Vertical and Horizontal Augmentation Using Guided Bone Regeneration

Ph.D. Thesis

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1. Introduction

Bone augmentation procedures are often necessary for the successful placement of endosseous dental implants. Several treatment modalities have been developed for bone growth, including distraction osteogenesis, onlay bone grafting, and guided bone regeneration (GBR). Guided bone regeneration may be used for either vertical augmentation or horizontal augmentation, and clinical studies will be presented that demonstrate the clinical significance of these types of procedures.

2. AIM OF THE STUDIES

Three studies will be presented: a retrospective study that utilized vertical augmentation; a horizontal augmentation study that utilized a new synthetic membrane (this study is referred to as "HA/1"); and a horizontal augmentation study that utilized a native, bilayer collagen membrane (this study is referred to as "HA/2").

2.1 Study on Vertical Augmentation

The aims of this retrospective study were to: (1) evaluate results of vertical GBR with particulated, autogenous bone grafts; (2) determine clinical and radiographic success and survival rates of implants placed in surgical sites after prosthetic loading; and (3) compare success and survival rates of implants placed in defects
treated simultaneously with sinus augmentation and vertical GBR to other areas treated with vertical GBR only.

2.2 Horizontal Augmentation Utilizing a New Synthetic Membrane (HA/1).

The purpose of this clinical series was to evaluate clinically and histologically the possibility of using a new synthetic resorbable membrane in combination with a mixture of anorganic bovine bone mineral (ABBM) and autogenous particulated bone in horizontal augmentation of knife-edge ridges.

2.3 Horizontal Augmentation Utilizing a Native, Bilayer Collagen Membrane (HA/2)

The use of a more rapidly resorbing native collagen membrane and 1:1 mixture of autogenous particulated bone/ABBM as grafting material for horizontal augmentation has not yet been investigated. Accordingly, the purpose of this clinical series was to evaluate clinically and histologically the use of a more rapidly resorbing native collagen membrane in combination with a mixture of ABBM and autogenous particulated bone in horizontal augmentation of knife-edge ridges to confirm the acceptability of the osteoconductive material in the procedure and to limit the amount of harvested autogenous bone required for the procedure.

3. MATERIALS AND METHODS

3.1 Vertical Augmentation

This retrospective study reported on patients who were consecutively treated with vertical augmentation using GBR and particulated autografts from June 1999 to Oct 2004.

Inclusion criteria: Cases were selected that required vertical bone regeneration (1) to achieve the necessary bone levels in order to place dental implants, and (2) to improve the crown/implant ratio and esthetics. Patients were required to have good oral hygiene prior to treatment.

Exclusion criteria: Patients were excluded if they were current smokers; engaged in excessive alcohol consumption; or had uncontrolled systemic conditions or uncontrolled periodontal disease.

Clinical Procedures: Briefly, all patients were treated with vertical ridge augmentation utilizing titanium reinforced, non-resorbable, expanded polytetrafluoroethylene (e-PTFE) membranes (GORE-TEX® Regenerative Membrane Titanium Reinforced or GTRM-TR, W.L. Gore & Associates, Flagstaff, AZ, USA) and particulated autografts.
The surgical site was allowed to heal for 6 to 9 months. Then, the GTRM-TR membranes were removed, and implants were placed or uncovered.

The objective was to place the implant platform to crestal bone level, leave in submerged healing for 6 months, then uncover the implants.

Clinical examination: Peri-implant mucosal conditions were assessed for redness, hyperplasia, suppuration, swelling, and presence of plaque. Probing depths were recorded

according to established methods (Buser et al 1990, 2002; Van Steenberghe et al 1990).

Radiographic examination: Periapical radiographs were taken at the abutment connection and then every 12 months thereafter with a long cone parallelling technique. Crestal bone levels were measured up to 0.01 mm using NIH image software, with the implant abutment junction as the baseline reference (Wyatt et al 2001).

Complications: Complications in bone graft healing, such as membrane exposure and/or subsequent infection, were recorded.

Implant Success Criteria: Success was evaluated according to established methods that evaluated the following : absence of pain, foreign body sensation, dyesthesia, mobility, or peri-implant radiolucency. Following the first year of function, there could be ≤ 0.2mm crestal bone remodeling annually (Albrektsson et al 1986), and ≤ 2.0 mm total crestal bone remodeling by the end of the fifth year was considered acceptable (Wennstrom & Palmer 1999).

3.2 Horizontal Augmentation Utilizing a New Synthetic Membrane (HA/1).

This case series reported on patients who were consecutively treated in the posterior mandible or maxilla with horizontal augmentation using GBR and particulated autografts from January 2003 through May 2006. All patients required augmentation of a "knife-edge" ridge for subsequent implant placement, including some patients (17 out of 22 maxillary cases) who also required a sinus floor elevation.

All patients were treated with horizontal ridge augmentation using a recently developed synthetic barrier membrane composed of a microporous structure of synthetic bioabsorbable glycolide and trimethylene carbonate copolymer fiber (GORE RESOLUT® ADAPT® LT Regenerative Membrane, W.L. Gore & Associates, Inc., Flagstaff, AZ). Either autogenous bone or a combination of autogenous bone and anorganic bovine bone-derived mineral (ABBM, Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland). The first 7 patients were treated with autogenous bone alone to confirm the technique and use of the new membrane. Subsequent patients were treated with a combination of autogenous bone and ABBM to confirm the acceptability of a new osteoconductive material in the procedure and to limit the amount of harvested autogenous bone required for the procedure.

Measurements of the alveolar ridge width were taken intra-surgically, at the original surgery and then after the healing phase before preparation of the implant bed. The same calliper was used to take all measurements 2 mm apically from the top of the crest.

Complications in bone graft healing, such as membrane exposure, subsequent infection, and/or morbidity associated with the harvest site, were recorded,

Periapical radiographs were taken at the abutment connection and then every 12 months thereafter with a long cone parallelling technique.

Functionally loaded implants were monitored to evaluate the following: Absence of pain, foreign body sensation, dyesthesia; Radiological contact between the host bone and the implant surface.

3.2 Horizontal Augmentation Utilizing a Native, Bilayer Collagen Membrane (HA/2).

This case series reports on patients who were consecutively treated in the posterior mandible or maxilla with horizontal augmentation using GBR and particulated autografts from March 2007 through February 2010. All patients required augmentation of a "knife-edge" ridge for subsequent implant placement (Cawood-Howell class IV), including some patients who also required a sinus floor elevation.

All patients were treated with horizontal ridge augmentation using a bilayer resorbable membrane derived from native collagen (Bio-Gide® Resorbable Bilayer Membrane, Geistlich Pharma AG, Wolhusen, Switzerland) and a combination of autogenous bone and anorganic bovine bone-derived mineral (ABBM, Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland).

Measurements of the alveolar ridge width were taken intra-surgically, at the original surgery and then after the healing phase before preparation of the implant bed. The same calliper was used to take all measurements 2 mm apically from the top of the crest. Periapical radiographs were taken at the abutment connection and then every 12 months thereafter with a long cone parallelling technique.

Complications in bone graft healing, such as membrane exposure, subsequent infection, and/or morbidity associated with the harvest site, were recorded. Functionally loaded implants were monitored to evaluate the following: Absence of pain, foreign body

sensation, dyesthesia; Radiological contact between the host bone and the implant surface.

4. RESULTS

4.1 Vertical Augmentation

This retrospective study sought to encompass the scope of clinical practice where vertical bone augmentation is required for the purpose of implant placement: 82 implants were placed in 35 patients with 36 three-dimensional ridge defects ranging from 2 mm to 12 mm. Thirty-three patients (94.3%) were partially edentulous, and 2 (5.7%) were completely edentulous. Fourteen (40%) patients were men and 21 (60%) were women, and the mean age was 44.9 years (range, 19 to 72 years). A staged approach that allowed the graft to heal uneventfully before implant placement was used in most cases. All patients presented with vertical bone defects and were divided into 3 treatment groups: Group A (12 patients) had single missing teeth, group B (16 patients) had multiple missing teeth, and group C (7 patients/8 defects) had vertical defects in the posterior maxilla only and were treated simultaneously with sinus and vertical augmentation.

Bone regeneration was evaluated clinically at the time of membrane removal. In general, all treated defect sites exhibited excellent bone formation, with an overall average of 5.5 mm (SD 2.29) of vertical augmentation. None of the patients showed less bone regeneration than the space created by the membrane, with one exception. This group B patient developed a fistula on top of the membrane area 2 weeks after bone grafting.

Regardless of which site was used for bone harvesting, there appeared to be no difference in the results in terms of bone quality and quantity at implant placement or during the follow-up period when implants were assessed clinically and radiographically.

At the time of abutment connection, all implants were stable and were fully embedded within bone.

In the 81 consecutively treated implants that were evaluated clinically and radiographically after the abutment connection, the period of functional loading in this study ranged from 1 to 6 years (mean: 40.3 months), and the mean radiographic follow-up was 34.2 months. At the 1-year examination, the mean crestal bone remodeling value for the 81 implants was 1.01mm (SD 0.57), and in most cases, the first bone-implant

contact was located near the first implant thread. There were no statistically significant differences between the 3 groups in mean marginal bone remodeling, and the crestal bone remained stable throughout the follow-up period.The mean probing depth was 3.03 mm (SD 0.61).Only 3 implants in group B showed increased bone remodeling (slightly more than 2 mm), and these were not considered clinically successful.

4.2 Horizontal Augmentation Utilizing a New Synthetic Membrane (HA/1).

Twenty-two (22) patients with 25 surgical sites presented posterior knife-edge ridges with an insufficient width for implant placement (Cawood-Howell class IV). All patients presented with a horizontal ridge of 4 mm or less and needed horizontal ridge augmentation prior to dental implant placement.For the maxillary cases, if an additional sinus proximity was present, a sinus floor augmentation was carried out simultaneously (17 out of 21 maxillary cases).

After horizontal augmentation and a mean graft healing period of 8.12 months ± 2.32 months (range 5.8 – 13.1 months) the mean ridge width was 7.68 mm ± 1.35 mm , giving an increase of 5.56 mm ± 1.45 mm in ridge width.

Intraoperative measurements indicated an average residual bone width of 2.20 mm ± 1.00 mm (range 1–4 mm)

After the graft healing period, a total of 58 implants with an anodized TiUnite® surface (Brånemark System®, Nobel Biocare, Göteberg, Sweden) were placed.

The graft and implant healing periods were uneventful in all cases, and no complications, such as membrane exposure, infections, or harvest site morbidity, were observed.

All 58 implants have survived to date (100.0% at all time points; life table analysis) with an average follow-up of 45.88 months ± 12.43 months.

4.3 Horizontal Augmentation Utilizing a Native, Bilayer Collagen Membrane (HA/2)

Seventy-eight (78) implants were placed in 25 patients with 31 knife-edge ridges (15 females and 10 males with a mean age of 52.7 years.

Intraoperative measurements indicated an average residual bone width of 2.20 mm (SD=0.65 mm; range 1–4 mm). For the maxillary cases, if an additional sinus proximity was present, a sinus floor augmentation was carried out simultaneously (16 out of 18 maxillary cases).

After horizontal augmentation and a mean graft healing period of 8.9 months (SD=2.1 months; range 6.0 – 14.0 months) the mean ridge width was 8.00 mm (SD=1.47 mm), giving an increase of 5.80 mm (SD=1.26 mm) in ridge width. There were no discernible statistical differences in bone width gain between maxillary and mandibular sites (p=0.2405). With one exception, the graft and implant healing periods were uneventful in all cases. One patient developed an abscess at the graft site (3.2%; 95% CI: 0.1%, 16.7%). The surgical site was opened and irrigated, and the patient was given antibiotics. The infection was treated effectively, but a major portion of the bone graft was lost and minimal bone gain of 2 mm was achieved.

All 78 implants have survived to date (100.0% at all time points; life table analysis) with an average follow-up of 20.9 months (SD=9.3 months).

6. CONCLUSIONS

6.1 Vertical Augmentation

The results of this retrospective study suggest that the following conclusions can be made: (1) vertical augmentation with e-PTFE membranes and particulated autografts is safe and predictable, with minimal complications; (2) clinical success and survival of implants placed in vertically augmented bone with the GBR technique appear similar to success and survival of implants placed in native bone under loading conditions, regardless of the harvest site, surgical area, or defect size; and (3) the success and survival rates of implants placed simultaneously with sinus and vertical augmentation techniques compare favorably to those in sites requiring vertical augmentation of single- or multiple-tooth ridge defects.

6.2 Horizontal Augmentation Utilizing a New Synthetic Membrane (HA/1).

In this case series, the treatment of horizontally deficient alveolar ridges with the GBR technique using autogenous bone with or without the addition of ABBM and a resorbable barrier membrane can be regarded as successful and may lead to implant survival. The regenerated bone can lead to good osseointegration of the dental implant. Histological evaluation of the regenerated bone has shown that the autogenous bone is mostly resorbed and replaced by vital bone and the bone substitute particles are connected by new vital bone.

6.3 Horizontal Augmentation Utilizing a Native, Bilayer Collagen Membrane (HA/2)

In this case series, the treatment of horizontally deficient alveolar ridges with the GBR technique using autogenous bone mixed with ABBM and a native collagen resorbable barrier membrane can be regarded as successful and may lead to implant survival. Within the timeframe of the study the regenerated bone leads to good osseointegration of the dental implant. Histologic evaluation showed that ABBM was connected with a dense network of newly formed bone of various degree of maturation.

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Publications related to the thesis

Urban IA, Jovanovic S, Lozada JL. Vertical Ridge Augmentation Using Guided Bone Regeneration (GBR) in Three Clinical Scenarios Prior to Implant Placement: A Retrospective Study of 35 Patients 12 to 72 Months After Loading. Int J Oral Maxillofac Implants 2009a;24:502-510.

UrbanIA, Caplanis N, Lozada JL. Simultaneous Vertical Guided Bone Regeneration (GBR)and Guided Tissue Regeneration (GTR) in the posterior maxilla using recombinant human platelet-derived growth factor (rhPDGF). A case report. J Oral Implantol. 2009b;35:251-256.

Urban IA, Nagursky H, Lozada JL. Horizontal ridge augmentation with a resorbable membrane and particulated autogenous bone with or without anorganic bovine bone-derived mineral: A prospective case series in 22 patients. Int J Oral Maxillofac Implants 2011a;26:404-414.

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. 2011b, submitted for publication.

Urban IA, Lozada JL, Jovanovic SA, Nagy K. Simultaneous Horizontal Guided Bone Regeneration (GBR) in the Posterior Maxilla using Recombinant Human Platelet-derived Growth Factor (rhPDGF-BB). A Case Report . 2011c, submitted for publication.