

Clinical and Radiographic Assessment of Peri-Implant Tissue in Posterior Areas with and Without the Need for Guided Bone Regeneration

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Abstract

Background: Dental implants are increasingly used in resorbed alveolar ridges, and the success of implants inserted concomitantly with guided bone regeneration (GBR) needs to be evaluated.

Objectives: This study aimed to clinically and radiographically assess the peri-implant tissues in the posterior maxilla and mandible in cases in which dehiscence or fenestration occurred at the time of implant surgery and treated with GBR (simultaneously with implant placement in one session). A comparison was also made between the above-mentioned patients and controls in which implants were placed in intact bone (entire length of implant in bone).

Patients and Methods: This study was conducted on 12 patients as cases who received 17 standard implants (dehiscence or fenestration occurred after placement of 4 mm diameter standard implants and GBR was performed) and 10 patients as the control group (those who received 17 standard implants, 4 mm in diameter and 10 mm in length, in adequate bone). Periapical (PA) radiographs were obtained in the first 24 hours post-surgery. Radiographs were repeated at one month, at the time of loading (two months post-surgery), and at three and six months after loading to assess marginal bone loss. To assess the peri-implant soft tissue, thickness and width of the keratinized gingiva were evaluated. Data were analyzed using t-test and repeated measures analysis of variance. The level of significance was set to $P = 0.05$.

Results: The difference in distance from the bone crest to the implant shoulder between the two groups of cases and controls was significant at the following time points: baseline and 2 months post-surgery ($P = 0.000$), baseline and 6 months after loading ($P = 0.01$), 2 months post-surgery and 3 months after loading ($P = 0.00$), and 2 months post-surgery and 6 months after loading ($P = 0.00$). Changes in the width of the keratinized gingiva were not significant in the two groups of cases and controls at 2 months post-surgery ($P = 0.87$) or at 6 months after loading compared with the baseline preoperative values ($P = 0.47$). Changes in the thickness of the keratinized gingiva were not significant in the case or control group at 2 months post-surgery ($P = 0.97$) or at 6 months after loading compared with the baseline preoperative values ($P = 0.25$).

Conclusions: Changes in the marginal bone level were greater when implants were placed concomitantly with GBR. No significant difference was noted in terms of changes in width or thickness of the keratinized gingiva between the two groups.

Keywords: Dental Implant, Guided Bone Regeneration, Dehiscence, Fenestration

1. Background

The demand for fixed and removable partial dentures has increased because of an increase in average life expectancy. Moreover, people are becoming more knowledgeable about oral and dental health and aesthetics, and therefore dental implant placement is now a common procedure routinely performed in dental clinics (1). Preserving the bone volume at the time of tooth extraction is very important. However, tooth extraction often results in alveolar bone loss and ridge resorption. The placement of dental implants in resorbed alveolar ridges can result in peri-implant bone defects such as dehiscence, fenestra-

tion, or intrabony defects (2). In cases in which preoperative assessments indicate inadequate alveolar bone volume due to trauma, advanced periodontal disease, periapical (PA) lesions, etc., bone defects must be surgically repaired through bone regeneration techniques for the implants to have good prognosis (3). Several methods have been introduced to increase bone volume and enhance implant placement in alveolar bone. Guided bone regeneration (GBR) is a well-accepted technique with a high success rate for bone regeneration around implants (2, 4). GBR is used for the repair of dehiscence and fenestration around dental implants and bone defects due to impacted

teeth surgeries (5). The main principles of GBR include preventing unwanted interference and involvement of cells and tissues, creation of a suitable space for repair of defect, maintaining and reinforcing blood clot in the created space, and providing biomechanical stability of the defect area (6). GBR is a surgical technique through which alveolar bone volume can be increased simultaneously with implant placement or at the site of future implant insertion. The target cells in GBR are the osteoblasts, which are responsible for new bone formation (7, 8). Protective membranes are also a fundamental requirement for GBR. Protective membranes are made of bio-inert materials and are applied to protect the blood clot and prevent the migration of soft tissue cells (epithelium and connective tissue) into the bone defect. They also enable the entry and stabilization of osteogenic cells. These membranes are divided into two groups of resorbable and non-resorbable membranes (9). Jung et al. in 2012 showed that resorbable and non-resorbable membranes enhanced the healing of the peri-implant tissues and reported no side effects due to the placement of membranes (10). In recent decades, the optimal properties of resorbable membranes have resulted in their higher application in GBR surgeries compared with the non-resorbable types. Among the resorbable membranes, collagen membranes can be the first choice (11, 12) because of their optimal properties such as hemostasis, chemotaxis for periodontal ligament and gingival fibroblasts, prevention of apical migration of the epithelium, weak immunogenicity, easy application, and ability to increase the thickness of tissue (13).

The sandwich bone augmentation GBR technique is a modality used in cases with slight, moderate, and severe horizontal defects in the alveolar ridge simultaneously with the implantation of fixture. In this method, graft materials are applied incrementally (according to GBR principles) to the exposed surface of the implant (fenestration or dehiscence defects) or thinned buccal cortical plate. Mineralized allograft of spongy bone alone or in combination with autogenous bone is applied as the first layer. Mineralized allograft of cortical bone or xenograft is applied as the external layer. Finally, a collagen membrane covers the whole area according to GBR principles (14, 15). GBR is a complex technique requiring meticulous surgery and the proper selection and use of graft materials. Knowledge about the topography of the bone defect and other local factors, such as the width of the keratinized gingiva and flap thickness, are among the important factors influencing the surgeon's decision. Considering the increasing demand for dental implants to be placed in resorbed alveolar ridges, the success of implants is important especially when placed concomitantly with GBR (7, 9).

2. Objectives

This study aimed to clinically and radiographically assess the peri-implant tissues in the posterior maxilla and mandible in cases in which dehiscence or fenestration occurred at the time of implant surgery and treated with GBR (simultaneously with implant placement in one session). A comparison was made between the abovementioned patients and controls in which implants were placed in intact bone (entire length of implant in bone).

3. Patients and Methods

This study was conducted on patients who presented to a private clinic in Hamadan city seeking implant treatment. The patients were fully edentulous or had edentulous posterior maxilla or mandible. The sample size was calculated to be at least 12 and 10 subjects in the intervention group and the control groups (17 standard implant per each groups), respectively, in consideration of the standard deviation and mean values obtained in a previous study (13) and the 95% confidence interval and power of 80%. In the first step, a primary examination was conducted that was composed of intra- and extra-oral clinical examination and panoramic, parallel PA, or cone-beam computed tomography radiographs based on the patients' needs and condition. Alcoholic patients, drug addicts, smokers, patients with immunosuppression, diabetes, hypertension, or cardiac diseases, those undergoing chemotherapy or radiotherapy, and patients with para-functional habits or periodontal disease were excluded. The selected subjects were informed about the study and signed written informed consent forms. The subjects were then randomly divided into two groups of cases and controls. The control subjects had an edentulous ridge with adequate volume to accommodate an implant 10 mm in length and 4 mm in diameter and after implant placement; the entire length of the implant was embedded in natural bone. The case group subjects were patients in whom dehiscence or fenestration occurred following implant placement (with the abovementioned dimensions) and the required immediate GBR. For the purpose of matching, equal numbers of implants (of the same diameter and length) were placed in the maxilla and mandible in the two groups. The TBR implant (T.B.R., Paris, France) was used in this study. Standard surgical technique was used in the control group. In the case group following implant placement, GBR was performed using nano bone (Rostock-Warnemünde, ARTOSS GmbH) powder resorbable xenograft with particles measuring 0.6 mm in diameter along with Biocollagen resorbable membrane (Biotech). Parallel PA radiographs were obtained within

the first 24 hours post-surgery and repeated at one month, at the time of loading two months after surgery, and at three and six months after loading. Three variables were evaluated to assess the peri-implant tissue status: width of the keratinized gingiva, thickness of the keratinized gingiva, and distance from bone crest to implant shoulder. The amount of bone loss (distance from implant shoulder to alveolar crest) was measured using a digital caliper (Absolute German) in a parallel manner on the PA radiographs. The width of the keratinized gingiva (distance from gingival margin to mucogingival junction) was measured using a Williams probe. The thickness of the keratinized gingiva was measured using an endodontic file with a rubber stopper under topical anesthesia before the surgery, two months after the surgery, and three and six months after loading. Data were analyzed using SPSS version 16, t-test, and repeated measures analysis of variance. The level of significance was set to $P = 0.05$.

4. Results

Among the 22 understudy patients, 12 were evaluated in the case group and 10 in the control group. The mean age of patients was 43.05 years in the case group and 43.41 years in the control group. The frequency percentage of males and females was 59% and 41% in the case group and 53% and 47% in the control group, respectively. The two groups were matched in terms of age and sex. A total of 34 TBR Connect implants were evaluated, among which 17 were placed in the intervention and 17 in the control groups. Based on the primary examinations, the two groups were matched in terms of bone quality and site of implant placement (in the maxilla or mandible). Evaluation of changes in the width of the keratinized gingiva (Table 1) revealed that changes in the width of the keratinized gingiva over time were significant in the intervention and control groups ($P = 0.000$). The width of the keratinized gingiva did not significantly change at two months post-operation compared with the baseline value in the two groups ($P = 0.87$). At six months after loading, no significant change was noted in the two groups in the width of the keratinized gingiva compared with the baseline ($P = 0.47$). No significant difference was noted in changes in the width of the keratinized gingiva between the two groups at similar time points ($P > 0.05$). Thickness of the keratinized gingiva significantly changed over time in the two groups similar to the width of the keratinized gingiva ($P = 0.000$). Thickness of the keratinized gingiva did not significantly change at two months post-surgery compared with the baseline in the two groups ($P = 0.97$). Moreover, thickness of the keratinized gingiva did not significantly change at six months after loading compared with

the baseline in the two groups ($P = 0.25$) (Table 2). Changes in the distance from bone crest to implant shoulder between the two groups were significantly different at different time points ($P = 0.000$) (Table 3). The difference in the distance from bone crest to implant shoulder between the two groups was significant at the following time points: baseline and two months post-surgery ($P = 0.05$), baseline and six months after loading ($P = 0.01$), two months after surgery and three months after loading ($P = 0.00$), and two months after surgery and six months after loading ($P = 0.00$). Based on the results of the t-test, the distance from bone crest to implant shoulder in the intervention group significantly increased over time compared with that in the control group. The only exception was found to be at three months after loading when the distance from alveolar crest to implant shoulder did not have a significant difference from its baseline value in the two groups ($P = 0.06$).

5. Discussion

Peri-implant bone changes may vary from partial loss of the crestal bone to complete implant failure (16). Chang et al. in 2010 evaluated bone loss and soft tissue changes in 42 implants at 2, 6, 12, 24, and 36 months and concluded that the greatest bone loss occurred in the first 6 months after loading and that the trend of bone loss did not significantly change between 6 and 36 months following loading (17). Based on previous studies (4, 7), parallel PA radiographs were obtained in the current study to accurately assess changes at the bone level from the time of surgery to six months after loading. The commonly suggested hypotheses on the causes of bone loss include elevation of periosteum during surgery, bone preparation for implant placement, presence of a gap between the abutment and implant body, small movements of the abutment components, bacterial invasion, and stress-related factors. These factors can be classified into three groups: patient-related, surgeon-related, and implant-related factors (18). Patient-related factors include stress and load applied to teeth (i.e., in bruxism, clenching, and tongue pressure, systemic conditions, periodontal health, and bone density), which has a direct correlation with its strength (3, 6, 19). The correlation of bone density with the modulus of elasticity, strength, and percentage of bone-implant contact following loading is different based on the type of bone density (20). In the D1 bone type, tension is concentrated in an area close to the bone crest and is not transferred to the apical areas. Therefore, the amount of stress is lower. In the D2 bone type, crestal tension is slightly higher in similar loading conditions. Consequently, the magnitude of stress extending toward the apical part along the implant

Table 1. Comparison of Changes in the Width of the Keratinized Gingiva at Different Time Points

Group/Time	Mean \pm SD, mm			P Value
	Baseline	3 Months after loading	6 Months after loading	
Intervention	3.64 \pm 1.61	3.25 \pm 1.83	3.27 \pm 1.86	0.000
Control	3.09 \pm 2.02	3.04 \pm 1.98	2.96 \pm 1.95	0.000
T-test	0.385	0.743	0.641	0.000

Table 2. Comparison of Changes in the Thickness of the Keratinized Gingiva at Different Time Points

Group/Time	Mean \pm SD, mm			P Value
	Baseline	3 Months after loading	6 Months after loading	
Intervention	1.12 \pm 0.30	1.17 \pm 0.33	1.15 \pm 0.32	0.000
Control	0.94 \pm 0.39	0.98 \pm 0.44	0.96 \pm 0.42	0.000
T-test	0.138	0.176	0.143	-

Table 3. Comparison of Changes in the Distance from Alveolar Crest to Implant Shoulder at Different Time Points

Group/Time	Mean \pm SD, mm				P Value
	Before surgery	2 Months after surgery	3 Months after loading	6 Months after loading	
Intervention	0.15 \pm 0.24	0.39 \pm 0.27	0.49 \pm 0.25	0.54 \pm 0.27	0.000
Control	0.18 \pm 0.09	0.21 \pm 0.07	0.31 \pm 0.08	0.37 \pm 0.11	0.000
T-test	0.306	0.015	0.008	0.020	-

body slightly increases. The D4 bone type shows the highest tension in the crestal area, and stress is more widely distributed along the implant body toward the apical region. Note that the mandibular bone often has D1 to D3 bone types (from the anterior toward the posterior areas). The bone type of the maxilla ranges from D2 to D4 (from the anterior toward the posterior regions) (4, 21, 22). Dahlin et al. showed that the success rate of implant treatment was 84.7% in the maxilla and 95% in the mandible (23). In our study, the maxillary and mandibular cases were equal in the two groups to eliminate the confounding effect of bone density on the results (the two groups were matched in terms of implant site). As stated earlier, the understudy patients had no systemic condition, were non-smokers, and had no parafunctional habits. Moreover, they were matched in terms of oral hygiene, sex, and age, did not use any immunosuppressive drugs, and were not alcoholics or drug addicts. According to the literature, the most common cause of implant failure is over-heating at the bone-implant interface during implant site preparation or implant insertion with excessive torque (18). As all implants were placed by the same surgeon with adequate experience and expertise, surgeon-related factors were the same

for the two groups. Implant-related factors included micro designs and length and diameter of implants (16, 18). In the current study, 34 TBR Connect standard implants (T.B.R., France, Paris) 4 mm in diameter and 10 mm in length were placed in 22 patients. Implant-related factors were also matched in the two groups. Zitzmann et al. in 2001 evaluated a control group (patients with alveolar bone loss who had no dehiscence, fenestration, or bone defects) and two case groups. One case group underwent GBR with protective collagen membrane (Biogides) placement and the second case group received e-PTFE (Gore-Tex). The implant success rate was reported to be 97.3%, 95%, and 92.6% in the three groups, respectively. Zitzmann et al. emphasized that the success of implants could be significantly enhanced by selecting a proper bone regeneration technique and an appropriate membrane in the resorbed ridges (24).

Zambon et al. in 2012 evaluated the efficacy of GBR along with Straumann MembraGel (Switzerland) for the repair of dehiscence and fenestration in the premolar teeth of 12 pigs. The results showed positive efficacy of this technique in a six-month period (25). In the current study, implants were placed in intact bone in the control group. In the case group, dehiscence occurred following implant

placement and reconstruction performed through the application of NanoBone material and collagen membrane. The results showed that the mean changes in the distance from crestal bone to implant shoulder in the case group from the time of surgery to six months after loading significantly increased (0.15 - 0.54 mm). These changes were statistically significant, but the values were within the clinically acceptable range. The same results were noted in the control group, but the reported magnitudes were smaller than those in the intervention group (0.18 - 0.37 mm). This difference was statistically significant and consistent with the results of Meijndert et al. (3), Christoph et al., (26) and Zitzmann et al. (24) but in contrast to the findings of Yeh et al. (27) and Lima et al. (28). The changes in the width and thickness of keratinized gingiva at different time points (from the time of surgery to six months after loading) were not significant in the intervention or control group. Moreover, no difference was noted between the two groups in this regard, consistent with the results of Jung et al. (29) and Chang et al. (30) but in contrast to those of Meijndert et al. (3) and Zitzmann et al. (24).

Evidence shows that GBR can effectively improve peri-implant bone defects such as dehiscence and fenestration. In the current study, changes at the marginal bone level were greater in the GBR group than in the control group, but no difference was noted between the two groups in terms of changes in the width or thickness of the keratinized gingiva. The results show that GBR has no adverse effects on peri-implant soft tissue. Future studies are required to assess the efficacy of GBR in cases with complete alveolar bone loss.

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