KEY WORDS
guided bone regeneration; periosteal pocket flap; follow-up

Case series

GUIDED BONE REGENERATION WITHOUT A MEMBRANE USING ANORGANIC BOVINE BONE. A ONE-YEAR FOLLOW-UP RETROSPECTIVE CASE SERIES

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PURPOSE. To evaluate the outcome of horizontal bone augmentation using a periosteal pocket flap after implant placement but no membrane.

MATERIALS AND METHODS. This retrospective case series included eight patients who received 10 implants in total. Guided bone regeneration using anorganic bovine bone and a periosteal pocket flap was performed in areas where the alveolar ridge morphology did not allow for proper implant placement. The buccal periosteum was tightly secured to the underlying bone graft instead of using a membrane. The buccal plate width was measured by two independent periodontists on limited view CBCTs immediately post-operatively, before abutment connection, and 1 year after crown fitting.

RESULTS. No drop-out occurred. All implant sites healed uneventfully and were successfully restored. No complications or failures were observed during the 1-year observation period. The mean preoperative buccolingual bone thickness was 3.5 mm, while the mean bone thickness from the implant shoulder to the buccal plate was 3.7 mm immediately post-operatively, 3.2 mm prior to abutment connection, and 3.1 mm after successful implant restoration; the reduction in bone thickness between immediate post-operative and 1-year time-points was statistically significant at 0.6 mm (P = 0.039). No buccal bone wall deficiency was radiographically detected around any of the 10 implants.

CONCLUSIONS. This retrospective case series demonstrates that it is possible to augment bone horizontally with a granular bone substitute without using a membrane, and that about 22% of the augmented bone is resorbed over the first year.

CONFLICT OF INTERESTS STATEMENT. The authors have no conflict of interest related to this article to report.

INTRODUCTION

Following tooth extraction, morphological changes affect the alveolar bone, leading to decreased alveolar ridge width and height[1-3]. An average of 1.5 mm crestal bone height and 3.9 mm of buccolingual width can be lost following extractions of anterior teeth or premolars[4]. According to a meta-analysis, these changes could be minimized by applying various socket preservation techniques, gaining up to 1.4 mm in buccolingual and 1.1 mm in apicocoronal directions as compared to non-grafted sockets[5]. According to several reviews, the need for further augmentation decreases when socket grafting is applied with respect to unassisted extraction. The need for additional augmentation during implant placement reportedly ranges from 0 to 15% in grafted socket sites and from 0 to 100% in non-grafted sites[6,7].

Doi: 10.36130/CTD.01.2021.05

As it seems that some degree of hard and soft tissue loss is unavoidable[7], several authors have advocated for guided bone regeneration (GBR) as a means of re-establishing hard tissue lost following tooth extraction[8-15]. GBR is a technique-sensitive procedure aimed at restoring the lost alveolar bone architecture, usually via application of a filler material underneath a barrier membrane. The role of the membrane is to stabilize the bone graft and prevent epithelial downgrowth from the wound margins by excluding the oral environment. Early membrane exposure results in decreased bone formation with both resorbable and non-resorbable membranes with respect to uneventful healing. Early membrane exposure rates range from 10 to 62.5%, according to different authors[11-13].

The outcome of the graft is dependent upon the graft material properties, the skill of the operator, and patient-related variables. Recently, Buser et al. reported 4- to 9-year outcomes of delayed implant placement with simultaneous contour grafting using locally harvested autogenous bone chips mixed with deproteinized bovine bone (Bio-Oss Geistlich, Wolhusen, Switzerland) covered by a non-crosslinked collagen membrane (Bio-Guide Geistlich). It was reported that 95% of the individuals presented with a CBCT-detectable buccal plate, but no information was provided about post-operative complications[14]. However, a previously published case series called into question the necessity of a barrier membrane, and introduced the use of a periosteal pocket flap design without the aid of a barrier membrane to protect the graft material during implant placement and horizontal ridge augmentation[10]. The authors reported that proper flap management allowed for tension-free closure and no post-operative complications. They claimed that avoiding the use of a barrier membrane may reduce barrier exposure in GBR procedures, but this conclusion was based on data from just five patients. As regeneration of lost alveolar bone using the periosteal pocket flap could reduce graft exposure rates, allow for tension-free closure, and reduce costs associated with the use of barriers, the aim of this paper is to report the short-term outcomes of the periosteal pocket technique in another series of patients receiving implants and simultaneous horizontal ridge augmentation without a barrier membrane.

MATERIALS AND METHODS

Study design

This retrospective case series comprised eight patients who received at least one implant each. All enrolled patients were in good health, non-smokers and not taking any medication for chronic diseases. Patients were treated at least 4 months after tooth extraction. All patients received a total of four limited-view CBCTs: i) preoperative CBCT to determine the feasibility of implant placement and map local anatomy; ii) CBCT taken immediately after implant and graft placement; iii) CBCT taken 6 months after implant placement (second stage); and iv) the final CBCT taken after fitting of the final restoration at the 1-year post-augmentation follow-up. All clinical procedures were performed in a private practice setting in Kaunas, Lithuania. This case series report adheres to the STROBE guidelines[16].

Outcome measures

The outcome measures were recorded as follows:

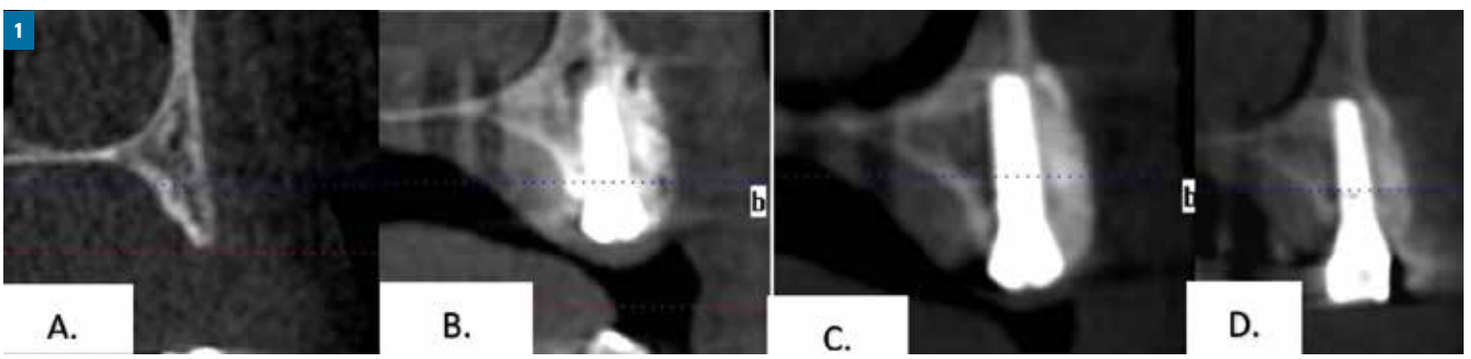
- Implant failure, recorded as yes/no;
- Postoperative complications, as reported by the patient and/or surgeon;
- Buccal bone thickness, calculated on limited-view CBCTs taken at three different time points, namely immediately after implant and graft placement, 6 months after implant placement, and 1 year post-augmentation.

All measurements were performed independently by two skilled periodontists (TS & AS) from the implant shoulder to the external buccal plate, as shown in **FIGS. 1A-D**. Each measurement was performed three times by each examiner, and the average of these measurements was then calculated and presented in **TABLE 1**.

Surgical procedure

All patients were premedicated with 1 g amoxicillin at least 1 hour before implant placement. As per the protocol described by Steigmann et al.[10], a full-thickness incision was made at a 45-degree angle paracrestal to the buccal wall. A full thickness mucoperiosteal flap was raised, and then five patients received five Straumann (Basel, Switzerland) Bone Level implants while three patients received five Straumann Tissue Level Roxolid implants. Implant position was determined by aesthetic and functional considerations, according to a pre-operative wax-up of the missing tooth. After implant placement and subsequent cover-screw placement, the periosteum was split from the buccal flap, roughly 10 mm apically from its edge, to allow for coronal advancement of the buccal flap while still maintaining the rigidity of the underlying periosteum to be used as a barrier membrane. The periosteum that was still attached to the underlying bone was then carefully elevated with a periosteal elevator to create a periosteal pocket. Deproteinized bovine bone (Bio-Oss) was positioned underneath the raised periosteum, and a single suture was placed to stabilize the periosteal barrier to the lingual flap. Later the flap was sutured with 4-0 coated Vicryl sutures, as illustrated in **FIGS. 2-3**. Patients were prescribed 500 mg amoxicillin three times per day for 7 days. Nimesulide 100 mg two times per day was prescribed for pain medication as needed. A limited-view CBCT was taken at this point. Patients returned for one- and two-week post-operative follow-up appointments. All implants were allowed to heal for 6 months before a second limited-view CBCT was taken prior to second-stage surgery. One month after the second-stage surgery, patients were referred to the restorative dentist for crown manufacture. A final limited-view CBCT was performed six months after the final restoration was fitted. The limited view CBCTs taken for 9 of the 10 implants are presented in **FIGS. 4A-D**. All patients were placed on a strict three-month maintenance recall programme.

Descriptive data analyses were conducted to provide mean and standard deviations (SD) of the buccal plate width across the different time intervals. In addition, repeated measures ANOVA and pairwise comparisons using Bonferroni adjustments were performed in order to



FIGS. 1A-D: *An example of the measurements taken from the limited-view CBCT at the four different time points: pre-op (A); immediate post-op (B); prior to second-stage surgery (C); and 12 months after implant placement (D)*

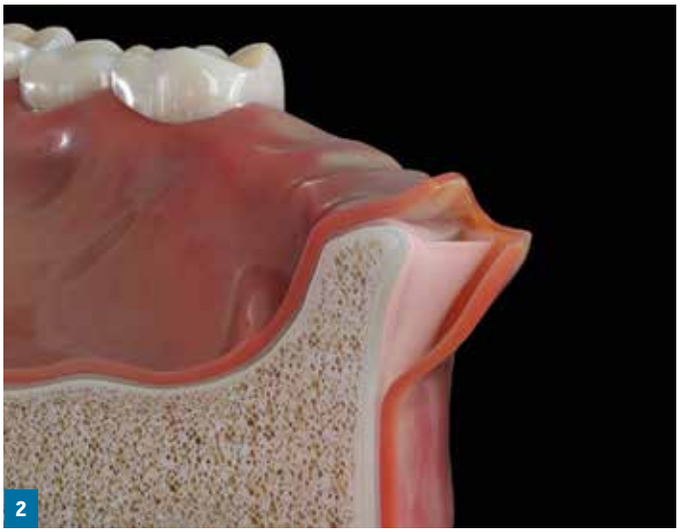
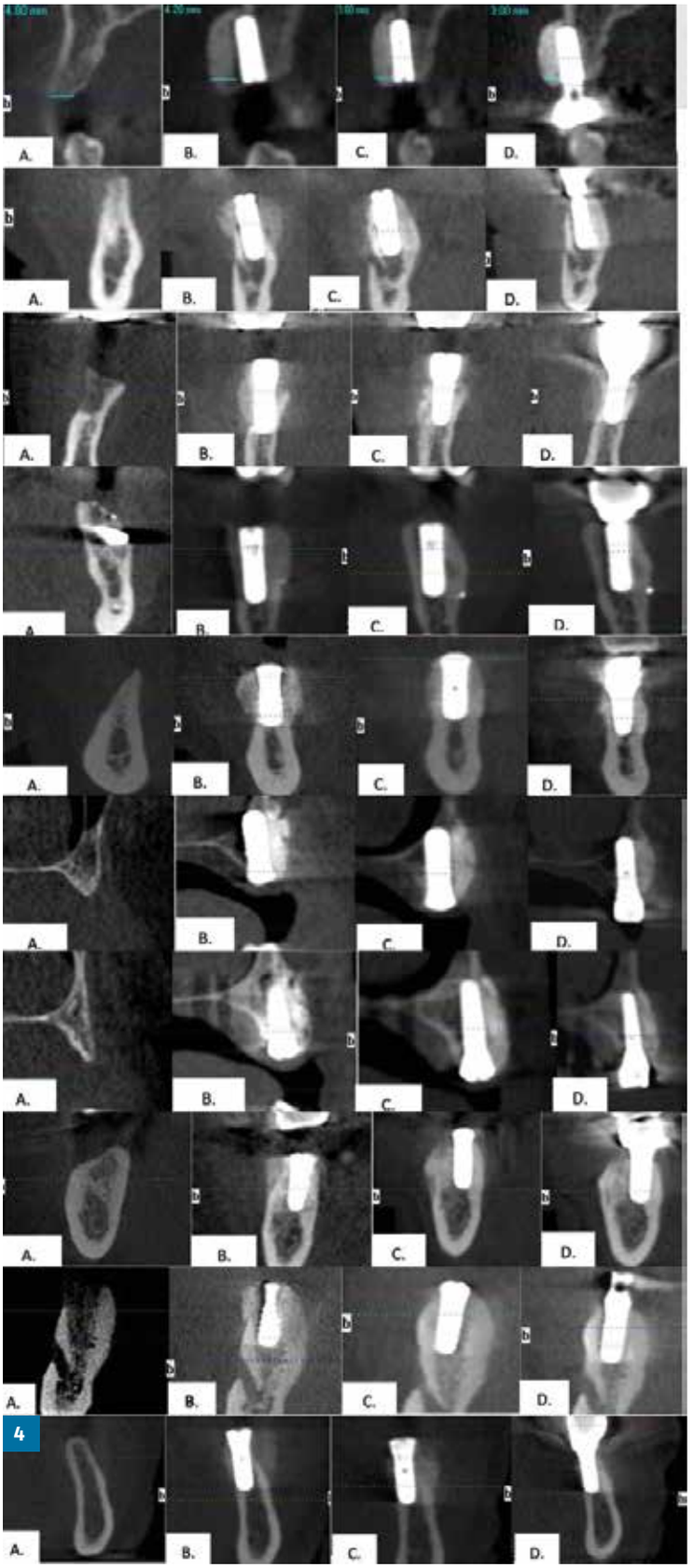


FIG. 2: *Full-thickness flap at a 45-degree angle paracrestal to the buccal wall, and separation of the periosteum from the buccal flap up to roughly 10 mm apically*

FIG. 3: *Implant and graft placement*



FIGS. 4A-D: *Limited-view CBCT scans of nine out of 10 implants placed, at the four different time points: pre-op (A); immediate post-op (B); prior to second-stage surgery (C) and 12 months after implant placement (D)*

estimate differences in the buccal plate width between the three post-surgical time-points, namely immediately post-operatively, after 6 months, and again after 12 months. Patient #5 received three different implants in different locations, but only one implant (#23) was randomly selected for measurements and included in the repeated measures ANOVA and pairwise comparisons. Data was analysed using IBM SPSS version 26 (Armonk, NY, USA).

RESULTS

The study group comprised eight enrolled patients, specifically two males and six females with a median age of 51 years (range from 35 to 67 years old). All patients were followed up to a period of one year after the augmentation procedure. All patients were systemically healthy. No adverse reactions were reported by any of the patients or recorded by the surgeon. Primary closure of the flaps was maintained in all cases. Table 1 presents the implant placement sites for the enrolled patients. One canine site, four premolar sites, and five molar sites received a single implant with bone graft using the periosteal pocket flap technique. As mentioned, one patient received three implants, but all the other patients received single implants. There were no dropouts or implant failures during the observation period, and no biological or prosthetic complications occurred in any of the patients.

TABLE 1 presents the means (±SD) of the measurements made on the limited-view CBCTs taken at the four different time points, specifically the pre-operative scan to ensure the feasibility of implant placement, the immediate post-op scan for ridge width, the 6-month post-op scan, and the 1-year follow-up scan. Repeated-measures ANOVA revealed that the mean buccal plate width measurements differed significantly across the three post-op time-points ($F(2, 14) = 7.102$, $P = 0.011$). Post-hoc pairwise comparisons revealed a statistically significant bone thickness reduction of 0.6 mm ($P = 0.039$) between immediate post-op and 1-year time-points (**TABLE 2**).

TABLE 1 RIDGE WIDTH MEASUREMENTS TAKEN ON LIMITED VIEW CBCTS OF THE DIFFERENT IMPLANT SITES AT THE FOUR DIFFERENT TIME-POINTS AND THE GLOBAL AVERAGE (MEAN IN MILLIMETRES/SD)

Implant site	Pre-op ridge width (B-L)	Immediate post-op scan (IS-B)	6 months post-op scan (IS-B)	1-year follow-up scan (IS-B)	Bone loss % (immediate post-op to 1-year)
Patient #1, tooth #14	4.8 mm	4.2 mm	3.6mm	3.0mm	28.57%
Patient #2, tooth #45	3.0 mm	2.8 mm	2.4mm	2.4mm	14.29%
Patient #3, tooth #46	2.8 mm	3.6 mm	3.6 mm	1.2 mm	66.67%
Patient #4, tooth #36	3.1 mm	3.6 mm	3.3 mm	3.3 mm	8.33%
Patient #5, tooth #45	2.8 mm	2.7 mm	2.7 mm	2.7 mm	-
Patient #5, tooth #26	2.6 mm	3.0 mm	3.0 mm	3.0 mm	-
Patient #5, tooth #23	3.2 mm	3.9 mm	3.3 mm	2.7 mm	30.77%
Patient #6, tooth #47	4.2 mm	3.9 mm	3.6 mm	3.6 mm	7.69%
Patient #7, tooth #45	4.5 mm	4.2 mm	2.1 mm	1.8 mm	57.14%
Patient #8, tooth #36	3.8 mm	5.1 mm	4.8 mm	4.8 mm	5.88%
Global Average	3.48 mm (±0.78)	3.70 mm (±0.73)	3.24 mm (±0.75)	2.85 mm (±0.98)	21.93% (±23.63)

B = Buccal plate; L = Lingual plate; IS = Implant shoulder

TABLE 2 PAIRWISE COMPARISONS OF THE DIFFERENCES IN BUCCAL PLATE WIDTH ACROSS THE DIFFERENT TIME POINTS. EIGHT IMPLANTS WERE INCLUDED (IMPLANTS #26, #45 IN PATIENT #5 WERE EXCLUDED)

	Mean buccal plate width in mm (±SD)	Mean difference (±SD)	95% confidence interval for difference	
			Lower border	Upper border
Immediately post-op	3.91 (±0.23)	0–6 months: 0.57 (±0.23) 0–12 months: 1.06 (±0.32)*	-0.14 0.056	1.29 2.07
Six months post-op	3.33 (±0.29)	6–12 months: 0.49 (±0.29)	-0.416	1.39
Twelve months post-op	2.85 (±0.39)			

P <0.05

DISCUSSION

The importance of the buccal plate width and thickness surrounding dental implants has been studied extensively. There are multiple reports suggesting that the minimal buccal plate width necessary for successful long-term aesthetic outcome around dental implants to be 1 to 2 mm[17-21]. Both the role of a barrier membranes for guided bone regeneration and the use of different bone substitute xenografts have also been studied extensively and are well reported in the literature[22]. The use of different barrier membranes for GBR can be technique-sensitive and may cause undesired complications and adverse reactions, with potential membrane exposures having a significant negative influence on the outcomes of the GBR.

Utilizing the underlying periosteum instead of a barrier membrane might reduce the risk of the post-operative and intra-operative complications that may negatively affect the mineralization of the underlying bone graft[10-13,23,24] and eliminate the additional expense of the membrane. Utilization of the periosteum as barrier against epithelial proliferation has been reported in the past, but it is still not routinely used and is lacking long-term follow up[10,25].

The periosteum has two layers, an outer fibrous layer and an inner cellular layer. The outer layer further divides into a superficial layer with a predominantly collagen matrix and few elastic fibres, while the internal portion of the outer layer contains elastic fibres. The outer layer is highly collagenous but has little vascularization and few cells. The inner layer is highly cellular and contains different cells, including osteoblasts, fibroblasts and mesenchymal progenitor cells[25]. These cells may help and secrete extracellular matrix, which offers a rich source of cells for bone tissue engineering. The above-mentioned characteristics suggest that the periosteum may present as an interesting alternative to traditional barrier membranes.

Indeed, splitting the periosteum allows for buccal flap advancement, which enables tension-free closure. Periosteal-releasing incisions conventionally used in traditional GBR procedures may compromise the blood supply arriving from the apical areas, whereas by splitting the periosteum from the buccal flap coronally, buccal flap advancement is enabled without potentially hindering the blood supply[10].

It is important to emphasize that the anorganic bovine bone used in this study (Bio-Oss) displayed a shrinkage of 22% during the one-year observation period, as opposed to the report by Jensen et al. that showed minimal contour changes when a barrier membrane is used[14,22,26]. However, without proper controls any attempted explanation is purely speculative.

The main limitations to the present case series are the lack of controls and its retrospective design. Hence, properly performed randomised controlled trials with longer observation pe-

riods are absolutely necessary to critically evaluate and compare the results of the periosteal pocket flap to traditional membrane-assisted GBR and to simple flap closure with periosteal-releasing incisions without membranes.

CONCLUSIONS

This retrospective case series demonstrates that it is possible to successfully augment bone horizontally with a granular bone substitute without using a membrane, and that approximately 22% of the augmented bone is resorbed over the first year.

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