One-year Re-entry Results of Guided Bone Regeneration around Immediately Placed Implants with Immediate or Conventional Loading: A Case Series

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Abstract

Objective: The aim of this one-year, re-entry case series was to evaluate clinically the amount of bone regeneration following the placement of immediate implants in fresh extraction sockets where bone allograft has been used to treat horizontal gaps and buccal-bone dehiscence defects in periodontally compromised patients. **Methods:** Sixteen patients consented to participate, each having one immediate implant with $\geqslant$ 3 mm buccal dehiscence bone defects and $\geqslant$ 2 mm horizontal defects between the implant and socket wall. Peri-implant defects were treated using a demineralized freeze-dried bone allograft and a bioresorbable collagen membrane. Measurements of the vertical and horizontal bone defects were performed at 4 sites: buccally, mesially, distally and lingually, and were done at baseline and at 1-year follow-up. **Results:** The mean reduction in vertical defects between baseline and re-entry for all sites was 2.42 mm ($p = 0.0005$). Compared to lingual sites, the buccal sites showed the greatest resolution in vertical defects dimension (6.37 mm), followed by proximal sites (0.78 mm). The overall mean reduction in horizontal defects was 1.59 mm ($p < 0.0001$). Compared to lingual sites, the buccal sites showed the greatest resolution in horizontal gap dimension (3.2 mm), followed by proximal sites (0.8 mm). Age, defect location in the mouth and implant length did not show significant effects on the reduction in defect dimension during the first year. **Conclusions:** A partially missing buccal plate was not a critical factor for implant success and bone regeneration of immediate implants in patients with a history of periodontal disease regardless of the time of implant loading (immediate/conventional). .

Key words: Bone regeneration; bone remodeling; immediate; periodontal disease; wound healing.

Introduction

A common presentation when a dental implant is placed immediately after tooth extraction is the presence of a residual gap between the coronal part of the implant and the socket's bony walls. This gap may compromise osseointegration and esthetics at the implant site. The use of barrier membranes and bone-grafting materials to fill the peri-implant defect around immediate implants has resulted in improved quality and quantity of regenerated bone. (Nemcovsky *et al.,* 2000; Rosenquist and Ahmed, 2000; Shibly *et al.,* 2010; Tehemar *et al.*, 2003). It has been shown that immediate implants have a high survival rate when autogenous bone graft is used to fill the peri-implant defects around these implants. (Schwartz-Arad and Chaushu, 1997; Cochran, 1999). Other authors (Becker *et al.,* 1994; Block and Kent, 1991; Gher *et al.,* 1994) have shown favorable results using demineralized, freeze-dried bone allografts (DFDBA) for the same purpose.

Furthermore, the presence of an intact buccal-

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crestal wall of the alveolar ridge is a major consideration when immediate implants are placed into extraction sites. The contemporary view is that the width of the buccal wall should be at least 2 mm to maintain the alveolar bone level at the implant platform (Qahash *et al.*, 2008). Immediate implant placement in patients with a history of periodontal disease is challenging because of the partial or complete loss of the buccal plate, particularly in the anterior zone.

Recently, Funato *et al.* (2007) proposed a classification system for use when planning treatment for immediate implants and described certain indications and limitations of immediate placement of implants based on the characteristics of the buccal bone and soft tissue profile. According to these recommendations, deficient buccal bone that deviates from the alveolar housing is considered a contraindication to immediate placement of implants. In this case, a delayed implant placement approach was recommended instead. The location where the implant is placed (anterior/posterior), as well as the thickness of the buccal-bone crest and the size of the horizontal buccal gap, significantly influenced the amount of hard tissue alteration that occurred during the period of healing following immediate implant placement into an extraction socket. The thickness of the buccal-bone crest significantly influenced not only the amount of horizontal gap fill, but also the amount of vertical crestal resorption. The implant sites in the anterior segment of the dentition respond differently than posterior sites (horizontal ridge reduction, gap fill and vertical crest resorption) and this may suggest that anterior sites are more susceptible to ridge alterations at implant placement than posterior sites (Ferrus *et al.*, 2010; Shibly *et al.*, 2010).

The purpose of this case series report was to evaluate the amount of bone regeneration of partial or complete buccal-plate defects around implants when they were placed immediately after extraction, and to study the effect of patient characteristics, such as age and gender, and local factors, including the type of site (buccal, lingual, mesial and distal), defect location (maxillary/mandibular, anterior/posterior), implant length and whether loading was immediate or conventional in patients with a history of periodontal disease.

Materials and Methods

Subjects

The study subjects included 16 patients comprising a subset of a larger group of 55 subjects used in a previous clinical trial that was designed to study various outcomes following placement of immediate implants in fresh extraction sites (Shibly *et al.*, 2010). The subjects ranged in age from 25 to 75 years (mean 58.4 y) and included 7 males and 9 females. They were recruited from among patients who had been actively treated for periodontal disease and were on a periodontal maintenance program at the State University of New York at Buffalo. The inclusion criteria were presence of a nonrestorable tooth that was scheduled for extraction and indicated for placement of an immediate dental implant to replace the extracted tooth. Further, the extraction site should have a buccal dehiscence bone defect of at least 3 mm and an open defect (gap) of at least 2 mm adjacent to the implant after implant installation. This paper will report only on subjects who consented to a re-entry protocol one year postoperatively.

The exclusion criteria were bruxism, smoking, and having a compromised general health condition that could negatively affect the healing potential of peri-implant tissue, including uncontrolled diabetes, immunodeficiency, kidney or liver disease, chemotherapy for the treatment of cancer or arthritis, and severely impaired cardiovascular function.

The subjects completed a health history and signed an informed consent form. The study was approved by the university's Institutional Review Board.

Surgical procedure

A sulcular incision was performed around the nonrestorable tooth and care was taken to preserve the attached gingiva and papillae. After elevation of the flap, the tooth was extracted atraumatically. The extraction socket was debrided of any granulation tissue and osteotomy was performed. The dental implant was installed directly into the alveolar bone and placed 3 mm apically to the cemento-enamel junction of the neighboring teeth. The implant had initial stability after insertion as evidenced by a minimum torque of 35 Ncm. The implant placed was a parallel-walled implant with bone and soft tissue stimulating capacity biomaterial on the surface (NobelReplace™ Straight Groovy, with TiUnite® surface, Nobel Biocare, Yorba Linda, CA USA). To ensure adequate nourishment for the graft, bone corticotomy was performed around the implant using a round bur size 2 on high speed. Bone defects adjacent to the implant were filled with sterile, demineralized, freeze-dried bone graft (DFDBA; OraGRAFT, LifeNet Health, Virginia Beach, VA). The defect was covered with a bioresorbable collagen membrane (Resorbable Collagen Membranes, Tissue Specialists, Little Rock, AR).

Six subjects enrolled in this follow-up report were in the immediate loading group and an abutment was screwed into the implant for these subjects. A temporary resin crown was fabricated and temporarily cemented onto the abutment; the gingival flap was adapted around the crown and sutured in place. The other 10 subjects were in the conventional loading group; a releasing incision for the buccal tissue was performed to allow for primary closure over the

Table 1. Bone defects (mm) measured at baseline and at re-entry one year later, by type of defect and site.

	Site	No. of sites	Baseline		One Year		
			Mean	SD	Mean	SD	% fill
Vertical defects							
	Buccal	16	9.63	3.74	3.25	3.44	63.9
	Lingual	16	2.63	2.70	2.13	1.67	17.1
	Mesial	16	3.63	2.85	2.50	1.79	33.2
	Distal	16	2.81	2.71	2.38	1.93	21.6
Horizontal defects (gap)							
	Buccal	16	3.75	2.11	0.50	0.89	88.9
	Lingual	16	1.19	1.05	0.25	0.58	53.1
	Mesial	16	1.19	0.98	0.56	0.63	54.2
	Distal	16	1.50	1.83	0.44	0.73	53.1

SD, standard deviation

implant. The implant was surgically uncovered three months postoperatively and a healing abutment was placed, followed by a fabrication of final restoration within four weeks of uncovering the implant.

Postoperative care

Sutures were removed 7 to 10 days after surgery. Patients were advised to clean the surgical area gently with a cotton swab moistened with 0.12% chlorhexidine gluconate (Peridex, Zila Pharmaceuticals, Fort Collins, CO) twice daily for two weeks. The definitive final crown was placed in both groups after three months. Follow-up evaluations were at 3, 6 and 12 months.

Measurement of bone defects

All 16 subjects consented to the re-entry procedure in which a full thickness flap was elevated to expose the bone around the implant. The elevation of the flap was conservative to allow direct measurement of the bony defect around the implant. No vertical releasing incision was done, and the flap was replaced and secured with sutures. Two variables were measured clinically during the surgical procedures at baseline and one year postoperatively. The first measurement assessed the vertical distance between the implant shoulder and the base of the bone defect at 4 sites: buccally, mesially, distally and lingually. The second variable assessed the horizontal gap between the implant and the bone socket walls at the same four sites. An experienced examiner who was not aware of the patients' group assignments performed the clinical measurements in millimeters using a UNC-15 periodontal probe. The procedures were performed at the Center for Dental Studies, School of Dental Medicine, State University of New York at Buffalo, NY. Both the surgeon and the restorative dentist were aware of the patients' group assignments; however, they did not perform the measurements of the variables.

Data analysis

The restricted maximum likelihood method (Wolfinger *et al.,* 1994) was used to fit multiple regression models to study the effect of local factors and patient information on the change in defect measurements during the 1-year follow-up period. Local factors included the type of site (buccal, lingual, mesial and distal), defect location (maxillary anterior, maxillary posterior and mandibular posterior) and implant length. Patient information included age (years) and gender. The treatment group (immediate or conventional loading) also was entered in the model. The analysis used the defects as the unit of analysis and adjusted for the covariance due to clustering of sites within subjects. The modeling was performed stepwise, and separately, for vertical and horizontal defects. Variables that showed an alpha value > 0.1 were removed from the model. The analysis was performed using SAS version 9.2 (SAS Institute Inc., Cary, NC).

Results

Sixteen implants were placed, one in each subject. Five implants were placed in the anterior maxilla, 7 in the posterior maxilla and 4 in the posterior mandible. A total of 64 defects in 16 subjects were measured at baseline and at the follow-up visit 1 year postoperatively. At baseline, the vertical and horizontal defects were most pronounced at the buccal sites (*Table 1*).

The mean reduction in vertical defects between baseline and re-entry for all sites predicted in the regression analysis was 2.42 mm ($p = 0.0005$). The final

Table 2. Regression analysis* of the change in vertical defects dimension during one year

Variable	Coefficient	SE	*p*
Intercept	2.55	0.54	0.0002
Buccal sites (vs. lingual)	3.82	0.74	<0.0001
Proximal sites (vs. lingual)	-1.77	0.67	0.015

*Mixed regression model procedure (adjusted R^2 = 71.9%). SE, standard error

Table 3. Regression analysis* of the change in horizontal defects (gap) dimension during one year.

Variable	Coefficient	SE	*p*
Intercept	1.63	0.18	<0.0001
Buccal sites (vs. lingual)	1.57	0.34	<0.0001
Proximal sites (vs. lingual)	-0.83	0.31	0.012
Females (vs. males)	-0.45	0.18	0.025
Immediate loading (vs. conventional loading)	-0.42	0.18	0.036

*Mixed regression model procedure (adjusted R^2 = 57.3%). SE, standard error

model, shown in *Table 2*, indicated that the type of site (buccal, lingual, proximal) had a significant effect on the magnitude of reduction in the vertical defects dimension ($p = 0.0001$). Compared to lingual sites, the buccal sites showed the greatest resolution in vertical defects dimension (6.37 mm), followed by proximal sites (0.78 mm). Other variables assessed in this study did not have a significant effect on vertical defects. The results were similar when the percentage of defect fill was used as a response variable in the model.

The mean reduction in horizontal defects for all sites predicted in the regression analysis was 1.59 mm ($p < 0.0001$). In the final regression model (*Table 3*), variables with significant effects were the type of site ($p = 0.0002$), gender ($p = 0.025$) and treatment group ($p = 0.036$). Compared to lingual sites, the buccal sites showed the greatest resolution in horizontal gap dimension (3.2 mm), followed by proximal sites (0.8 mm). The reduction in gap dimension was significantly higher in males than females ($p = 0.025$) and in the conventional loading groups than the immediate loading groups ($p = 0.036$). A test of the interaction effect of sex and loading type showed no significant effect. Age, defect location in the mouth and implant length did not show significant effects on the reduction in gap dimension during the first year.

Discussion

This investigation reported a case series of patients who consented to re-entry aimed at evaluating the amount of buccal-bone regeneration and the pattern of remodeling around 16 immediate implants with partially missing buccal plate; 6 implants were immediately loaded after placement and 10 implants had conventional loading as part of a previously published protocol (Shibly *et al.*, 2010). Although the consent form of the main study included re-entry evaluation, only 16 patients agreed to do re-entry at one year follow-up. Hence, randomization and study power, which was achieved in the original study, were compromised in this follow-up, re-entry study. Despite these shortcomings, this case series provides useful information regarding bone regeneration around implants.

In the present investigation the surgical protocols that included the application of bone grafting material and membrane in combination with immediate loading (unsubmerged healing) or conventional loading (submerged healing) resulted in coronal displacement of the mucogingival junction in some cases, especially in the conventional loading group. The reason is that the surgical protocol for conventional loading requires a releasing incision for the buccal tissue to allow for

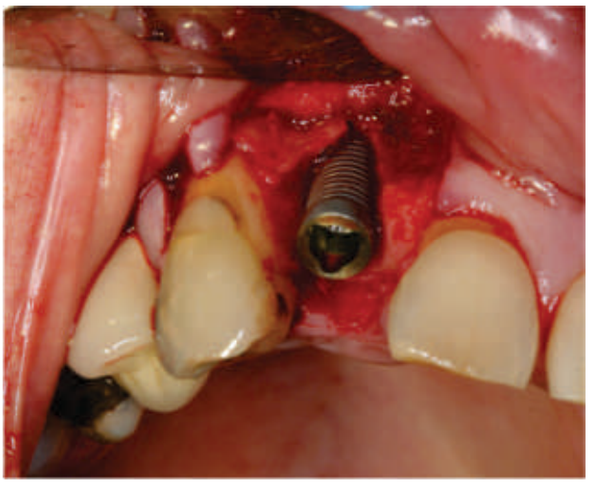

Fig. 1A

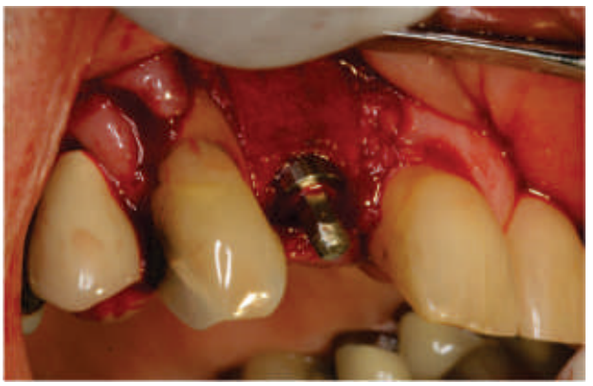

Fig. 1B

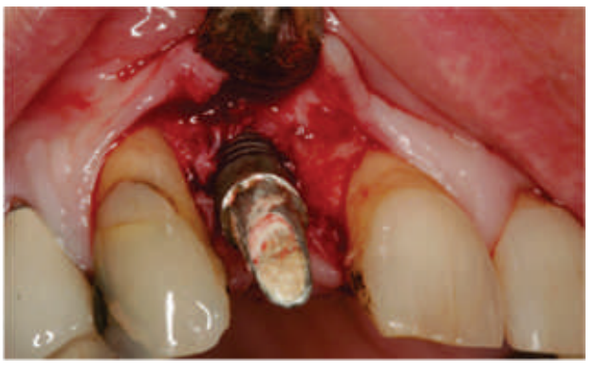

Fig. 1C

Figure 1. Stages of procedure for the treatment group immediate implant with immediate loading. A) An implant was placed immediately after extraction of tooth number 7 showing partial loss of buccal plate. B) A demineralized freeze-dried bone allograft was placed and covered with collagen membrane. Temporary abutment in place. C) One year re-entry showing significant bone regeneration of the buccal plate.

primary closure over the implant (Shibly *et al.*, 2010). The pattern of buccal-bone remodeling in both groups indicates that the problem associated with complete or partial loss of the buccal plate prior to implant placement in a fresh extraction socket can be overcome if an appropriate guided bone regeneration (GBR) procedure is implemented and if there is enough interproximal and lingual bone to allow the implant initial stability. We have previously reported a 1-year implant survival rate of 95% using this protocol (Shibly *et al.,* 2010). However, when immediate placement results in a fenestrated implant or a dehiscence defect, the surgeon must decide whether additional bone augmentation procedures should be conducted or, alternatively, whether a delayed approach would be a better choice. Furthermore, studies show that when the defect around the immediate implant is a self-maintained, four-wall bony defect, it may heal without performing a GBR procedure (Arau´ jo, *et al.,* 2006; Botticelli *et al.*, 2004; Ferrus *et al.,* 2010; Funato *et al.,* 2007; Nevins *et al.*, 2006; Shibly *et al.,* 2010).

The results of this study suggest that applying the GBR principle to large bony defects, including loss of the buccal bone, at the time of implant placement in fresh extraction sockets may result in clinically successful bone regeneration around the implant at the defect site. This finding is consistent with recent studies suggesting that when a large buccal defect or dehiscence existed at the time of placement of an immediate implant, GBR application is necessary to regenerate bone around the implant to maintain the soft and hard tissues. Augmentation of larger defects usually dictates the use of a barrier membrane with or without bone grafting materials (Gher *et al.,* 1994; Nemcovsky *et al.,* 2000; Rosenquist and Ahmed, 2000; Shibly *et al.,* 2010; Tehemar *et al.,* 2003).

In this study, clinical evaluation at the re-entry surgery showed that in general the implants were clinically stable, asymptomatic and free of osseous defects. The probing and measurements of hard tissue around the implants were indicative of new hard tissue filling the peri-implant defect, and thus indicative of buccal-bone regeneration. This finding agrees with results of other studies (Covani *et al.,* 2008; Ferrus *et al.,* 2010; Mardinger *et al.,* 2009) and is consistent with the hypothesis that the main factors necessary to induce bone healing are initial implant stability, presence of bony walls capable of maintaining a firm blood clot, and the use of barrier membranes and bone-grafting materials when a buccal-bone defect exists.

The peri-implant osseous gap originally observed in our study at baseline was clinically filled by hard tissue, which could not be probed. The bone regeneration that filled the vertical gap was not influenced by patients' age or gender, or local factors, such as defect location (maxillary/mandibular, anterior/posterior) and length of implants. On the other hand, the bone fill of the horizontal gap was modestly higher (statistically significant at $p < 0.05$) in males than females, and in the conventional group than the immediate loading group. However, generalizing these results must be done with caution because of the relative small sample size, lack of randomization and unequal groups.

At one-year re-entry, all peri-implant gaps assessed from the internal socket wall to the implant surface were healed and the horizontal defects were filled with bone. However, the vertical buccal defects showed mean reduction in the bone effect from 9.63 to an average residual vertical defect of approximately 3 mm. In a few implants threads were still exposed on the buccal aspect (*Figure 1*). *Figure 1* (implant #7 with cemented crown) shows mucosal recession and metal transparency, which is an obvious esthetic concern, particularly in the anterior area. Based on this clinical observation, GBR was successful in obtaining significant bone regeneration. However, it did not result in complete resolution of the buccal defect. This may be attributed to various reasons, including immediate placement, immediate loading protocol or buccal implant placement.

A major limitation of this investigation is the lack of histological analysis to describe the characteristics of the tissue that came into contact with the implant. The amount of bone regeneration found in this study was based on clinical appearance and probing. Histological evaluation would have given a definite answer as to whether we observed true bone or dense connective tissues. Also, the present findings of a significantly greater reduction in gap dimension in males than females and in the conventional than immediate loading groups should be validated in another better-powered study.

Conclusions

This case series report suggests that bone regeneration was successful around implants placed immediately in fresh sockets, regardless of whether the time of loading of the implant was immediately after placement or delayed. A partially missing buccal plate was not a critical factor for the stability and successful osseointegration of immediate implants, and these defects could heal clinically using GBR. Measurements performed at re-entry surgery showed significant bone regeneration of the buccal plate as a result of the GBR procedure. Even complete loss of the buccal plate did not pose a challenge to an immediately placed implant in the esthetic zone if an adequate amount of lingual and interproximal bone was available to ensure initial stability and a GBR procedure was used. This case series showed some regeneration of the buccal bone in all 16 cases that consented to re-entry.

However, future studies, including histological evaluation, are needed to validate these findings. Also, placement of immediate implants must be done cautiously in the anterior zone of periodontally compromised patients, as this report did not show complete resolution of the buccal plate, which may impose an esthetic concern that can be manifested by buccal mucosal recession.

An adequately powered, prospective, randomized, clinical trial will be valuable to study the effects of patient characteristics and local factors.

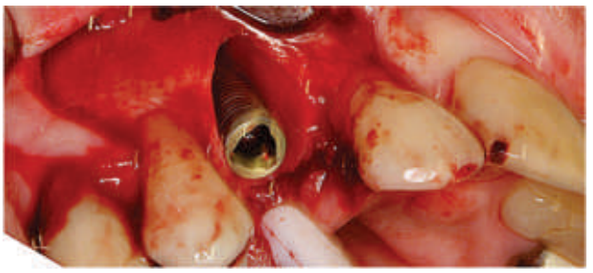

Fig. 2A

Fig. 2B

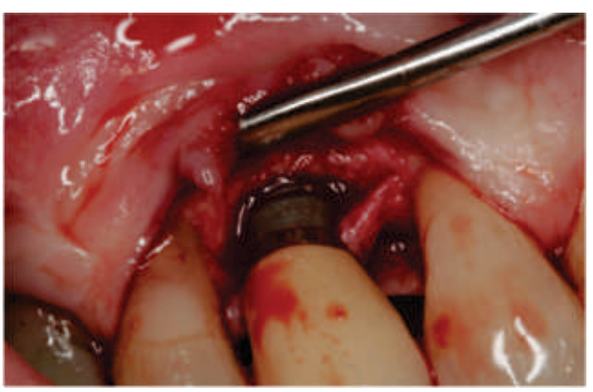

Fig. 2C

Figure 2. Stages of procedure for the treatment group immediate implant with conventional loading. A) An implant was placed immediately after extraction of tooth number 6. B) A demineralized freeze-dried bone allograft was placed and covered with collagen membrane. C) One year re-entry showing significant bone regeneration of the buccal plate.

Acknowledgments

The study was supported by grant 2005-398 from Nobel Biocare Services AG.

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