

A SYSTEMATIC REVIEW ON THE MANAGEMENT OF OSSEOUS DEFECTS DURING DENTAL IMPLANT PLACEMENT

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Review Article

ABSTRACT

This systematic review focuses on the management of two types of osseous defects, i.e. dehiscence and fenestration that arise during the placement of dental implant in the edentulous area (delayed implant placement). A systematic online search of main database from 1975 to 2009 was made. Five randomised controlled trials have been identified based on the inclusion criteria. Different management procedures were identified, in which guided bone regeneration procedure was most commonly advocated. Resorbable and non-resorbable membranes were compared, in which resorbable membrane was preferred as it caused less complication of membrane exposure or risk of infection. The benefit of using bone substitute along with membrane in repairing bony defects cannot be concluded.

Key words: dental implant; dehiscence; fenestration; systematic review

INTRODUCTION

Dental implant treatment has become widely popular since the early 1980s. Osseointegration of implant determines the prognosis of the implant treatment. However, due to multiple factors such as poor quality bone, surgical procedures or dental implant design, quite frequently surgeons encounter osseous defects while placing the implants, resulting in exposure of the implant. Two types of osseous defects, i.e. dehiscence and fenestration can arise during the placement of dental implant in the edentulous area. Dehiscence defect refers to the exposure of the coronal part of implant, while fenestration refers to the exposure of the body of implant in which the coronal part of the implant is still covered with bone. This complication may happen during immediate implant placement into an extraction socket (1-3), or during implant placement in an edentulous area (healed extraction socket) (4-8), or from an inflammation or infection as in peri-implantitis (9-12). This review will focus on osseous defects which occur during implant placement in the edentulous area, and exclude those osseous defects resulting from fresh extraction sockets or peri-implantitis. There are still some controversial issues in managing the dehiscence or fenestration with regards to the indications for guided bone regeneration (GBR),

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the use of resorbable or non-resorbable barrier and the need of bone filling materials.

OBJECTIVE AND METHODS

The aim of this review is to identify the most effective interventions for treating osseous defects namely dehiscence or fenestration that occur during dental implant placement in the edentulous area. Based on a conventional hierarchy of study designs, the highest evidence of study design, randomised controlled trials (RCT) were selected. This review excluded those interventions of osseous defects which occur during immediate implant placement into freshly extraction sockets or due to peri-implantitis as they are different in term of their aetiologies and thus influences bone regeneration mechanisms. Based on the search protocol recommended in Cochrane Handbook for Systematic Reviews of Interventions 5.0.1, a combination of controlled vocabulary and free text terms were used to identify relevant studies. Only English articles published since 1975 onward were selected, as the first dental implant study was published by the pioneer, PI Branemark only in 1977 (13).

RESULTS

Characteristics Of the trial setting and investigators

A total of 18 eligible trials were identified but only 5 trials (4-8) fulfilled the criteria of the review. The excluded 13 trials were due to: non-RCT trials (14, 15), inappropriate analyses as data were analysed on implant sites not on patient basis (1, 14-17), marginal defects which occur during immediate implant placement into extraction sockets (1-3, 18).

The five included trials were done in different countries, i.e. Sweden (4), the United Kingdom (5), the

United States of America (New York) (6) and Switzerland (7, 8). Three trials used a split-mouth design and two trials used parallel group study design (6).

Characteristics of the intervention

The implant placements were all performed after the healing of extraction sites with a minimal of 6 week duration prior to implant placement. Dehiscence defects were mainly investigated (5, 7, 8). Site of defects were or maxillary arch (4), mandibular arch (5) and both arches (7). No detailed information on the type of osseous defects and site of defects were reported in two trials (6, 8).

All trials used guided bone regeneration (GBR) technique as the main intervention technique to treat the defects. Two main types of barriers, i.e., non-resorbable barrier namely expanded polytetrafluoroethylene (e-PTFE) (Gore-Tex®) (5, 6) and resorbable barrier such as Bio-absorbable collagen membrane (Bio-Gide®) (6, 7) and synthetic bioresorbable polyethylene glycol (PEG) (8) were used. These barriers, except for PEG, were secured with either resorbable pins (6-8), cover screws (5, 6) or beneath the flap (4).

All trials were completed at stage 2 surgery which was 5-7 months from the implant placement. All trials have 100% follow-up rate except one trial (7) which had one patient who withdrawn due to incomplete wound closure at the time of suture removal.

Characteristics of the outcome measures

Clinical outcomes as well as *in-vitro* analysis were used to evaluate the success of the interventions. Reduction of bone defects (5-8), implant failure as well as the complications and side effects of intervention (6) were reported. In order to examine the quality of regenerated bone, biopsies of the healing sites were obtained for histomorphometric analysis (5, 7).

Effects of interventions

In total, 108 patients (one withdrew) with more than 94 implants (two implants were excluded due to the one withdrawal case) were obtained from these five trials. The exact number of implants was not able to be determined because in *lung* et al.'s article (2009), the number of implant treated was not reported clearly (8). Different surgical procedures were reported in treating dehiscence or fenestration which occurred during implant placement in the edentulous sites.

i) Is it necessary to use barrier to cover the osseous defect? (two trials)

Two trials compared the advantage of using barriers in GBR procedure to repair the osseous defects. Using split-mouth design, two trials compared the use and without the use of non-resorbable e-PTFE barrier (Gore-Tex, WL Gore and Associates, Inc., Flagstone, USA) around implants which have either

fenestration (4) or dehiscence (5) during implant insertion. No bone filling materials were used as space maintainer (4, 5), but a small space was maintained over the exposed implant surface by manual convex shaping of the barrier (4). The barriers were either secured beneath the flap (4) or with cover screw (5) for 5-7 months (4, 5). In cases without barrier usage, the soft tissue flap was repositioned to cover the osseous defects. All implants placed were turned surface, screw-type, titanium self tapping Brfmark (NoDeI Biocare, Göteborg, Sweden).

The results from both trials indicated that better reduction of defect size or bone gain was achieved when a barrier was used in GBR. However, there wasn't any statistical difference.

ii) Resorbable versus non-resorbable barriers (one trial)

A parallel-group design study compared the type of barrier used in GBR, i.e. resorbable porcine-derived collagen barrier (Bio-Gide, Geistlich Pharmaceutical, Wolhusen, Switzerland) versus non-resorbable e-PTFE barrier (Gore-Tex, WL Gore and Associates, Inc., Flagstone, USA) (6). In both groups, bone filling materials were used to support the overlaying barrier and to stimulate bone regeneration. The bone filling materials were made from mixture of bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland) and autogenous bone derived from the implant osteotomy sites in a ratio of 1:1. Both types of barriers were secured with either two polylactic acid bioabsorbable pins (Osseofix, Implant Innovations Inc., West Palm Beach, FL, USA or Resor-Pin, Geistlich Pharmaceutical, Wolhusen, Switzerland), or the implant cover screw, or the mucogingival flap. They were kept for 6 months. All implants placed were turned surface, screw-type titanium (Implant Innovations Inc., West Palm Beach, Florida, USA).

There was no significant difference in the reduction of defect size in both groups. Both barriers were suitable to be used in guided bone regeneration. However, non-resorbable e-PTFE barrier have significant higher risk of membrane exposure during healing (12.5%) versus resorbable collagen membrane (8.7%).

A new synthetic hydrogel of polyethylene glycol (PEG) which is in a liquid form was compared to the standard collagen membrane (BioGide) in one trial (8). In both groups, bone substitutes (BioOss) was used to graft the osseous defects. The result reveals that no statistical significant difference was observed in percentage of vertical defect fills.

iii) Is adding bone morphogenic protein into bone substitute mineral improve the GBR procedure? (one trial)

A split-mouth, placebo-control trial compared the effectiveness of recombinant human bone morphogenetic protein-2 (rhBMP-2; 1 ml of 0.5 mg/

ml) versus placebo (1 ml of 0.01% trifluoroacetic acid which is the solvent for rhBMP-2) on GBR (7). The bone morphogenic protein was mixed with bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wollhusen, Switzerland) and covered with resorbable porcine-derived collagen barriers (Bio-Gide, Geistlich Pharmaceutical, Wollhusen, Switzerland) on implant sites which had mainly dehiscence defects. The barriers were secured using polylactic acid bioabsorbable pins (Resor-Pin, Geistlich Pharmaceutical, Wollhusen, Switzerland) and kept for 6 months. All implants were turned surface, screw-type, Branemark implants (Nobel Biocare, Göteborg, Sweden).

There was a significant improvement in bone defects reduction when rhBMP-2 was added.

DISCUSSION

Systematic reviews on the management of bone defects in extraction sockets for implant placement (19) and peri-implantitis (20) are available. In this review, the author is only interested in reviewing trials on the intervention of a rather specific type of osseous defects, i.e. dehiscence or fenestration which happen during implant placement in thin edentulous area. In fact, this topic was reviewed in a systematic review in 2008 (19) but two additional trials (5, 8) are added into this review. The intervention of this type of defect may be different from the bone regeneration in immediate implant placement in extraction sockets (1-3) or augmentation of the alveolar ridge prior to implant placement (21) or if the defects are due to peri-implantitis (9-12, 22). For example, if osseous defect is associated with peri-implantitis, the primary goal of management is to remove the bacteria around the implants. Different treatments such as smoothing the implant surface, decontamination of implant surface with chemical agents (11) or laser beam (12) have been suggested. The common goal of managing osseous defects related to peri-implantitis is by elimination of the bacteria around implants first, then followed by restorative procedure (9) or bone regenerative procedures (10, 22).

The highest form of study design was available for this review, i.e. the randomised controlled trials (RCTs) which include parallel group and split-mouth designs; hence they were selected. Five trials were identified based on the inclusion criteria in this review. These trials vary slightly in term of the type of osseous defects for investigation, i.e. dehiscence (5, 8), fenestration (4) or both types of the defects (6, 7). Different interventions for bone regeneration around the defects were used. The outcomes assessed in the trials varied too, with some assessing clinical features such as the reduction of osseous defect size (5-7), while others assess the histomorphometric features (5, 7). Thus, with the presence of clinical and methodological heterogeneity in all the included trials, meta-analysis

was not appropriate in this review. Nevertheless, all trials show good external validity, as the initial size of the defects equivalent to the majority dehiscence defect (23).

Meanful estimate of effect from data can be achieved if the data from different trials were measured in the same way and have rather similar population profile. For example, if the population profile is similar, the effectiveness of interventions can be evaluated from the outcome measure on the reduction of osseous defect size. In three trials which measure the reduction of defect sizes, the reduction unit used was in millimetre (5-8). The author would suggest that comparison of this outcome be more meaningful if the percentage (%) of defect size reduction was used as in Jung et al.'s (8) report, due to the fact that the initial defect sizes vary in different trials.

Unfortunately, all trials did not provide a power calculation except one (8) and used rather small sample size, thus failed to demonstrate any significant difference between groups. Another common methodological flaw during analysis of the outcome is that the unit of analysis was performed on the implant rather than the patient (1, 14-17) in a split-mouth design. By using implant as unit of analysis, the patient factor was not taken into account as a confounding factor.

Without the use of barrier, it was suggested that the titanium oxide surface of the implant at the defect site will come into direct contact with the overlying periosteum connective tissue, instead of blood and bone. Thus, this cause limited bone formation over the defects (4). By using the barriers, it prevents the contact of periosteum onto the implant surface and allows osteogenesis on the defect sites. This feature was supported in animal model, where it was shown that when no bone filling materials were used to support the barriers, there would be complication of membrane collapse onto the implant surface and obstruct osteogenesis (24). In this review, no trials have investigated the indication of the bone filling materials during GBR. However, in other clinical trials, the group with bone allograft used concomitantly with either e-PTFE (15) or resorbable collagen membrane (2) revealed higher success rate of full coverage of the defects than the use of barrier alone without bone filling materials, though no statistical difference was observed. Nevertheless, there was a disadvantage in using bone filling materials especially autogenous bone grafts. Even with careful precaution in harvesting the autogenous bone grafts and use of antibiotic prophylaxis, bacteria contamination was still detected (25). Thus, the advantages of concomitant use of bone filling materials with barrier still require further well design trials to prove it.

The disadvantages of using non-resorbable e-PTFE (Gore Tex) are the need of second surgical procedure to remove the barrier and also higher risks of premature exposure and bacterial contamination (6, 16, 26). In

Table 1. Summary of five included trials

Dahlin 1991	
Methods	Randomised, split-mouth study (follow up to abutment connection; 6 to 7 months). No withdrawals. Study done in Sweden.
Participants	Maxilla only. All defects were buccal fenestration. Total of 7 patients (5 males).
Interventions	Non-resorbable e-PTFE versus no barrier. Barriers were secured under the flap. No bone chips or filling materials. All implants were turned surface, screw-type, titanium self tapping Branemark (Nobel Biocare, G6teborg, Sweden).
Outcomes	Newly formed bone was measured from photographs taken at implant placement and after healing (during 2 nd stage surgery for abutment connection) using computer image analysis software.
Palmer 1994	
Methods	Randomised, split-mouth study (follow up to abutment connection; 5 months). No withdrawals. Study done in the UK.
Participants	Mandible only. All dehiscence were created and standardised on both side. Total of 6 patients (1 male).
Interventions	Non-resorbable e-PTFE versus no barrier. Barriers were secured with cover screw. No bone chips or filling materials. All implants were ad modum titanium Branemark (Nobel Biocare, G6teborQ, Sweden).
Outcomes	Bone defect were measured clinically before (during implant placement) and after intervention (during 2 nd stage surgery for abutment connection). The percentage of new bone formation and the bone-metal contact were measured, by surgical removal of the implants and process for histological analysis.
Carpio 2000	
Methods	Randomised, parallel group study (follow up to abutment connection; 6 months). No withdrawals. Study done in New York, USA.
Participants	Maxilla & mandible. Dehiscence & fenestration. Total of 48 patients (20 males).
Interventions	Resorbable porcine-derived collagen barrier membrane (Bio-Gide) (23 patients) versus non-resorbable e-PTFE barrier (Gore-Tex) (25 patients). Barriers were secured with either 2 polylactic acid bioabsorbable pins, cover screw or mucogingival flap. Both groups had a 50%:50% mixture of bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland) and autogenous bone. All implants were turned surface, screw-type, titanium (Implant Innovations Inc., West Palm Beach, Florida, USA).
Outcomes	Bone defects were measured clinically before (during implant placement) and after intervention (during 2 nd stage surgery for abutment connection). Morbidity after operation such as implant exposure, soft tissue dehiscence, barrier exposure and implant failure were evaluated postoperatively at days 2, 5, 7, 10, 15, 21 and 28 days.
Jung 2003	
Methods	Randomised-split-mouth, placebo-controlled study (follow up to abutment connection; 6 months). 1 patient was lost in follow up due to incomplete wound closure during suture removal stage after implant placement. Study done in Switzerland.
Participants	Maxilla & mandible. Dehiscence (21 implants) & fenestration (1 implant). Total of 11 patients (4 males). Distance between test and control implants was at least 7 mm.
Interventions	Recombinant human bone morphogenetic protein-2 (rhBMP-2; 1 ml of 0.5 mg/ml) versus placebo (1 ml of 0.01 % trifluoroacetic acid) on GBR using bovine anorganic bone (Bio-Oss) and. Barriers were secured with resorbable polylactic acid pins. All implants were turned surface, screw-type, titanium Mark II, III or IV Branemark implants (Nobel Biocare, G6teborQ, Sweden).
Outcomes	Bone defects were measured clinically before (during implant placement) and after intervention (during 2 nd stage surgery for abutment connection). Post-operative complications such as implant or barrier exposure were recorded during healing period. Cylindrical bone biopsies from augmented areas were obtained for histomorphometric analysis.
Jung 2009	
Methods	Randomised, parallel-group study, controlled study (follow up to abutment connection; 6 months). Study done in Switzerland.
Participants	Maxilla & mandible. Dehiscence only. Total of 37 patients. Defect height was ~ 3mm.
Interventions	Synthetic bioresorbable polyethylene glycol (PEG) hydrogel membrane versus resorbable porcine-derived collagen barrier (Bio-Gide) which was secured with polylactic acid bioabsorbable pins (Resor-Pin). All implants used were Straumann SLA solid screw implant (Institute Straumann AG).
Outcomes	Bone defects were measured clinically before (during implant placement) and after intervention (during 2 nd stage surgery for abutment connection). Times taken for the procedures were compared.

contrast, resorbable collagen membrane (BioGide) has the advantage of having less complication of membrane exposure (6). However, the resorbable liquid form of barrier (PEG) was reported to have higher adverse events such as pain or discomfort and delayed dehiscence.

The benefit of adding bone morphogenetic protein was not obvious. The trial comparing the use of collagen membrane barrier with bone substitute either with or without the bone morphogenetic protein showed almost full coverage of the defects. The bone defects reduction was 97.1% and 93.1% in rhBMP-2 and control group respectively (7), but was not statistically different.

For clinical implication, when assessing the coverage of the exposed implants clinically, the apparent bone-like structure may be actually soft tissue in histological evaluation, as evident in one trial (5). In addition, some new bone formations around the implant defects do not reveal osseointegration to the implant (27).

AUTHOR'S CONCLUSIONS

Implications for practice

No single intervention can be concluded to be effective in treating dehiscence or fenestration during implant placement in edentulous areas. The use of barriers during GBR procedures revealed better reduction in osseous defects and bone gain in two trials but without statistical significance (4,5). Both the two different types of barrier, i.e. resorbable (Bio-Gide) or non-resorbable (Gore-Tex) showed good bone regeneration in one trial but with significant higher risk of complication in membrane exposure for non-resorbable barriers (6). The barriers need to be secured to avoid any movement which may affect the bone regeneration process underneath the barriers. The new synthetic liquid form barrier (PEG) may have the advantage of needing less preparation time when compared to the standard collagen membrane, but the benefit of it in GBR still needs further exploration.

Implications for research

More well-designed RCTs should be conducted in this area. Most available trials fail to provide significant difference between interventions. This could be due to: i) too few patients can be included in the trials, ii) in actual fact there aren't any differences among the tested groups. In general, larger sample size obtained from power calculation will help detecting the effectiveness of various interventions. Well-designed multicentre trials will help solving the problem of lack of patients. One common methodological flaw found in most dental implant studies is that the unit of randomisation was the implant rather than the patient, thus the patient as a confounding factor was not taken into account during

statistical analysis. The statistical analysis should be based on the patients, and not the implants. It is not uncommon that some important information was missing or unclear during reporting of the studies. The Consolidated Standards of Reporting Trials (CONSORT) guidelines (<http://www.consort-statement.org/>) should be followed when reporting the trials (28). Future clinical trials should fill in the gap of knowledge in the following issues in treating dehiscence or fenestration during implant placement in edentulous areas:

- The need of bone filling materials
- The potential benefit of adding bone morphogenetic proteins (rhBMP-2) with autogenous bone or in combination of xenogenic bone substitute
- The benefit of using liquid form of barrier (PEG) in GBR
- A longer follow-up duration
- Include aesthetic evaluation by patients and dentists as one of the outcome measures
- Cost effectiveness on using the bone filling materials, barriers, bone morphogenetic proteins, secured pins and others.

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