mg, q 4–6 hours). An Essex retainer was delivered as an esthetic transitional prosthesis during the 3-month healing period.

**Case 2 (Figs 7 to 11)**

A 47-year-old woman with a nonsignificant medical history presented for full mouth rehabilitation. The case was treatment planned to be staged using selected teeth as abutments for a fixed temporary prosthesis. CBCT guided surgery was used for the placement of the implants. Eventually all maxillary teeth were extracted due to severe periodontitis. Tooth 14 was selected for extraction and GBR with TST as part of the maxillary grafting procedures (Fig 7).

The site showed complete loss of the facial wall and moderate resorption of the palatal wall due to severe periodontitis. The interproximal bone was well preserved (Fig 8). Tenting screws 1.4 × 10 mm and 1.4 × 12 mm were placed in prepared osteotomies, interposed by mineralized crushed cortical bone (RegenerOss Allograft) (Fig 9) and covered by a resorbable collagen membrane (OsseoGuard Flex). Periosteal releasing incisions were followed by horizontal mattress and single interrupted vicryl 4-0 sutures, stabilizing the flap and achieving primary closure. The patient was prescribed amoxicillin 500 mg every 8 hours for 7 days, chlorhexidine gluconate rinse twice a day for 2 weeks, and nonsteroidal anti-inflammatory medication (ibuprofen

**Fig 4** Three months post-augmentation. Newly formed bone to the level of the head of the tenting screws at the maxillary lateral incisor areas.

**Figs 5a and b** Significant bone formation at reentry in 3 months. Newly formed bone to the level of the head of the tenting screws utilized at the maxillary lateral incisor areas.

**Figs 6a and b** Optimal implant positioning at tooth 12 and 22 areas.
600 mg, q 4–6 hours) for 7 days postoperatively. The patient had been given 2 g amoxicillin premedication. Reconstructing the dentition through a staged approach allowed a provisional prosthesis to be tooth-supported during implant integration for 3 months, and later conversion to an implant-supported prosthesis.

**Case 3 (Figs 12 to 15)**

A 54-year-old healthy woman presented complaining of difficulty eating when wearing her maxillary removable prosthesis.

Teeth 13, 23, 25, and 26 were abutments for the existing removable partial denture and were deemed to have a questionable prognosis due to severe periodontitis. The treatment plan included a 12-unit full maxillary implant fixed restoration from tooth 16 to 26 with implant abutments in areas 16, 15, 13, 11, 21, 23, 25, and 26. Due to the existing severe labial concavity and compromised buccal-lingual ridge width (2 mm), proper placement of the implants required augmentation of the existing deficient alveolar ridge in area 12 to 22.
The augmentation procedure was performed with 1.4 × 10 mm and 1.4 × 12 mm tenting screws that extended 5 mm buccally from the cortical plate on the labial aspect and passed through the thin alveolus to slightly penetrate the palatal cortex and provide 5 to 6 mm of space maintenance (Fig 13). A 3 cm³ allograft composed of demineralized freeze dried bone (Regenaform, Exactech) was covered with a collagen membrane (Bio-Gide, Geistlich) (Fig 14). The membrane was stabilized with three titanium tacks 3 mm in length (Titanium Bone Tacks, Salvin), two buccally and one palatally. Periosteal releasing incisions allowing passive flap adaptation were additionally performed. Horizontal mattress vicryl 4-0 sutures were used for the horizontal incision, and single interrupted chromic gut 3-0 sutures were placed for the vertical releasing incisions. Preoperative medications prescribed 1 hour before the appointment included 2 g amoxicillin and 2 tablets of methylprednisolone (Medrol) 4 mg as directed on the pack. Postoperative medications included amoxicillin 500 mg every 8 hours for 7 days, chlorhexidine gluconate rinse twice a day for 2 weeks, co-codamol (Tylenol 3: 300 mg paracetamol/30 mg codeine) every 4 hours as needed for 7 days, and 19 tablets methylprednisolone (Medrol) 4 mg as directed on the pack. The patient was treatment planned to receive a transitional removable partial denture, with no labial flange and total acrylic relief in the maxillary anterior area, for the 6-month healing period.
RESULTS

Case 1
On re-entry, bone formation to the level of the screw head was evident (Figs 4 and 5). The result allowed prosthetic-dictated implant placement, which was the goal of the procedure (Fig 6).

Case 2
At 3 months, tenting screw removal and implant placement were performed. Ideal dimensional alveolar socket reconstruction was demonstrated by CBCT evaluation of the maxillary right first premolar area (Fig 10). The cross-sectional view revealed three-dimensional bone formation around the tenting screws, to the level of the screw head and slightly above, with adequate width and height of bone housing for the implant placement in a prosthetic-directed position (Fig 11).

Case 3
After 6 months of uneventful healing, the site was reentered and significant increase in bone volume in a buccal-palatal dimension was present (Fig 15). The membrane tacks and tenting screws were removed and the three-dimensional alveolar reconstruction showed an increase of 5 mm of bone width slightly above the level of the tenting screw heads. CBCT demonstrated the previously severe buccal concavities were filled with bone and the thin alveolar ridge was now 7 to 8 mm wide.

The soft tissue maintenance concept for the cases presented was confirmed by clinical bone sounding at the time of flap reflection and uncovering of the tenting screws. It was revealed that the bone graft material maintained at the approximate level of the screw heads and the soft tissue contour followed the underlying bony architecture.

DISCUSSION

GBR takes advantage of the physiologic fact that cells from native bone will grow into a maintained space and form new bone. GBR has altered implant dentistry and can be used when implants are placed in a delayed approach in implant patients with insufficient bone volume. Lack of primary stability and severe bone resorption involves risks if simultaneous implant placement is attempted. In these cases, a delayed approach is preferable due to the extent of the defect and esthetic concerns. The goal was localized ridge augmentation with new bone formation for future implant prosthetic-directed implant placement.

Successful bone regeneration may be compromised by failure of the vascular supply, mechanical instability of the tenting screws, competing tissues of high proliferative activity, and contamination of the graft material through tissue dehiscence.

The main parameter for successful GBR is space maintenance over the residual bone. Since most membranes are not rigid enough to resist collapse, support must be provided under the barrier membrane. The use of an appropriate supporting device is required in cases where the buccal wall is compromised. Starting in the 1990s, numerous reports were published describing the supracrestal placement of implants, tenting pins or screws extending several millimeters above and beyond the crest, a combination of pins and implants, and cortical columns, to support membranes and achieve successful ridge augmentation. There are no previous data on augmenting severely resorbed extraction sockets utilizing TST.

Bone grafts of various types have been used to aid in space maintenance. The 1996 study by Schwarz et al showed that demineralized freeze dried bone has the potential to promote regeneration. In TST, the ideal graft material allows for capillary penetration and vital bone formation.

Both nonresorbable and resorbable membranes have been used successfully to protect the blood clot and prevent gingival connective tissue in-growth and to maintain space into which osteogenic cells can migrate. In cases when membranes were prematurely exposed, results were compromised most likely because of bacterial contamination.

TST has been successful in gaining 3.5 to 7 mm of bone height. The proximal bone height on the adjacent teeth determines the vertical bone increase after the augmenta-
tion.26 The amount of regeneration depends on the distance from the tenting screw head to the residual bone. Additional advantages of tenting screw space maintenance technology include time and ease of screw placement, minimal morbidity, one surgical site, and space maintenance for the GBR materials. This results in increased bone formation, as compared to traditional GBR procedures without TST.27

Alternative GBR procedures include autogenous block grafts, alloplastic bone blocks, and particulate graft materials used in conjunction with nonresorbable or titanium-reinforced membranes. Future clinical and histologic comparative studies are needed to better understand the use of tenting screws in combination with growth factors and different materials.

Limitations of TST and GBR are associated primarily with soft tissue concerns. Gingiva with a thin biotype, under tension to obtain primary closure, has the potential for tenting screw exposure and graft contamination during the healing period. Soft tissue augmentation, to increase the amount and thickness of keratinized tissue, will minimize the risk of exposure of the screw heads. Finally, proper radiographic examination can help to avoid damaging vital structures.

**CONCLUSION**

Clinical results from this study suggest that TST for implant site development can successfully augment severely deficient ridges and extraction sites. It can result in successfully increasing alveolar dimension and has the advantages of restricting the surgery to one site and less morbidity. It is recommended that tenting screws be considered as part of the clinician’s armamentarium for extractions and ridge augmentations when optimum three-dimensional bone reconstruction is desired.

**REFERENCES**


