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A prospective clinical study of bone augmentation techniques at immediate implants

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Abstract: The efficacy of combinations of membranes and autogenous bone grafts at immediate implants were compared in a prospective study. Sixty-two consecutively treated patients each received an immediate implant for a single tooth replacement at a maxillary anterior or premolar site. Dimensions of the peri-implant defect at the implant collar were measured as follows: vertical defect height (VDH), horizontal defect depth (HDD) and horizontal defect width (HDW). Each implant randomly received one of five augmentation treatments and were submerged with connective tissue grafts: Group 1 ($n = 12$) – expanded polytetrafluoroethylene membrane only, Group 2 ($n = 11$) – resorbable polylactide/polyglycolide copolymer membrane only, Group 3 ($n = 13$) – resorbable membrane and autogenous bone graft; Group 4 ($n = 14$) – autogenous bone graft only, and Group 5 ($n = 12$) – no membrane and no bone graft control. At re-entry, all groups showed significant reduction in VDH, HDD and HDW. Comparisons between groups showed no significant differences for VDH (mean 75.4%) and HDD (mean 77%) reduction. Significant differences were observed between groups for HDW reduction (range, 34.1–67.3%), with membrane-treated Groups 1, 2 and 3 showing the greatest reduction. In the presence of dehiscence defects of the labial plate, HDW reduction of 66.6% was achieved with membrane use compared with 37.7% without membranes. Over 50% more labial plate resorption occurred in the presence of a dehiscence defect irrespective of the augmentation treatment used. The results indicate that VDH and HDD reduction at defects adjacent to immediate implants may be achieved without the use of membranes and/or bone grafts.

Techniques for placing implants into sockets at the time of tooth extraction are gaining considerable interest (Schwartz-Arad & Chaushu 1997a; Mayfield 1999). The advantages of immediate implant placement are a reduction in the number of surgical procedures and treatment time required (Lazzara 1989; Parel & Triplett 1990), ideal axial orientation of the implant (Werbitt & Goldberg 1992; Schultz 1993), preservation of the bone at the extraction site and optimal soft-tissue aesthetics (Werbitt & Goldberg 1992). Furthermore, there is evidence to show that immediate implant placement is a predictable alternative to conventional placement, with high success rates reported over 4–11-year observation periods (Schwartz-Arad & Chaushu 1997b; Becker et al. 1998, 1999; Schwartz-Arad et al. 2000; Wagenberg & Ginsburg 2001).

A variety of regenerative techniques using combinations of bone grafts and barrier membranes have been suggested to promote bone regeneration in localised defects at implants placed into extraction

sockets (for reviews see Schwartz-Arad & Chaushu 1997a; Mayfield 1999). The claimed success of guided bone regeneration (Dahlin et al. 1988) has provided the justification for the use of barrier membranes in conjunction with immediate implants (Lazzara 1989). Non-resorbable membranes manufactured from expanded polytetrafluoroethylene (e-PTFE) have been reported to be effective in promoting bone regeneration at immediate implants (Lazzara 1989; Becker & Becker 1990; Nyman 1991). However, premature membrane exposure was associated with significantly less reduction in vertical defect height in a prospective clinical study (Becker et al. 1994a). Membranes have also been used in combination with bone grafts with varying degrees of success. Non-resorbable e-PTFE membranes placed in conjunction with demineralised freeze-dried bone (Werbitt & Goldberg 1992; Gelb 1993; Gher et al. 1994; Landsberg et al. 1994) and hydroxyapatite (Block & Kent 1991; Knox et al. 1993) have previously been described.

Various combinations of resorbable membranes and bone grafts have also been used, including collagen membranes with demineralised freeze-dried bone allograft (Goldstein et al. 2002), collagen membranes with deproteinised bovine bone (Nemcovsky et al. 2000a, 2000b), and dermal matrix membranes with bioactive glass (Novaes et al. 2002). However, there have been few reports comparing different modalities of treatment. Biopsies of regenerated sites showed enhanced bone formation with a combination of hydroxyapatite and a e-PTFE membrane compared with either a e-PTFE membrane or hydroxyapatite alone (Wachtel et al. 1991). A study comparing collagen and e-PTFE membranes in conjunction with anorganic bovine bone grafts reported similar amounts of bone fill (Zitzmann et al. 1997). When three modalities for flap closure over immediate implants were compared, sites grafted with anorganic bovine bone and covered with a collagen membrane showed similar results to no graft /no membrane control sites and sites treated with bone graft only (Nemcovsky et al. 2000b).

A number of authors have questioned the need to use barrier membranes with immediate implant placements. Autogenous bone alone has been shown to successfully promote bone regeneration (Becker et al. 1994a; Schwartz-Arad & Chaushu 1997b). Other studies have suggested that neither grafts nor membranes are required for immediate implant success. In a histological case report (Wilson et al. 1998) and a prospective clinical histological study of immediate implant sites (Paolantonio et al. 2001) with horizontal defect dimensions of less than 2 mm, spontaneous bone fill occurred within these defects without grafts or membranes. Five year success rates of 93.3% have been reported for immediate implants placed without grafts or barrier membranes (Becker et al. 1998).

Thus, although some studies suggest that various combinations of bone grafts and membranes are effective at immediate implant defects, these augmentation techniques may not always be necessary (Gelb 1999). It has recently been concluded that there was no consensus regarding indications for use of barrier membranes and bone grafts, either alone or combined, in defects associated with immediate implant placements (Schwartz-Arad & Chaushu 1997a; Mayfield 1999). Therefore, the aim of the present clinical investigation was to compare different combinations of barrier membranes and autogenous bone grafts for bone augmentation at immediate implants.

Material and methods

Selection criteria

A total of 62 consecutive patients were recruited from a private specialist periodontal practice. Patients were selected on the basis that they provided informed written consent, were over the age of 18 years, and that immediate implant placement was planned in one maxillary anterior or maxillary premolar tooth site. Patients were excluded if there was acute infection, suppuration or sinus formation associated with the tooth, or if they smoked. Patients were also excluded if there were psychological or systemic contraindications to treatment.

Clinical procedure

Preparation for surgery was made according to standard protocols. Following administration of local anaesthesia (0.2% xylocaine with 1 : 80,000 adrenaline, Astra Pharmaceuticals, Sydney, Australia), inverse-bevel incisions were made on the buccal and palatal aspects of teeth to be extracted and sulcular epithelium removed. Full thickness mucoperiosteal flaps were raised with vertical releasing incisions where necessary. Teeth were carefully luxated and removed with forceps. Care was taken not to fracture the labial plate of bone and to retain gingival tissue attachment at the mesial and distal crestal bone. Extraction sockets were debrided with hand instruments to remove granulation tissue and prepared for implantation according to the technique described by Becker & Becker (1990). Titanium implants with a turned surface (Branemark System, Nobel Biocare, Gothenburg, Sweden) were then placed with the collar of the implant at the level of the bone crest on the labial aspect. Where the labial plate was damaged or absent, the level of the labial crest prior to loss was estimated in the following way: a periodontal probe was placed horizontally at the bone crest of intact portions of the labial plate on either side of the dehiscence defect. The implant was then placed with the collar positioned at this level. All implants were placed with primary stability and were completely housed within the extraction socket.

Following implant placement, the following measurements were taken with a calibrated Williams periodontal probe to the nearest millimetre:

1. Vertical height of the defect (VDH) measured from the most apical extent of the defect to the coronal aspect of the implant collar.
2. Horizontal width of the defect (HDW) measured mesio-distally at the most labial extent of the implant collar.
3. Horizontal depth of the defect (HDD) measured bucco-lingually from the most buccal extent of the implant collar to the labial bone crest. At dehisced sites, the HDD was estimated by measuring the horizontal distance from the implant collar to a periodontal probe placed against the intact portions of the labial plate at the level of the implant collar.
4. Horizontal distance from the labial plate to the collar of the implant at the mid-buccal aspect.

In addition, the presence or absence of dehiscences or fenestrations of the labial plate were recorded.

Following implant placement, the resultant peri-implant defect was treated randomly in one of five ways:

1. e-PTFE membrane alone (Goretex Augmentation Material G-TAM™, WL Gore & Associates, Flagstaff, AZ, USA);
2. bioresorbable membrane alone (Resolut™; WL Gore & Associates);
3. bioresorbable membrane (Resolut™) with autogenous bone graft;
4. autogenous bone graft alone without membrane; and
5. control – no membrane or bone graft.

When used, barrier membranes were trimmed and adapted to ensure that implants and peri-implant defects were completely covered. Membranes were tucked beneath the palatal and buccal flaps and extended at least 3–4 mm apical to the crestal bone. Interproximally, care was taken to ensure that the edges of the membranes were at least 1 mm from the proximal surfaces of adjacent teeth. Bioresorbable and e-PTFE membranes were adapted in the same way. When used, autogenous bone was obtained as an osseous coagulum during the drilling procedure and harvested by means of a filter attached to a dedicated suction line (Osseous Coagulum Trap, Quality Aspirators, Duncanville, TX, USA). Wound closure was achieved by use of connective tissue grafts harvested from the palate, according to the technique described by Chen & Dahlin (1996). Flaps were closed with e-PTFE sutures (WL Gore & Associates).

Postoperatively, amoxycillin (500 mg t.d.s.) was prescribed for 7 days (erythromycin (250 mg q.i.d.) for 7 days if the patient was allergic to penicillin). Patients were instructed to refrain from mechanical plaque removal around the implant sites and to rinse twice daily with 0.2% solution of chlorhexidine digluconate (Periogard, Colgate, Sydney, Australia) for 2 weeks. Sutures were then removed and mechanical plaque removal reinstituted at the implant sites.

After a healing period of 6 months, implant sites were re-entered surgically for connection of healing abutments. At this time, peri-implant defect dimensions were recorded. Non-standardised periapical radiographs were obtained at this time. Patients were then recalled following insertion of the final prosthesis and again at 12 and 24 months following prosthesis insertion.

Data analysis

Analysis of variance (ANOVA) models were used to test differences in means between groups. Post hoc multiple comparison tests were performed when significant differences were found. The gender differences between groups in Table 1 and healing patterns differences between groups were tested using the Pearson χ^2 test. All analyses were carried out using the statistical package SPSS (SPSS 2001).

Results

Demographic profile and baseline data

Of the 62 patients recruited for the study, 29 (46.8%) were male and 33 (53.2%) were female. The number of patients included in each treatment group, age and gender are presented in Table 1. The mean age of patients at the commencement of the study was 41.8 years. There were no significant differences between the treatment groups in relation to age and gender.

Reasons for extractions were as follows: root fracture (53.2%), root resorption (17.7%), persistent endodontic infection (11.3%), caries (8.1%), trauma (8.1%) and chronic periodontitis (1.6%). All teeth extracted were in the maxilla and included 31 (50%) maxillary central incisors, 17 (27.4%) maxillary lateral incisors, 11 (17.7%) maxillary canines and three (4.8%) premolars. No significant differences were found between groups for sites and indications for extraction. The mean initial defect dimensions for height, width and depth are also presented in Table 1 and no significant differences were found between groups for these initial measurements.

Post-operative healing

At 56 of the 62 sites (90.3%), healing progressed uneventfully. Revascularisation of the connective tissue grafts resulted in complete mucosal coverage of the extraction sites. However, adverse healing was noted at six sites (9.7%). Two of these sites (one each in Groups 3 and 4) developed abscesses soon after placement. This resulted in loss of one implant at one site (Group 4). The implant at the other site was successfully retained following treatment of the infection with systemic antibiotics (amoxycillin, 1.5 g daily for 5 days).

At four sites (two in Group 2 and one each in Groups 3 and 4), the connective tissue grafts failed to incorporate completely, resulting in partial exposure of the implant cover screw at three sites and complete exposure of the implant cover screw at one site. Patients were instructed to apply 0.2% chlorhexidine digluconate gel (Periogard Gel, Colgate) twice daily to the exposed cover screws until surgical re-entry at 6 months.

Thus, surgical re-entry and connection of temporary healing abutments occurred at 61 implants. One implant in treatment Group 4 subsequently developed a peri-implant infection 6 weeks after surgical re-entry and was later removed. The remaining 60 implants were restored with single implant-supported crowns with no

***Table 1*. Patient demographics and mean initial vertical defect height (VDH), mean initial horizontal defect depth (HDD) and mean initial horizontal defect width (HDW)**

Group	Treatment	*N*	Age (% male)	Initial VDH (mm)	Initial HDD (mm)	Initial HDW (mm)
1	e-PTFE membrane only	12	42.0 ± 3.2* (25)	8.4 ± 0.5	2.6 ± 0.2	5.0 ± 0.5
2	Resorbable membrane only	11	43.2 ± 3.6 (36.4)	7.5 ± 0.7	2.5 ± 0.3	5.3 ± 0.4
3	Resorbable membrane + bone	13	40.3 ± 2.9 (46.2)	9.1 ± 0.7	2.1 ± 0.2	5.3 ± 0.2
4	Bone graft only	14	42.0 ± 2.7 (64.3)	9.9 ± 0.5	2.2 ± 0.2	5.3 ± 0.3
5	Control	12	41.9 ± 3.8 (58.3)	9.7 ± 0.6	2.0 ± 0.3	5.0 ± 0.3

e-PTFE, expanded polytetrafluoroethylene.
*mean±SE.

losses or complications observed over a 2-year post-restoration period. The 2-year survival rate was 96.8%.

Treatment results

Percentage changes in defect dimensions are presented in Table 2 and Fig. 1. Techniques employed in all five treatment groups were found to be effective in reducing mean VDH, HDW and HDD of the initial peri-implant defects. The reduction in VDH ranged from 5.4 to 7.8 mm (69.1–83.1%) and the reduction in HDD ranged from 1.5 to 1.9 mm (69.2–89.7%) between groups (Table 2). The differences in these reductions between treatment groups were not statistically significant. The results indicate that the various combination of membranes and/or bone grafts used in the present study had no additive effect on the reduction of VDH and HDD when compared with control sites.

In contrast, significant differences were observed between treatment groups for reduction in HDW (range, 1.8–3.8 mm; $P = 0.02$) and percentage reduction in HDW (range, 34.1–71.2%; $P = 0.006$) (Fig. 1). Significantly greater HDW reductions were observed in 'membrane' Groups 1, 2 and 3 when compared with Group 4 and control Group 5 where no membranes were used. The results indicate a better reduction in HDW when either resorbable or non-resorbable membranes were used. No differences were found between the membrane Groups 1, 2 and 3.

Differences between groups were also observed for labial plate resorption (Fig. 1). Resorption between groups ranged from 0.5 to 1.6 mm ($P = 0.04$) or 22.9–64.1% ($P = 0.002$). Group 1 showed significantly less percentage resorption than Groups 2, 3 and 5. Groups 2 and 3 had significantly more resorption than Group 4. These findings indicate that treatments involving non-resorbable membrane alone or bone graft alone were associated with less labial plate resorption. Interestingly, use of resorbable membranes either alone or in conjunction with bone graft showed the greatest degree of resorption.

A total of 19 out of 61 sites were found to have a dehiscence defect of the labial plate at the time of extraction. Dimensions of the dehiscence defects ranged from 2 to 9 mm in height and 2–6 mm in width at the labial crest. No differences were found between treatment groups with respect to VDH and HDD reductions on comparing intact sites with dehisced sites.

Treatment outcomes were evaluated for sites treated with membranes (Groups 1–3) and compared with sites treated without membranes (Groups 4 and 5) (Fig. 2). A mean HDW reduction of 66.6% was achieved when membranes were used compared with 37.7% when membranes were not used ($P < 0.001$). In the presence of a dehiscence defect, the use of membranes reduced the HDW of the defect by 52.5% compared with 32.3% when no membrane was used ($P = 0.04$). Similar effects were not observed for VDH and HDD reduction. Thus, the use of membranes had a positive effect on HDW reduction at both intact sites and dehisced sites.

An analysis of resorption of the buccal plate of bone in relation to the condition of the buccal plate is presented in Fig. 3. Mean resorption of 63.6% was observed at dehisced sites compared with 40.6% at intact sites ($P = 0.005$). This showed that over 50% more resorption of the labial plate occurred in the presence of a dehiscence of the labial plate when compared with intact sites, irrespective of the treatment employed.

A further analysis was performed to estimate the initial defect depth at the level of the regenerated bone using the formula dRB = (initial defect depth × gain in bone height)/initial defect height (Table 3). This was found to range from 1.5 to 1.8 mm with no significant differences between groups.

At re-entry, four patterns of bone healing were observed at the peri-implant defects. Complete fill of bone was seen at 23% of sites and dehiscence defects with no bony walls was observed at 34.4% of sites. Remaining sites healed with three-wall or moat defects (26.2%) or a combination of a dehiscence and moat defect (16.4%). Thus, the majority of sites healed with a residual defect. No differences were seen between groups with respect to the pattern of healing (Pearson χ^2 test; $P > 0.05$). Group 3 sites showed the best clinical outcome with 46.2% of sites healing with complete bone fill. The most frequent pattern of healing at Group 4 and 5 sites was a dehiscence defect.

Discussion

In this prospective clinical study of 62 immediate dental implants it was found that the connective tissue grafts at six sites (9.7% of sites) did not incorporate completely, resulting in exposure of the underlying implants at four sites and abscess formation at two sites. This relatively low complication rate is in agreement with other studies using connective tissue grafts and pedicle flaps of the palatal mucosa for wound closure (Chen & Dahlin 1996; Nemcovsky et al. 2000a). In contrast, studies using buccal flap advancement techniques at immediate implants have reported complication rates ranging from 15% to 67% when used in conjunction with e-PTFE membranes (Gher et al. 1994; Mensdorff-Pouilly et al. 1994; Becker et al. 1994b; Augthun et al. 1995) and 16% with bone graft alone (Schwartz-Arad & Chaushu 1997b).

Premature exposure of implants at immediate extraction sites has been associated with reduced volumes of bone regeneration when compared with unexposed sites (Becker et al. 1994a; Gher et al. 1994). In the current study however, only one out of four sites with premature exposure showed unsatisfactory bone regeneration. This suggests that bone regeneration may not always be compromised

Table 2. **Effect of treatment on percentage reduction in vertical defect height (VDH) and horizontal defect depth (HDD)**

Group	Treatment	Percentage VDH reduction	Percentage HDD reduction
1	e-PTFE membrane only	74.9 ± 8.0*	73.6 ± 8.8
2	Resorbable membrane only	69.1 ± 8.3	75.8 ± 10.3
3	Resorbable membrane + bone	83.1 ± 6.6	89.7 ± 5.5
4	Bone graft only	75.3 ± 5.8	75.6 ± 7.2
5	Control	73.6 ± 7.0	69.2 ± 12.8

e-PTFE, expanded polytetrafluoroethylene.
*mean±SE.

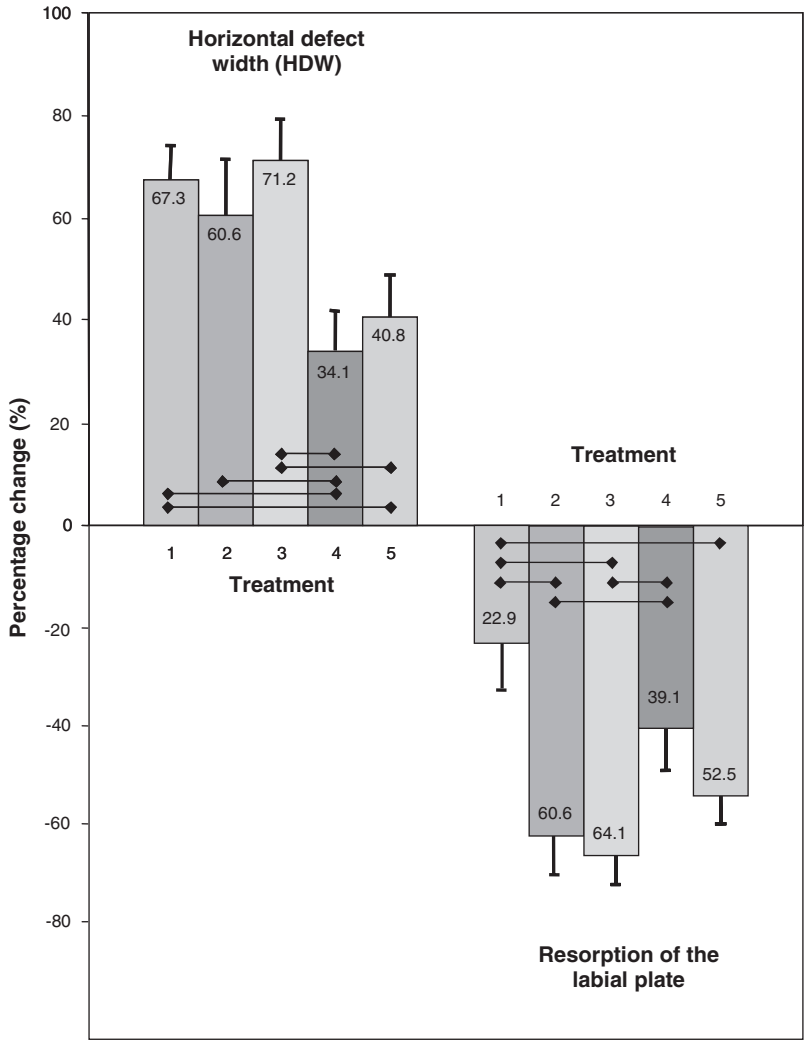

Fig. 1. Effect of treatment on percentage reduction in horizontal defect width (HDW) and resorption of the labial plate by treatment group (connecting bars indicate significant differences between treatment groups $P<0.01$). Treatment Group 1, expanded polytetrafluoroethylene membrane only; 2, resorbable membrane only; 3, resorbable membrane + bone; 4, bone graft only and 5, control.

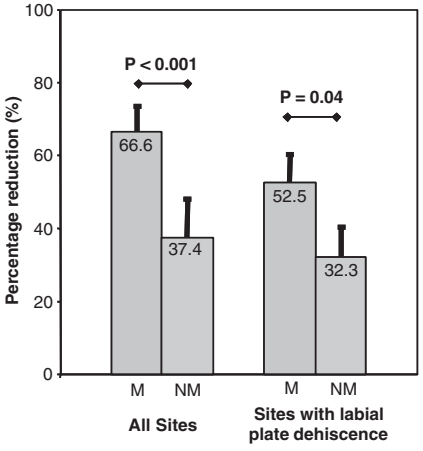

Fig. 2. Percentage reduction in horizontal defect width (HDW) at sites with barrier membranes (M) vs. sites without barrier membranes (NM) at all sites and at sites with labial plate dehiscence defects.

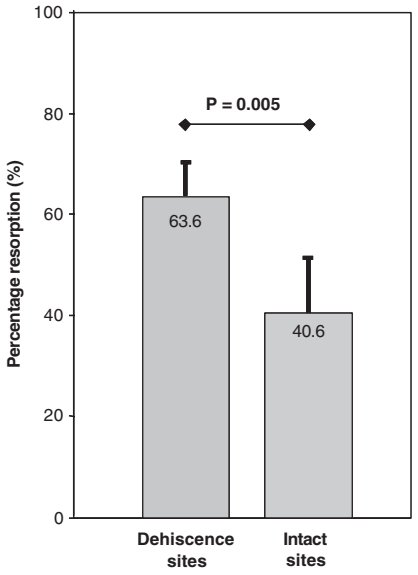

Fig. 3. Percentage resorption of labial plate at sites with dehiscence defects vs. sites with no dehiscence (all groups).

provided meticulous plaque control is maintained. In this regard, resorbable membranes may have an advantage over non-resorbable membranes that tend to promote penetration and migration of bacteria once exposed to the oral environment (Simion et al. 1994; Zitzmann et al. 1997). At two sites with abscess formation, bone regeneration was found to be poor. This is consistent with other reports of reduced bone regeneration at infected sites (Novaes et al. 1998; Grunder et al. 1999).

The most significant clinical parameter in determining successful bone regeneration at immediate implants is the reduction in VDH. In the current study, both VDH and HDD reduction were similar in treatment and control groups indicating that use of membranes and/or bone grafts had no additive effect on bone regeneration for these two parameters. This is in agreement with several reports that have shown that barrier membranes and bone grafts may not be required for successful bone regeneration at immediate implants (Becker et al. 1998; Wilson et al. 1998; Paolantonio et al. 2001). In an undisturbed extraction socket, early osteoid formation begins after 7 days, mineralisation commences at 21 days and is well advanced by 6 weeks (Amler 1969). Thus, it would be reasonable to expect spontaneous bone regeneration to occur at immediate implants provided that the blood clot remains protected, irrespective of graft or membrane use.

Previous studies have reported VDH reductions ranging from 3.6 to 5.8 mm using different regenerative techniques (Becker et al. 1994a, 1994b; Gher et al. 1994; Schwartz-Arad & Chaushu 1997b). In these studies, initial defect heights ranged from 2.4 to 8.4 mm. In the current study, a greater VDH reduction was observed (mean 7 mm). The enhanced result is likely to be because of the larger size of the initial defects in the current study sample (mean initial defect height of 9 mm). Thus, it would seem more appropriate to report defect reductions in terms of percentage change rather than actual change. In the current study, an overall percentage defect height reduction

***Table 3*. Effect of treatment on initial horizontal defect depth (HDD) at the level of regenerated bone (RB)**

Group	Treatment	Estimated defect depth at RB (mm)
1	e-PTFE membrane only	1.8 ± 0.2*
2	Resorbable membrane only	1.8 ± 0.3
3	Resorbable membrane + bone	1.7 ± 0.2
4	Bone graft only	1.6 ± 0.2
5	Control	1.5 ± 0.3

e-PTFE, expanded polytetrafluoroethylene.
*mean±SE.

of 75.4% was found. This was similar to the percentage reduction reported in studies comparing anorganic bovine bone graft with or without resorbable membrane (Nemcovsky et al. 2000b) and at immediate implants with anorganic bovine bone and resorbable collagen membrane (Nemcovsky et al. 2002). In contrast, percentage height reductions of over 85% were noted at implants placed using a 'delayed-immediate' protocol 4–6 weeks after extraction (Nir-Hadar et al. 1998; Nemcovsky et al. 2002).

The reasons for the limit in VDH reduction with immediate implants remain unclear. One possibility may be that extraction sockets have a limited potential for regeneration amounting to about 75% of the initial defect height because of the loss of crestal bone as part of physiological remodelling. Several authors have noted 1–3 mm loss of crestal bone height in the first 6 months following tooth extraction (Johnson 1963; Lekovic et al. 1998; Camargo et al. 2000). In contrast, percentage defect reductions of 85% or more have been reported around immediate implants using allografts (Goldstein et al. 2002) and xenografts (Zitzmann et al. 1997, 1999; Hammerle & Lang 2001). These bone substitutes have slow resorption rates, which may reduce crestal bone loss and enhance defect fill.

Another possible explanation may be that vertical bone regeneration is related to the distance between the socket wall and surface of the implant, or the horizontal defect dimension (Wilson et al. 1998). There has been limited human histology to show that bone regeneration with osseointegration occurs when horizontal defect dimensions are less than 2 mm (Wilson et al. 1998; Cornelini 2000; Paolantonio et al. 2001). In the current study, vertical bone regeneration occurred to a height where the initial HDD was 1.5–1.8 mm (mean, 1.7 mm). This finding may provide further evidence of a critical horizontal defect dimension of about 2 mm beyond which bone apposition to the implant may not predictably occur. It should be noted that the present study used implants with a turned surface. A recent human histological study reported that bone regeneration and osseointegration can be achieved in horizontal defects of 4 mm or more at implants with sand-blasted and acid-etched surfaces (Wilson et al. 2003), indicating that implant surface characteristics may influence the critical defect dimension.

A surprising finding of the current study was that VDH and HDD reductions were not adversely affected by the presence of labial plate dehiscence defects. Furthermore, the clinical outcomes at dehisced sites were not enhanced with membrane and/or bone graft usage when compared with controls. This is at odds with recommendations by others that regenerative techniques are necessary when the labial plate is damaged (Gelb 1993, 1999; Salama & Salama 1993; Gher et al. 1994; Schwartz-Arad & Chaushu 1997a; Nemcovsky et al. 2000a). In the current study, implants were placed well within the confines of the extraction sockets and at least two bony walls remained. It is likely that despite the presence of dehiscence defects of the labial plate, natural space maintaining properties and protection of the blood clot were retained. Thus, the results suggest that membranes and/or bone grafts are not required for VDH and HDD reduction at immediate implants under the defect conditions of the present study. However, we did find that HDW reduction was enhanced when membranes were used. Furthermore, membranes were found to improve HDW reduction when dehiscence defects of the labial plate were present. The clinical relevance of this outcome is unclear.

In the current study, labial plate resorption of greater than 50% occurred with the control group (Group 5) and resorbable-membrane-treated groups (Group 2 and 3). Significantly less labial plate resorption occurred in the non-resorbable-membrane-treated group (Group 1) and where bone graft only was used (Group 4). This is consistent with previous studies showing maintenance of the bone crest width using e-PTFE membranes in experimental defects (Becker et al. 1991). An interesting observation was that use of resorbable membranes in Groups 2 and 3 resulted in greater labial plate resorption than bone graft alone (Group 4). This may suggest that polylactide/polyglycolide copolymer membranes (Resolut™) have a detrimental effect on bone regeneration possibly because of degradation products of the copolymer and decreasing membrane stability that occurs at the later stages of wound healing (Hürzeler et al. 1997; Schliephake et al. 2000). The degree of resorption with bone graft alone (Group 4) was similar to use of e-PTFE membranes alone. A further observation was that resorption was 58% greater in the presence of a labial plate dehiscence defect compared with intact sites. The combinations of membranes and/or bone grafts did not alter the treatment outcome. The clinical impact of the large differences in labial plate resorption between groups is unknown. However, it has been suggested that bone loss during the healing and remodelling phase of implant treatment may adversely affect the aesthetic results of anterior implant reconstructions (Avivi-Arber & Zarb 1996). In this context, allografts or xenografts with slower resorption rates may be a better alternative to autogenous bone for reconstruction of labial plate dehiscence defects (Hämmerle et al. 1998).

Conclusions

It may be concluded from this study that:

1. VDH and HDD reduction at immediate implants can be achieved without the need for membranes and/or bone grafts, provided that implants are placed well within the confines of the

socket and at least two intact bony walls remain.
2. Membranes increase HDW reduction; however, the clinical significance of this is unclear.
3. Where the labial plate is damaged, significant resorption of the labial plate occurs irrespective of membrane and/or bone graft use. This may have negative implications at aesthetically sensitive sites. In these situations, the use of barrier membranes and bone grafts or substitutes with slower resorption rates merits further investigation.

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Résumé

L'efficacité des associations membranes et grefffes d'os autogène au niveau d'implants immédiats a été comparés dans cette étude prospective. Soixante-deux patients ont reçu un implant immédiat pour le remplacement d'une dent unique au niveau antéro-maxillaire ou prémolaire. Les dimensions de la lésion paroïmplantaire au niveau du collet de l'implant ont été mesurées de la manière suivante : hauteur de la lésion verticale (VDH), profondeur de la lésion horizontale (HDD) et largeur de la lésion horizontale (HDW). Chaque implant a reçu de manière randomisée un des cinq traitements d'épaississement et a été enfoui avec des greffons de tissu conjonctif : groupe 1 ($n = 12$) membrane en téflon, groupe 2 ($n = 11$) membrane en copolymère polyglycolide/polylactide résorbable, groupe 3 ($n = 13$) membrane résorbable et greffon osseux autogène, groupe 4 ($n = 14$) greffon osseux autogène et groupe 5 ($n = 12$) ni membrane ni greffon. Lors de la réentrée tous les groupes accusaient une réduction significative de VDH, HDD et HDW. Les comparaisons entre les groupes n'ont montré aucune différence significative de réduction VDH (moyenne 75,4%) et de HDD (77,0%). Les différences significatives nt été observéees entre les groupes pour la réduction d'HDW (de 34 à 67,3%), avec les groupes traités par membrane 1, 2 et 3 montrant la plus importante réduction. En présence de déhiscence au niveau vestibulaire la réduction HDW de 66,6 % a été obtenue avec la membrane comparée à 37,7 % sans membrane. Plus de 50% de résorption au niveau vestibulaire se présentaient en présence de déhiscence quel que soit le type de traitement utilisé. Les résultats indiquent que la réduction VDH et HDD au niveau de lésions adjacentes à des implants immédiats peut être effectuée sans l'utilisation de membranes ou de greffons osseux ou des deux.

Zusammenfassung

In einer Langzeitstudie verglich man die Wirksamkeit einer Kombination von Membranen und autologen Knochentransplantaten bei Sofortimplantaten. 62 fortlaufend behandelte Patienten erhielten je ein Sofortimplantat zum Ersatz eines verloren gegangenen Einzelzahnes in der Oberkieferfront – oder prämolarenregion. Die Grösse der periimplantären Defekte am Implantathals wurde wie folgt vermessen: vertikale Defektgrösse (VDH), horizontale Defekthöhe (HDD) und horizontaler Defektdurchmesser (HDW). Für jedes der Implantate wählte man zufällig eines der folgenden fünf Augmentationsverfahren und deckte die Implantate anschliessend mit einem Bindegewebstransplantat ab: Gruppe 1 ($n = 12$) – nur ePTFE-Membran, Gruppe 2 ($n = 11$) – nur resobierbare Polylactide/Polyglycolide Membran, Gruppe 3 ($n = 13$) – resorbierbare Membran und autologes Knochentransplantat, Gruppe 4 ($n = 14$) – nur autologes Knochentransplantat, und Gruppe 5 ($n = 12$) – keine Membran und kein Knochentransplantat/Kontrolle. Bei der Wiedereröffnung zeigten alle Gruppen eine signifikante Abnahme der VDH, HDD und HDW. Der Vergleich unter den Gruppen zeigt keine signifikanten Unterschiede bei der Abnahme der VDH (Mittelwert 75.4%) und der HDD (Mittelwert 77%). Bei der Abnahme der HDW fand man allerdings signifikante Unterschiede zwischen den verschiedenen Gruppen (Mittelwerte zwischen 34.1% und 67.3%), wobei die mit Membranen behandelten Gruppen 1, 2 und 3 die grössten Reduktionen zeigten. Wenn zu Beginn bei der labialen Knochenwand ein Dehiszenzdefekt vorhanden war, konnte bei der HDW mit Membraneinsatz eine Reduktion von 66.6% erreicht werden, ohne Membranen jedoch nur eine von 37.7%. Bei einer Wunddehiszenz kam es zu einer bis zu 50% grösseren Resorption der labialen Knochenwand, unabhängig von der verwendeten Augmentationsmethode.
Diese Resultate zeigen, dass die Reduktion der VDH und HDD bei den um Sofortimplantaten vorhandenen Defekten auch ohne den Einsatz von Membranen und/oder Knochentransplantaten erreicht werden kann.

Resumen

Se comparó la eficacia de la combinación de membranas con injertos de hueso autógeno en implantes inmediatos en un estudio prospectivo. Sesenta y dos pacientes tratados consecutivamente recibieron un implante inmediato cada uno para sustitución de un diente unitario en un lugar de la zona maxilar anterior o premolar. Se midieron las dimensiones del defecto periimplantario en el cuello del implante de la siguiente manera: altura del defecto vertical (VDH), profundidad del defecto horizontal (HDD) y anchura del defecto horizontal (HDW). Cada implante recibió de forma aleatoria uno de cinco tratamientos de aumento y se sumergieron con injertos de tejido conectivo: Grupo 1 ($n = 12$) – membrana de ePTFE únicamente, Grupo 2 ($n = 11$) – membrana reabsorbible de copolimero poliláctido/poliglicólido, Grupo 3 ($n = 13$) – membrana reabsorbible e injerto de hueso autógeno, Grupo 4 ($n = 14$) – injerto de hueso autógeno únicamente, y Grupo 5 ($n = 12$) – sin membrana y sin injerto como control. A la reentrada, todos los grupos mostraron en reducción significativa en VDH, HDD Y HDW. Las comparaciones entre los grupos no mostraron diferencias significativas para la reducción de VDH (media 75.4%) y de HDD (media 77%). Se observaron diferencias significativas entre los grupos para reducción de HDW (rango 34.1–67.3%), con los grupos tratados con membrana 1, 2 y 3 mostrando la mayor reducción. En presencia de defectos de dehiscencia de la placa labial, la reducción de HDW del 66.6% se logró con el uso de la membrana comparado con el 37.7% sin membranas. Más de un 50% de reabsorción de la placa labial tuvo lugar en presencia de un defecto de dehiscencia irrespectivamente del tratamiento de aumento utilizado. Los resultados indican que la reducción de VDH y de HDD en defectos adyacentes a implantes inmediatos puede lograrse sin el uso de membranas y/o injertos óseos.

要旨
即時埋入インプラント部位でのメンブレンと自家骨移植の併用の有効性について前向き試験で比較検討した。連続６２名の患者において、上顎前歯部または臼歯部の単独歯牙修復のために各々１本の即時インプラントを埋入した。インプラント埋入前の欠損について、インプラント頚部での以下の寸法を測定した；欠損の垂直的高さ（VDH）、欠損の水平的深さ（HDD）と欠損の水平的幅径（HDW）。各インプラントを無作為に以下の５つの増生治療法の１つに割り振った；１群（ｎ＝１２）－ePTFEメンブレンのみ、２群（ｎ＝１１）－吸収性ポリ乳酸／ポリグリコライド・コポリマー・メンブレンのみ、３群（ｎ＝１３）－吸収性メンブレンと自家骨移植、４群（ｎ＝１４）自家骨移植のみ、５群（ｎ＝１２）メンブレン無し、骨移植無しの対照群。二次手術時に全てのグループにおいてVDH、HDDとHDWは有意に減少していた。群間比較ではVDH（平均７５．４％）とHDD（平均７７．０％）の減少には有意差はなかった。HDWの減少（３４．１％－６７．３％の領域）には群間に有意差が認められ、メンブレンを用いた１、２、３群が最大限に減少した。唇側骨板の裂開型欠損の存在下では、HDWはメンブレン使用群で６６．６％、メンブレン無しの群では３７．７％減少した。採用した増生法にかかわらず裂開型欠損の存在下では５０％以上の唇側骨板の吸収が起こった。本結果は、即時埋入インプラントに隣在する欠損でのVDHとHDDは、メンブレン及び/あるいは骨移植無しに減少させることが可能であることを示唆している。

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