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Clinical and Radiographic Evaluation of Single-Tooth Dental Implants Placed in Grafted Extraction Sites: A One-Year Report

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Abstract

Objective: The aim of this report was to clinically and radiographically evaluate changes to the hard and soft tissues around implants placed in extraction sockets grafted with medical grade calcium sulfate hemihydrate (MGCSH) mixed with platelet-rich plasma (PRP) and a collagen resorbable plug after one year of function.

Methods: This evaluation was part of a previous study conducted to evaluate extraction socket grafts. Fourteen subjects out of 16 were evaluated. After tooth extraction, eight subjects received MGCSH mixed with PRP in the extraction sockets (test group), and six subjects received collagen resorbable plug dressing material (control group). After three months of bone healing, dental implants were placed. Three months after implant installation, provisional restorations were placed and implants were loaded in function for one month followed by definitive restorations. Follow-up examinations and intraoral digital radiographs were made at baseline and one year after definitive restorations to evaluate the marginal bone level in each subject.

Results: At the one-year follow-up, the survival and success rate was 100% for all implants. There was no statistically significant difference in the amount of vertical bone loss between groups after 1year ($p > 0.05$). For the test group, there was a mean mesial bone loss of -0.8 ± 0.6mm and a mean distal bone loss of -0.5 ± 0.4mm. For the control group, there was a mean mesial bone loss of -1.1 ± 0.7mm and a mean distal bone loss of -0.6 ± 0.6mm.

Conclusions: At the one-year follow-up, the implant placement in grafted sockets was not affected by the type of the graft material. Implants placed in sockets grafted with MGCSH mixed with PRP showed less marginal bone loss after one year in comparison to those with collagen resorbable grafts.

Key words: Dental implant, tissue regeneration, implant abutment, extraction sockets

Introduction

Dental implant treatment is considered a safe and predictable method of replacing extracted or missing teeth. The ultimate aim of an implant-supported restoration is to offer a predictable treatment, to restore missing or extracted teeth by placing implants in anatomically, esthetically, and functional restorative positions for long-term patient benefit. Success rates for dental implants are reported to be greater than 90% (Albrektsson *et al.*, 1986; Albrektsson and Isidor, 1994; Roos *et al.*, 1997).

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Extraction socket wound healing is characterized by resorption of the alveolar bone at the extraction site. This bone resorption results in esthetic and restorative challenges that reduce the bone volume available for implant placement. Major changes in an extraction socket occur during the first year after tooth extraction, with two thirds of the bone loss occurring within the first 3 months (Fickl *et al.*, 2008a; Johnson, 1969; Lam *et al.*, 1960; Schropp *et al.*, 2003; Van der Weijden *et al.*, 2009). In a recent systematic review, an average of 3.8 mm reduction of buccolingual bone width and 1.24 mm reduction of apicocoronal bone height after 6 months of tooth extraction were reported (Hämmerle *et al.*, 2012). Several factors contributed to the variations in osseous resorption after tooth extraction: the size of the socket has a major effect on the rate of healing, i.e., healing of a wide socket takes longer than a narrow socket (Schropp *et al.*, 2003); facial bone architecture and thickness has an impact on the rate and amount of alveolar ridge remodeling (Kan *et al.*, 2007); the rate of ridge remodeling is faster in the maxilla than in the mandible (Atwood and Coy, 1971); gingival biotype,

surgical trauma, flap elevation, and presence of infection also have an effect on bone remodeling in the extraction sites. The dynamics of bone regeneration in tooth extraction sockets have been described as initial clot formation, which is then replaced with granulation tissue, connective tissue, and bone formation, respectively (Amler, 1969; Cardaropoli *et al.*, 2003

Alveolar bone preservation following tooth extraction has a major advantage on the esthetic outcome of final restorative treatment. The extraction socket preservation technique implies preservation of the alveolar architecture (Bartee, 2001; Cardaropoli and Cardaropoli, 2008; Darby *et al.*, 2009; Fickl *et al.*, 2008b; Fickl *et al.*, 2008c; Hoffmann, 2008; Iasella *et al.*, 2003; John *et al.*, 2007; Keith and Salama, 2007; Kutkut *et al.*, 2012a; Lekovic *et al.*, 1998; Lekovic *et al.*, 1997; Misch and Silc, 2008). Several classifications of extraction sockets have been proposed to provide clinical guidelines on alveolar ridge preservation to minimize the amount of bone resorption. The thickness of the soft tissue "gingival biotype" as well as the thickness of facial bone are important factors to be considered for the preservation of extraction sockets (Juodzbalys *et al.*, 2008; Elian *et al.*, 2007). However, a well-documented animal study showed that bone graft particles placed in fresh extraction sockets has a positive effect on ridge resorption (Araújo *et al.*, 2008). The potential benefit of socket preservation therapy was documented and resulted in significantly less vertical and horizontal resorption of the alveolar bone crest. The scientific evidence does not provide clear guidelines in regards to the type of biomaterial, or surgical procedure (Vignoletti *et al*, 2012). Sometimes synthetic bone substitutes are a predictable clinical alternative bone graft when patients reject receiving allografts or xenografts for treatment.

Calcium sulfate ($CaSO_4$) is a biocompatible, osteoconductive, and bioabsorbable biomaterial that is widely used in bone grafting and dental devices as a bone substitute. This material is well tolerated by the recipients. It has been histologically demonstrated that $CaSO_4$ is completely resorbed within 3 months in human fresh extraction sockets and does not interfere with bone healing (Crespi *et al.*, 2009a; Guarnieri *et al.*, 2004; Guarnieri *et al.*, 2005; Kelly *et al.*, 2001; Kutkut and Andreana, 2010; Thomas and Puleo, 2009; Walsh *et al.*, 2003). The combination of $CaSO_4$ and PRP presented a preserved crystalline structure well integrated by organic matrix. This combination showed the highest cell proliferation levels and demonstrated that the PRP was activated when combined with $CaSO_4$. When $CaSO_4$ was used as a carrier for platelet-derived growth factor (PDGF), it showed increased cell proliferation and was an efficient carrier for PRP or PDGF. This supports *in vivo* the use of these combinations as bioactive matrices (Intini *et al.*, 2002; Intini *et al.*, 2007). Extraction socket preservation graft before implant placement with $CaSO_4$ hemihydrate (CSH) and platelet-rich plasma (PRP) showed a new vital bone regeneration percentage of 66.5% in sockets grafted with CSH mixed with PRP compared to 38.3% collagen resorbable plug after 3 months of healing (Kutkut *et al.*, 2012b).

Platelet-rich plasma is commonly used to improve peri-implant bone regeneration, promote bone graft healing, and enhance soft tissue healing with better epithelialization. Further more, PRP delivers growth factors in high concentration to the bone augmentation site. Platelet-rich plasma offers many advantages: it decreases the frequency of intraoperative and postoperative bleeding at the recipient sites, aids in the initial stability of the grafted tissue at the recipient sites as a result of its cohesive and adhesive nature, may promote rapid vascularization of the healing tissue by delivering growth factors, and, in combination with bone replacement materials, induces soft and hard tissue regeneration (Freymille and Aghaloo, 2004; Intini, 2009; Intini *et al.*, 2002; Intini *et al.*, 2007; Marx, 2004; Sanchez *et al.*, 2003; Tozum and Demiralp, 2003; Zechner *et al.*, 2003).

Previous studies indicated that the combination of CSH and PRP used in the test group was successful in preserving the alveolar ridge by limiting the amount of bone resorption following tooth extraction prior to implant placement. Histomorphometric analysis demonstrated creation of greater new vital bone with a significantly higher maturation rate of the healed sockets as compared to the collagen dressing graft material over a 3-month period (Aimetti *et al.*, 2009; Kutkut *et al.*, 2012b; Shi *et al.*, 2007). Intini *et al.* reported on a composite graft engineered by the absorption of PRP onto $CaSO_4$ based on *in vitro* osteoblast proliferation and scanning electron microscopy (SEM) analyses. The combination of $CaSO_4$ and PRP presented a preserved crystalline structure well integrated by organic matrix. This combination showed the highest cell proliferation levels and demonstrated that the PRP was activated when combined with $CaSO_4$. When $CaSO_4$ was used as a carrier for PDGF, it showed increased cell proliferation and was an efficient carrier for PRP or PDGF. This supports the *in vivo* use of these combinations as bioactive matrices (Intini *et al.*, 2002; Intini *et al.*, 2007).

As part of site preparation for implant restoration, placing a graft into an extraction socket provides a scaffold for the in-growth of cellular and vascular components to form new bone of acceptable quality and quantity. Extraction socket preservation, however, is technique-sensitive, not 100% successful, and at times unpredictable. Current techniques may delay implant placement for months, and the quality of regenerated bone is questionable (Darby *et al.*, 2009; McAllister and Haghighat, 2007; Schropp and Isidor, 2008). The remaining crestal bone level around a dental

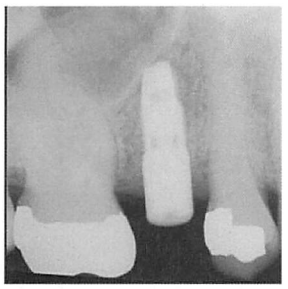


Figure 1A

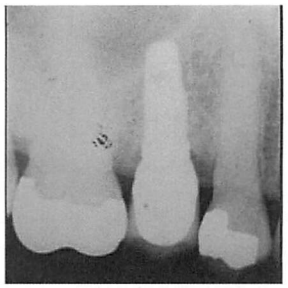


Figure 1B

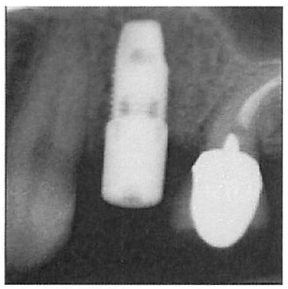


Figure 1C

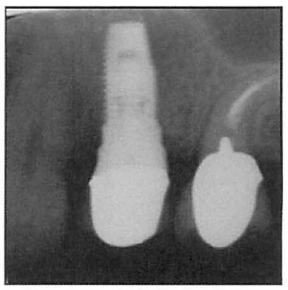


Figure 1D

Figure 1. The implant platform was used as a reference point to measure preoperative and postoperative amount of vertical bone resorption mesially and distally adjacent to dental implant. A, Control group periapical radiograph immediately after implant placement. B, Control group - periapical radiograph 12 months after definitive restoration. C, Test group - periapical radiograph immediately after implant placement. D, Test group periapical radiograph 12 months after definitive restoration.

implant is considered an important criterion to evaluate the success of dental implants. It is an important factor for preserving the marginal gingival and interdental papillae. Several studies have reported that a radiographic marginal bone loss of 1.5 mm during the first year of implant placement followed by a crestal bone loss of 0.2 mm radiographically during each succeeding year is an important criterion for evaluating the implant success (Alberktsson and Isidor, 1994; Choquet *et al.*, 2001; Roos *et al.*, 1997; Tarnow *et al.*, 1992; Tarnow *et al.*, 2000).

The rates and patterns of marginal bone resorption around implants placed in grafted extraction sockets in humans have not been extensively studied. The aim of this follow-up report was to evaluate clinical and radiographic changes to hard and soft tissues around implants placed in extraction sockets grafted with MGCSH mixed with PRP and collagen resorbable plug after one year of rehabilitation.

Materials and methods

This investigation was part of previous study (Kutkut *et al.*, 2012b) approved by the IRB at the State University of New York at Buffalo, Buffalo, NY, and was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000.

Sixteen participants (8 women and 8 men), aged 19 to 75 years (mean age 52 ± 16 years) were included in the study. Four women and four men (mean age 53 ± 19 years; range, 19 to 75 years) were randomly assigned to the test group by a computer-generated randomization table, and four women and four men (mean age 51 ± 14 years; range, 23 to 64) were randomly assigned to the control group *(Table 1)*.

Fourteen out of 16 individuals with a non-restorable single tooth requiring extraction followed by implant placement were enrolled in this investigation. Eight participants received MGCSH bone graft (Dento Gen; Orthogen LLC, Springfield, NJ) mixed with PRP (test group), and eight participants received CRP dressing material (ACE Surgical Supply Inc., Brockton, Mass; control group). Fourteen successful treatment cases that had had bone core samples retrieved and implants placed after 3 months of the grafting procedure were included in this follow-up investigation. Two cases from the control group were excluded because of the failure of implant placements after 3 months of healing.

After 3 months of bone healing, dental implants (Nobel Replace; Nobelbiocare, LLC, Yorba Linda, California) were placed in grafted sites. Three months after implant installation, definitive custom abutments with appropriate emergence profile and interim restorations were fabricated. Zirconia custom abutments were milled for anterior teeth, and titanium custom abutments were milled for posterior teeth.

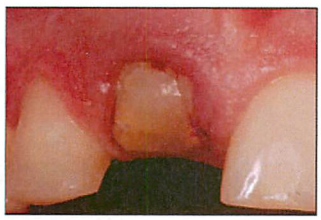
Figure 1A 

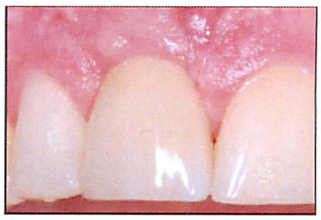
Figure 1B 

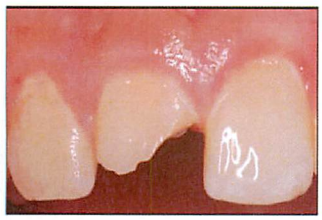
Figure 1C 

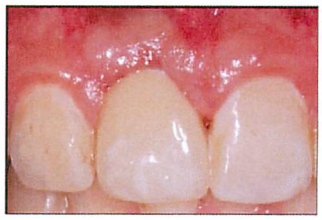
Figure 1D 

Figure 2. Papilla height measurement was referenced clinically to incisal edges of adjacent teeth and performed prior to tooth extraction and 12 months after definitive restoration. A, Control group - Papillae heights prior to extraction surgery. B, Control group - Papillae heights 12 months after definitive restoration. C, Test group - Papillae heights prior to extraction surgery. D, Test group - Papillae heights 12 months after definitive restoration.

Implants were loaded in function by interim restorations for 1 month followed by definitive restorations, which were veneered lithium disilicate crowns for anterior teeth and metal ceramic crowns for posterior teeth. Follow-up examinations were performed and intraoral digital radiographs were made at baseline and 1 year after definitive restorations to evaluate the marginal bone level in each participant. Esthetic outcomes were reported as changes in the position of the papillae. Papillae height measurements were referenced clinically to the incisal edges of adjacent teeth and performed prior to tooth extraction and 12 months after definitive restoration. Means for marginal bone loss and papilla height recession after one year were compared with the Student's 2-sample *t*-test by using the Statistical Package for the Social Sciences program (SPSS 12.0 for Windows software).

Study treatment

The inclusion and extrusion criteria were reported in the previous study (Kutkut *et al.*, 2012b). This study included replacement for maxillary central and lateral incisors, maxillary canines, and maxillary and mandibular premolars. Indications for tooth extraction included root or crown fractures, non-restorable caries and residual roots. Seven anterior teeth replacements in the premaxilla and nine single-rooted posterior teeth replacements (six in the maxilla and three in the mandible) were included in the investigation. All patients had a routine hygiene visit prior to treatment and were followed up every 6 months. Standardized intraoral radiographs were made at baseline immediately after implant placement and at the 1-year follow-up using a collimator device modified with an autopolymerizing resin occlusal index to obtain reproducible radiographic images near the maximum intercuspation position. The implant platform was used as reference point to measure the preoperative and postoperative amount of vertical bone resorption mesially and distally adjacent to the dental implant. Clinical and radiographic measurements were recorded by the same examiner.

Surgical procedure for test group

Extraction of the non-restorable tooth was performed atraumatically (Kutkut *et al.*, 2012a; Kutkut *et al.*, 2012b). The extraction sockets were debrided of any granulation tissue, then filled with the mixture of MGCSH and PRP paste material up to the gingival margin. Resorbable collagen membrane (Con FORM Membrane 15 mm × 20 mm; ACE Surgical Supply Inc.) was inserted just below the free gingival margins without pouch or flap elevation. The membrane was intentionally exposed and secured using a reverse cross mattress resorbable suture (3-0 Vicryl Polyglactin 910 Sutures; ETHICON INC., Piscataway, NJ). After 10 days, wound healing was evaluated and the sutures were removed. Participants returned approximately 3 months after the extraction appointment when the

Table 1. Study population, implant location, diameter x length (mm).

Subject number Control	Gender	Tooth #	Implant
S01	M	4	4.0 x 11.5
S07	M	10	3.5 x 13.0
S10	F	29	4.0 x 11.5
S11	M	20	4.0 x 11.5
S15	F	7	3.5 x 13.0
S16	F	11	4.3 x 13.0
	3 male/ 3 female	3 anterior/ 3 posterior	Nobel Biocare
Test	**Gender**	**Tooth #**	**Implant**
S02	F	8	4.3 x 13.0
S03	M	10	3.5 x 13.0
S05	F	5	4.0 x 11.5
S06	F	5	4.0 x 11.5
S08	M	8	4.3 x 13.0
S09	F	12	4.0 x 11.5
S12	M	20	4.0 x 11.5
S13	M	13	4.0 x 11.5
	4 male/ 4 female	3 anterior/ 5 posterior	Nobel Biocare

bone grafting had healed. At implant surgery, a papilla-sparing crestal incision was made and a full thickness flap reflected. A dental implant (Nobel Replace) was placed after a complete osteotomy, prepared according to implant manufacturer recommendations. Healing abutments or cover screws were placed based on primary stability of the implant and the final implant torque of at least 35 Ncm, and flaps were secured with polytetrafluoroethylene interrupted sutures (ACE, Surgical Supply Inc.). No additional bone graft was needed to cover any part of the implant body. Radiographs were made immediately after the implant placement surgery. All patients received a temporary tooth replacement "treatment partial denture" after extractions. The temporary partial denture was relieved to prevent any pressure or impingement to the grafted site.

Surgical procedure for control group

Surgical protocol for the control group subjects was followed exactly as for the test group except that the extraction socket was grafted with a collagen resorbable plug (CRP).

Restorative protocol

Three months after the implant placements, impression copings were screwed into the internal trilobe of the implant and secured with guide screws. Impressions were made with a polyvinyl siloxane material (PVS; 3M ESPE, St. Paul, Minnesota)using the closed-tray impression technique. Definitive titanium custom abutments (for posterior implants) or zirconia custom abutments (for anterior implants) were milled and screwed into dental implants with 35 Ncm torque. All interim crowns were placed in function with full contact in centric occlusion. After 1 month, definitive complete ceramic or metal ceramic restorations were cemented to the abutments. Occlusion was evaluated with an 8-μm foil (Shimstock Occlusion Foil, Patterson Dental, St. Paul, MN), which was to resist withdrawal only under maximal intercuspation. All implants were restored by the first author. All prosthetic restorations

Table 2. Radiographic results were reported at baseline immediately after implant installations and 12 months from definitive restorations. No statistically significant differences were reported between groups ($p > 0.05$)

Control	Mesial Resorption (mm)	Distal Resorption (mm)
1	-0.5	-0.1
2	-1.8	-1.4
3	-0.8	-0.2
4	-0.8	-1.1
5	-0.5	-0.1
6	-2.0	-0.8
Mean	**-1.1 ± 0.7**	**-0.6 ± 0.6**
Test	**Mesial Resorption**	**Distal Resorption**
1	-1.2	-0.2
2	-1.6	-1.3
3	-0.1	-0.7
4	-0.2	-0.3
5	-1.5	-1.0
6	-0.5	-0.3
7	-0.7	-0.1
8	-0.4	-0.3
Mean	**-0.8 ± 0.6**	**-0.5 ± 0.4**

utilized the manufacturer's (Nobel Biocare) recommended components and protocol.

Follow-up evaluation

Clinical parameters of the implants were checked at baseline and 12 months after definitive restorations for pain, occlusion, and prosthesis mobility. Success criteria for implant survival were: the presence of clinical implant stability, absence of radiolucency around the implants, absence of periimplant mucositis or inflammation, and absence of pain. Clinical examinations and radiographic measurements were performed at baseline and 12 months after definitive restorations *(Figure 1)*. Esthetic outcomes were reported as changes in the position of the papillae. Papillae height measurements were referenced clinically to the incisal edges of adjacent teeth and performed prior to tooth extraction and 12 months after definitive restoration *(Figure 2)*.

Statistical analyses

Data are presented as mean values ± SD. Comparison between groups was performed by the (SPSS) Student's two-sample *t*-test.

Results

Clinical and radiographic findings

Clinical healing was uneventful and free of infection or symptoms in both groups. Age, gender, implant diameter and length did not show significant effects on the clinical outcome of this study.

Surgical and restorative procedures

After 3 months of healing, when implant placement was performed, the test group sockets were completely filled by dense bone. When osteotomies were prepared, the test group bone exhibited greater density, with high resistance to drilling application compared to the control group sockets, which showed less resistance to drilling application. At the 12-month follow-up, a survival rate of 100% was reported for all implants (Misch *et al.*, 2008). No pain or final prosthesis mobility

Table 3. Average papilla recession for mesial and distal sites at the one-year follow-up visit. No statistically significant differences were reported between groups ($p > 0.05$).

Control	Mesial Recession (mm)	Distal Recession (mm)
1	-1	-1
2	-1	0
3	-1	-1
4	-1	0
5	-1	-1
6	-1	-1
Mean	**-1 ± 0.8**	**-0.7 ± 0.5**
Test	**Mesial Recession**	**Distal Recession**
1	0	0
2	-1	-1
3	0	-2
4	-2	-2
5	-1	-1
6	0	0
7	0	0
8	1	0
Mean	**- 0.4 ± 0.9**	**- 0.8 ± 0.9**

was recorded. The wound healing around custom abutments was within normal limits associated with good adaptation of soft tissue to provisional crowns. No mucositis or irritation was found.

Radiographic evaluation

Radiographic results were reported at baseline immediately after implant installations and 12 months following definitive restorations. For both groups, mean mesial and distal bone loss values were calculated *(Table 2)*.

The results indicated that at the 1-year follow-up there was no statistically significant difference in the amount of vertical bone loss radiographically assessed between groups ($p > 0.05$).For the MGCSH/PRP test group, a mean mesial bone loss of -0.8 ± 0.6 mm and a mean distal bone loss of -0.5 ± 0.4 mm were reported. For the CRP control group, a mean mesial bone loss of -1.1 ± 0.7 mm and a mean distal bone loss of -0.6 ± 0.6 mm were reported. In all participants implants were loaded in function 3 months after implant placement. Vertical bone resorption was not statistically significantly different between groups but was more clinically pronounced at control sites than at test sites *(Table 2)*.

Esthetic outcome

Esthetic outcomes were reported as changes in the position of the papillae. Papillae height measurements were referenced clinically to the incisal edges of adjacent teeth and performed prior to tooth extraction and 12 months after definitive restoration (Cooper *et al.*, 2010). The health of the gingival tissue around the implants in all patients was satisfactory, as reported by

low bleeding on probing. Bleeding on probing was reported occasionally; one participant in each group. Visually, all soft tissues appeared pink and healthy. No participants complained of pain and there was no evidence of infection associated with any implants.

The evaluation of the papillae revealed minor recession in papillae heights over the 12 months follow-up period. The average papilla recession for the mesial and distal sites is reported in *Table 3*. After 1 year, mean changes for the mesial papillae were -0.4 ± 0.9 mm for the MGCSH group compared to -1.0 ± 0.8 mm for the CRP group. Similar changes were reported for the distal papillae: -0.8 ± 0.9 mm for the test group and -0.7 ± 0.5 mm for the control group. This difference was not statistically significant ($p > 0.05$).

Discussion

Many patients have concerns about the risks of cross-infection with allogeneic grafts or xenografts and prefer to have alternative treatments. Moreover, there has been considerable research and development of synthetic graft materials. This investigation aimed to evaluate clinical and radiographic changes to the hard and soft tissues around implants placed in extraction sockets grafted with a combination of MGCSH mixed with PRP and CRP after one year in function. It has been reported in the literature that most morphologic extraction socket changes take place within this time frame (Albrektsson *et al.*, 1986; Albrektsson and Isidor, 1994; Lam *et al.*, 1960; Roos *et al.*, 1997; Schropp *et al.*, 2003). Sailer *et al.* reviewed the performance of ceramic and metal implant abutments supporting implant restorations and estimated a 95% 5-year survival rate for the implants in function. The 5-year rate for soft tissue recession around ceramic abutments was clinically more pronounced than around metal abutments (8.9% and 3.8%, respectively). The estimated 5-year rate for soft tissue recession was 2.1% for ceramic abutments and 4.1% for metal abutments. The rate for bone loss was higher for implants supporting metal abutments (3.9%) than for those supporting ceramic abutments (1.7%). The total estimated 5-year rate for aesthetic complications for ceramic and metal abutments supporting fixed restorations was 5.4%. Problems with esthetic outcome were more frequently reported for metal abutments (Sailer *et al.*, 2009). There is a strong suggestion from the literature that peri-implant soft tissue aesthetics can be achieved through provisional restoration contouring. Clinical and histological studies showed that gold, titanium and zirconia ceramic abutment materials exhibit excellent biological responses around dental implant restorations (Lewis and Klineberg, 2011). The implant survival rate was 98.6% when placed into healed ridges, and radiographic analysis of proximal bone levels surrounding a dental implant reported that the mean mesial and distal bone changes that can be expected from the time of surgical implant placement into healed ridges to 12 months were 0.96 and 0.83 mm, respectively (Cavallaro, 2011). In another study, a 100% survival rate was reported at the 24-month follow-up for all implants placed in three different grafted sockets: magnesium-enriched hydroxyapatite (MHA), calcium sulfate (CS), and heterologous porcine bone (PB). For the MHA group, a mean mesial bone loss of -0.21 ± 0.08 mm and a mean distal bone loss of -0.22 ± 0.09 mm were reported; for the CS group, a mesial bone loss of -0.14 ± 0.07 mm and a distal bone loss of -0.12 ± 0.11 mm were measured; for the PB group, a mean mesial bone loss of -0.15 ± 0.10 mm and a mean distal bone loss of -0.16 ± 0.06 mm were reported. No statistically significant differences were reported among groups (Crespi *et al.*, 2009a). Records of dental implants placed in post-extraction sockets augmented with demineralized freeze-dried bone allograft (DFDBA) and implants placed in native bone for a mean follow-up time of 12 months were reviewed. For sockets grafted with DFDBA, the mean marginal bone level change was -0.15 ± 0.25 mm calculated on the implant level. Similarly, for the native bone group, the mean marginal bone level change was -0.15 ± 0.26 mm on the implant level. There were no significant differences between groups, with overall survival rate from baseline to the last follow-up visit of 100% for both groups (Koutouzis and Lundgren, 2010). The level of marginal bone loss was 0.76 ± 0.3 mm for extraction sites that received no graft, and 0.75 ± 0.3 mm for sites grafted with corticocancellous porcine bone at the 1-year follow-up examination. No statistically significant differences were detected for marginal bone changes between the two groups, and the cumulative implant success rate at the 3-year follow-up visit reached 95% for both groups (Barone *et al.*, 2012). Alveolar ridge preservation sites treated with a synthetic bone graft (Straumann Bone Ceramic™, Straumann USA LLC, Andover, MA; SBC) and collagen barrier compared to a deproteinized bovine bone mineral (DBBM) and the same collagen barrier. The mean radiographic measurements for distal height (Dh) and mesial height (Mh) at 1-year post-loading reported for the SBC group were 0.35 ± 0.74 mm and 0.12 ± 0.40 mm, respectively, and 0.13 ± 0.63 mm and 0.20 ± 0.58 mm, respectively, for the DBBM group. No statistically significant differences in Mh and Dh were observed between the SBC and DBBM groups at any observation period, with a survival rate of the implants in both groups of 100% at 1-year post-loading (Patel *et al.*, 2013).

However, the healing pattern and osseointegration process of implants placed with different grafting materials in humans have not been intensively studied. The initial implant integration most likely occurs from areas where the implant surface comes into contact with new vital bone. Also, within

the grafted site, an increasing volume of new vital bone would have grown during the osseointegration process and following the functional loading period.

At the time of implant placement and the one-year follow-up, there was no statistically significant difference between the two groups ($p > 0.05$). For all sites in all patients, implants appeared to successfully osseointegrate, based on no clinical signs of mobility and the absence of pain or infection. No implant losses were recorded. In the present study, the absence of statistically significant differences of crestal bone level around implants between groups confirmed the results reported in previous studies (Chen and Buser, 2009; Choquet *et al.*, 2001; Crespi *et al.*, 2009b).

There are reports in the literature of dental implants placed in extraction sites grafted with different bone substitutes (bioactive glasses, MHA, $CaSO_4$, and heterologous PB) with results similar to this study's findings. Radiographic results were reported at 12 and 24 months from implant placement. Mean distal and mesial bone loss values were reported with no statistically significant differences among groups, concluding that placement of implants in grafted sockets was not influenced by the different biomaterials studied (Chen and Buser, 2009; Kutkut *et al.*, 2012a; Norton and Wilson, 2002).

To achieve an optimal aesthetic on implant restorations, the peri-implant soft tissue should be modified to create an appropriate emergence profile and natural contour at the provisional stage. Custom abutments can be used to improve the implant restoration emergence along with provisional crowns. Peri-implant soft tissue manipulation depends on the depth of the implant and gingival biotype. Gradual transfer from the implant platform to a natural emergence profile can be easily fabricated with customized implant abutment when implants are placed 3 - 4 mm subgingivally in a thick soft tissue biotype. Shallow implants with a thin peri-implant soft tissue biotype will make the restorative outcome difficult, with a less than satisfactory emergence profile (Alani and Corson, 2011; Lewis and Klineberg, 2001). Moreover, preserving the attached gingiva at the time of tooth extraction without any flap or pouch elevation and papilla-saving incisions at the time of implant placement can optimize esthetic outcome with a minimum of bone and soft tissue changes (Kutkut *et al.*, 2012b)

Conclusion

This 12-month follow-up study showed a 100% survival rate for implants placed in sockets grafted with two different materials. At the one year follow-up, the implants placed in grafted sockets were not affected by the type of grafted material. Implants placed in sockets grafted with MGCSH mixed with PRP showed less marginal bone loss after one year in comparison to CRP dressing material. However, further clinical and histologic studies are needed to better understand the healing pattern of these biomaterials in relationship to dental implants positioned in grafted sites with bone substitutes. Although the sample size investigated in this present study was small, the findings are clinically relevant. Further long-term studies and larger sample sizes are also suggested.

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