Peri-implant Tissue Response Following Connective Tissue and Bone Grafting in Conjunction with Immediate Single-Tooth Replacement in the Esthetic Zone: A Case Series

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Purpose: *This case series evaluated the peri-implant tissue response following extraction and immediate placement and restoration of an implant in conjunction with subepithelial connective tissue grafting (SCTG) and bone grafting in the esthetic zone. Implant success rates and the peri-implant tissue response were also reported.* ***Methods and Materials:*** *Ten patients (four men, six women) with a mean age of 48 years (range, 35 to 70) underwent extraction and immediate tooth replacement with SCTG and were evaluated clinically and radiographically presurgically (T0), immediately after immediate tooth replacement and SCTG (T1), and at 3 months (T2), 6 months (T3), and 12 months (T4) after surgery. Data was analyzed using Friedman and Wilcoxon signed-ranks tests at the significance level of $\alpha = .05$.* ***Results:*** *At 1 year, all implants remained osseointegrated, with an overall mean marginal bone change of +0.10 mm and a mean facial gingival level change of −0.05 mm. Modified Plaque Index scores showed that patients were able to maintain a good level of hygiene throughout the study. Papilla Index scores indicated that at T4, more than 50% papilla fill was observed in 80% of all sites.* ***Conclusions:*** *The results of this case series suggest that, in addition to a favorable implant success rate and peri-implant tissue response, the facial gingival level around single immediately placed implants can also be maintained following connective tissue grafting when proper three-dimensional implant positioning is achieved and bone is grafted into the implant-socket gap.* Int J Oral Maxillofac Implants 2011;26:427–436

Key words: *biotype, esthetics, gingival biotype, gingival recession, IIPP, immediate implant placement, immediate loading, immediate provisionalization, papilla, single tooth replacement*

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The natural appearance of a restoration and the stability of the surrounding gingival architecture are the foundation for a successful treatment outcome.[1–3] This begins with strategic placement of the implant and a properly contoured provisional restoration.[3–5] The concept of immediate single-tooth replacement was introduced in 1998 and has been widely accepted as the treatment of choice in ideal esthetic situations.[6] In the past decade, many studies have described immediate single-tooth replacement as a predictable procedure, with success rates similar to that of delayed implant placement with delayed prosthetic loading procedures.[6–9]

While immediate tooth replacement with immediate implant placement and provisionalization has

Fig 1 Preoperative labial view of the failing maxillary left central incisor.

Fig 2 Preoperative periapical radiograph of the failing maxillary left central incisor because of root fracture.

Fig 3 (Left) Occlusal view of the implant platform immediately following implant placement.

been shown to be a successful procedure, slight facial gingival recession has been reported following the first year of function.[10–14] Enhancement of gingival thickness through augmentation procedures has been suggested to make the gingival tissue more resistant to recession.[1] Tissue augmentation procedures with a connective tissue graft have proven to be successful in preserving soft tissue levels when performed in conjunction with implant placement or prior to the time of abutment connection.[10,15,16] However, to date, studies regarding the efficacy of connective tissue grafts at the time of immediate tooth replacement have been rare.[17–19]

The purpose of this case series was to evaluate the effects of using a subepithelial connective tissue graft (SCTG) in conjunction with immediate tooth replacement in the esthetic zone. The null hypothesis that there were no significant changes in the peri-implant tissue status was tested, and the implant success rate was also reported.

MATERIALS AND METHODS

Patient Selection

This study was approved by the Institutional Review Board of Loma Linda University and was conducted in the Center for Prosthodontics and Implant Dentistry,

Loma Linda University School of Dentistry, California. To be included in this study, patients had to (1) be at least 18 years of age or older with good hygiene, (2) have a single failing anterior maxillary tooth (first premolar–first premolar) with the presence of adjacent and opposing natural dentition and without active infection, (3) have sufficient bone volume to accommodate placement of a single implant with minimum dimensions of 3.5×13 mm. Any patients (1) with a history of smoking,[20] head and neck radiation treatment,[21–23] bruxism,[24] or parafunction; (2) with a lack of stable posterior occlusion; and (3) in whom primary implant stability could not be achieved were excluded from this study.

Clinical Procedures

All patients received standardized diagnosis and treatment-planning procedures and consented to the treatment (Figs 1 and 2). An acrylic resin provisional shell was fabricated prior to implant surgery using autopolymerizing acrylic resin (Jet, Lang Dental). Following the administration of local anesthetic, the failing tooth was removed atraumatically and an implant (OsseoSpeed, Astra Tech) was placed immediately, with the implant-prosthetic platform placed 3 mm apical to the predetermined gingival margin (Fig 3).[7] Primary implant stability was achieved with an insertion torque between 25 and 35 Ncm according to the manufacturer's recommendation. Xenograft (Bio-Oss,

Fig 4 Periapical radiograph immediately after implant surgery.

Fig 5 Labial view of the provisional restoration and connective tissue graft implant surgery.

Osteohealth) was used to fill the implant-socket gap. A customized provisional titanium cylinder (Temporary Abutment, Astra Tech) was then placed and hand-tightened onto the implant. Flowable composite resin (PermaFlo, Ultradent Products) was expressed into the site and photopolymerized to recreate the cervical emergence of the extracted tooth. The prefabricated provisional shell was relined with acrylic resin (Jet, Lang Dental) and adapted to the custom provisional abutment. The provisional restoration was adjusted to clear all contacts in centric and eccentric movements, polished, and cemented with zinc oxide–eugenol (IRM, Dentsply International). A periapical radiograph was obtained to ascertain the fit of the provisional restoration (Fig 4).

An SCTG was harvested from the palate using a single-incision technique.[25] A full-thickness envelope was created between the labial bony plate and the gingiva of the extraction site.[1] The SCTG was inserted into the prepared envelope space and secured with resorbable sutures (6-0 chromic gut blue, Ethicon Johnson & Johnson) (Fig 5). Light pressure was applied over the SCTG with moist gauze for 10 minutes to minimize blood clot and dead space formation between the graft and the underlying bone.[1]

Antibiotics and analgesics were prescribed for postoperative use. Patients were instructed to rinse with 0.12% chlorhexidine gluconate solution (Peri-dex, Zila Pharmaceuticals), refrain from functioning at the surgical site, and to remain on a liquid diet for 2 weeks following surgery. For the following 3 months, a soft diet was recommended.

At 6 months, the final implant impression was made with poly(vinyl siloxane) (Aquasil Monophase, Dentsply). A prefabricated zirconia abutment (ZirDesign, Astra Tech) was prepared, finished, and torqued to the manufacturer-recommended 25 Ncm, and the definitive all-ceramic restoration (Procera, Nobel Biocare) was cemented with resin cement (Rely-X Unicem, 3M ESPE) (Figs 6 and 7).

Data Collection

All examinations and corresponding data collection were performed by the same examiner. The data, when indicated, were collected and compared between each follow-up time interval: presurgery (T0), immediately after implant placement and SCTG (T1), and at 3 months (T2), 6 months (T3), and 12 months (T4) after surgery. The implant success/failure rates and marginal bone level (MBL) changes were evaluated at T1, T2, T3, and T4; facial gingival level (FGL) changes were evaluated at T0, T2, T3, and T4; Periotest values (PTVs) were determined at T1 and T3; modified Plaque Index (mPI) was calculated at T2, T3, and T4; and Papilla Index scores (PIS) were recorded at T1, T2, T3, and T4 as follows.

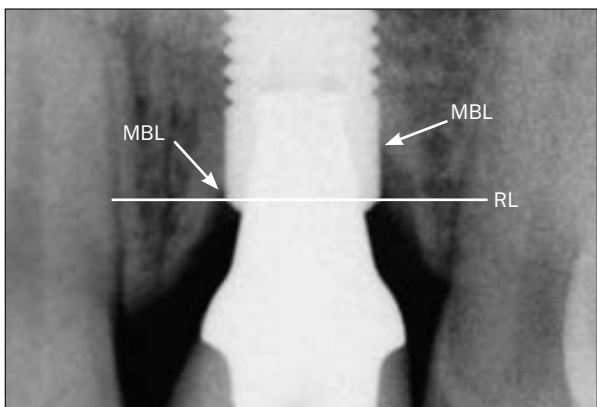Fig 6 *(Above)* Labial view of the definitive restoration after 1 year of function.

Fig 7 *(Above)* Periapical radiograph 1 year after the implant surgery.

Fig 8 *(Left)* RL used to determine changes in MBL.

Implant Failure. The implants were evaluated according to the criteria proposed by Smith and Zarb where applicable.[26] The implants were considered a failure with the presence of mobility, peri-implant radiolucency, persistent pain, discomfort, and/or infection.

MBL Change. The MBLs on the mesial and distal aspects of each implant were measured with the use of sequential periapical radiographs and long-cone paralleling technique with a commercial Rinn XCP holder (XCP post bite blocks 54-0862, Dentsply).[27] An occlusal jig constructed with poly(vinyl siloxane) (Exabite II, GC America) was used to standardize the position and angulation of the film to the x-ray beam. The junction between the microroughened surface and the machined surface was used as the reference line (RL) (Fig 8). The distance between the RL and the first implant-bone contact was measured. A measured value of zero was given when the MBL was coronal to the RL. A negative value was given when the MBL was apical to the RL. The average value of the mesial and distal measurements was used as the overall MBL for each implant. The MBLs were compared between each follow-up time interval (T1, T2, T3, and T4), and the change in MBL was calculated. The intraexaminer reliability of the measurements was determined through double assessments of MBLs, performed 3 months apart by one examiner and expressed as the intraclass correlation coefficient (ICC).

FGL Change. A master cast was made at different time intervals (T0, T2, T3, and T4) to evaluate the FGL. A customized stent fabricated from the preoperative master cast was used to standardize probing points and the direction of probe insertion. Baseplate wax (Type II, Dentsply) was placed around the failing tooth, and the modified cast was duplicated. A vacuum-formed, 0.060-inch-thick polyethylene terephthalate, glycol-modified clear template (Ultradent Products) was adapted and trimmed to remove all undercuts. This allowed for sufficient clearance to accommodate changes in the contours of the restoration from the provisional to the definitive implant restoration. A perpendicular slot was created at the most apical part of the midfacial gingival level, and the lower border of the customized stent was used as a reference line. The FGL was evaluated at each time interval using a periodontal probe (15 UNC Color-Coded Probe, Hu-Friedy) and the FGL change was calculated. All measurements were made to the nearest 0.5 mm. The intraexaminer reliability of the measurements was determined through double assessments of FGL, performed 3 months apart by one examiner and expressed as the ICC.

Patient no.	Implant location	Implant size (D × L, in mm)	Overall MBL (mm)			
			0 mo	3 mo	6 mo	12 mo
1	CI	4.5 × 15	−0.24	0	0	0
2	P1	4.5 × 15	0	0	0	0
3	CI	4.0 × 15	−0.63	−0.53	−0.35	−0.44
4	CI	5.0 × 15	−1.57	−1.75	−1.3	−1.0
5	P1	5.0 × 17	0	0	0	0
6	CI	4.0 × 13	0	0	0	0
7	LI	4.0 × 17	0	0	0	0
8	C	5.0 × 15	0	−0.2	0	0
9	CI	5.0 × 15	0	0	0	0
10	CI	5.0 × 15	0	0	0	0
Mean ± SD			−0.24 ± 0.51	−0.25 ± 0.55	−0.17 ± 0.41	−0.14 ± 0.33

Table 1 Locations, Dimensions, and Overall MBL of Each Implant

CI = central incisor; LI = lateral incisor; C = canine; P1 = first premolar; D = diameter; L = length.

Implant Mobility. The Periotest instrument (Siemens) was used to evaluate implant stability at T1 and at T3.[28–31] A 10-mm healing abutment (Healing Abutment Uni, Astra Tech) was hand-tightened onto the implant and used as the tapping surface for the Periotest instrument. Measurements were made two to four times until two duplicate PTVs were registered and recorded.

Modified Plaque Index. The presence of plaque was assessed at the mesiolabial, labial, distolabial, mesiolingual, lingual, and distolingual surfaces of the provisional and definitive restorations according to the mPI of Mombelli et al[32] (0 = no plaque; 1 = plaque recognized only by running a probe across the marginal surface of the implant restoration; 2 = plaque visible to the naked eye; 3 = abundance of soft matter). Only the highest mPI score of each implant was used for statistical analysis.

Papilla Index Score. The interproximal soft tissue was evaluated using the PIS of Jemt[33] (0 = no papilla; 1 = papilla extends less than half of the height of the interproximal space; 2 = papilla fills at least half of the height of the interproximal space; 3 = papilla fills up the entire interproximal space; 4 = hyperplastic papilla). Mesial and distal PIS were analyzed individually.

Surgical and Prosthetic Complications. Surgical complications were documented as connective tissue graft necrosis, infection around the implant, and/or any deviation from the manufacturer's placement protocol that necessitated additional modifications to the surgical site to establish adequate primary stability. Prosthetic complications were documented as any repairs or modifications of the provisional restoration or definitive prosthesis. These included but were not limited to debonding of the provisional restoration, fracture of the provisional restoration, occlusal adjustments, and/or abutment screw loosening.

Data Analysis

Descriptive statistics were used to explain the MBL change. The Friedman test was used to evaluate FGL, mPI, and PIS; the Wilcoxon signed-rank test was used to analyze PTVs. The level of significance was set at $\alpha = .05$.

RESULTS

Four male and six female patients between the ages of 35 and 70 years (mean, 48 years) participated in this study. All implant positions and their corresponding sizes are presented in Table 1.

Table 2 Comparison of FGL at Different Time Intervals

Time	Mean ± SD	Median	Minimum	Maximum
	FGL (mm)			
Presurgery	−2.20 ± 0.59	−2	−3	−1
3 mo	−2.30 ± 1.01	−2.25	−4	−1
6 mo	−2.20 ± 1.11	−2.25	−4	−0.5
12 mo	−2.25 ± 1.21	−2.5	−4	−0.5

P = .90 (Friedman Test at α < .05); n = 10.

Table 3 Distribution of mPI Scores at Different Time Intervals

Time	0	1	2	3	n
	mPI				
3 mo	7	3	0	0	10
6 mo	8	2	0	0	10
12 mo	7	3	0	0	10

P = .93 (Friedman test at α = .05).

Table 4 Distribution of PIS at Different Time Intervals

| | | | **PIS** | | | | | | | | |
| | **Mesial (n = 10)** | | | | | **Distal (n = 10)** | | | | |
Time	0	1	2	3	4	0	1	2	3	4
0 mo	2	1	4	3	0	1	1	2	6	0
3 mo	2	1	4	3	0	1	0	1	8	0
6 mo	2	1	4	3	0	1	0	1	8	0
12 mo	2	1	2	5	0	1	0	1	8	0
P			.87					.87		

Friedman test at α = .05.

Implant Failures

After 1 year of function, all implants were stable and had osseointegrated. One implant developed a periapical infection 3 weeks after implant placement. A semilunar flap was created around the apex of the implant to expose the infected area. The infection was effectively eliminated by debridement and disinfection. The defect was then grafted with xenograft (Bio-Oss, Osteohealth) and covered with a resorbable membrane (Bio-Gide, Osteohealth). Because the implant remained in function and the peri-implant mucosal margin was unaffected, the authors continued to collect data at the scheduled follow-up examinations. Despite this, the implant was still considered a failure based on the implant success criteria[26] used in this study, resulting in an overall cumulative implant success rate of 90%.

Clinical Parameters

The ICC for MBL measurements was 0.99, indicating that the measurement method was reliable and reproducible. Overall MBL values for each implant at different time intervals are presented in Table 1. All implants with MBL at or coronal to the RL (MBL = 0) at T1 showed the same value at T4. The mean MBL change from T1 to T4 was +0.10 mm.

The ICC for FGL measurements was 0.92, indicating that the measurement method was reliable and reproducible. Statistical comparisons of the FGL measurements are presented in Table 2. The mean FGL change from T1 to T4 was −0.05 mm. No statistically significant differences (P = .90) for FGL were noted between all time intervals.

The mean PTV at T3 (−2.6 ± 2.5) was statistically significantly lower than that at T1 (−0.2 ± 3.8) (P = .039). This indicated good stability of the implants.

mPI scores of 0 and 1 were consistently recorded throughout the study (Table 3). There was no statistically significant difference in the mPI scores (P = .93) among the three time intervals (T2, T3, and T4).

The PIS ranged from 0 to 3 at all time intervals in this study (Table 4). No statistically significant difference was noted for either mesial or distal papilla levels with respect to time (P = 0.87) (Table 4). At T4, more than 50% papilla fill was observed in 80% of all sites.

Surgical and Prosthetic Complications

Rotational instability was observed with three implants at the time of placement and was resolved through the placement of longer and/or larger-diameter implants. Necrosis of the SCTG was observed in two patients resulting in facial gingival recession of 1.0 and 1.5 mm, respectively.

During the provisional phase, an episode of provisional debonding and an episode of abutment screw loosening were observed at 2 and 3 months after implant placement, respectively. The provisional restoration was recemented and the abutment screw was retightened and no further complications were observed. A fistula tract was noted at 2 months during the provisional phase 3 mm apical to the facial free gingival margin of one implant resulting from residual subgingival provisional cement. After the cement was removed, the fistula healed uneventfully. An abutment screw (Abutment Screw Design 3.5/4.0, Astra Tech) fracture was noted in one patient during the final tightening with the torque wrench. This might have been a result of torque application that exceeded the manufacturer's recommendation (Astra Tech). It has also been established that extended clinical use and repeated sterilization of preset torque wrenches can introduce variances, which can result in torque values that are higher than what is indicated.[34] Fortunately, the fractured screw was removed successfully with no damage to the implant, and the new screw was tightened without further complications.

DISCUSSION

The cumulative implant success rate following single immediate tooth replacement and SCTG in this study was 90% after a follow-up period of 1 year. Although comparable implant success rates have been reported with immediate single-tooth replacement without SCTG with a similar implant system (91% to 100%),[35–48] these rates are slightly lower than for similar procedures performed without SCTG with other implant systems (98% to 100%).[6,7,11–13,49–56] This may be a consequence of the small sample size, since each implant corresponds to 10% in the present case series.

Studies involving single-tooth replacement have reported peri-implant MBL changes from −0.2 to −1.0 mm for immediate tooth replacement procedures[7,11,13,50,53,55] and −0.4 to −1.6 mm for delayed loaded implants after the first year of function.[9,57,58] With regard to implants placed in the esthetic zone and restored with platform switching, MBL changes have ranged from 0 to −0.78 mm with follow-up periods of 6 to 57 months.[35–48] In the present study, the mean peri-implant MBL change was +0.10 mm at T4, which was less than the range of the aforementioned studies and other similar studies. Furthermore, the fact that all implants with no marginal bone loss at T1 possessed the same value at T4 indicated that peri-implant MBLs can be well maintained at or coronal to the implant platform with the present treatment protocol.

Although minimal mean facial gingival tissue recession (−0.5 to −0.8 mm) has been observed in short-term studies (1 to 2 years follow-up) with immediate tooth replacement procedures in the esthetic zone,[7,11,13] FGL loss remains an inherent risk since the labial bone of the extraction socket is subjected to remodeling.[17] In this study, the viability of SCTG was examined in conjunction with immediate tooth replacement. Despite necrosis in two patients, the overall mean FGL change was minimal at T4 (−0.05 mm; Table 2). In fact, the mean FGL change of the remaining eight implants was +0.25 mm. This is similar to the data reported by Kan et al and Cornelini et al, respectively, where a mean facial gingival tissue gain of 0.2 mm was observed 1 year after immediate implant placement with SCTG.[17,18] This implies that SCTG in conjunction with immediate tooth replacement in the esthetic zone may be beneficial in minimizing facial gingival tissue recession when a proper three-dimensional implant position is achieved and grafting material is placed into the implant-socket gap.[17] Nevertheless, the high necrosis rate (20%) observed in this study also implies that bilaminar SCTG in conjunction with immediate tooth replacement procedures is a technique-sensitive procedure with inherent risks that must not be overlooked; inadvertent thinning or perforation of the flap or partial exposure of the SCTG can result in partial or complete necrosis of the SCTG. Therefore, it has been suggested that full-thickness dissection be employed when preparing the bilaminar envelope.[17]

The validity of the Periotest instrument has been the subject of debate. However, the PTV of an implant seems to provide an acceptable level of objectivity for diagnosing initial implant stability.[28,59] It has been suggested that a PTV of −5 to +5 is required for proper osseointegration.[28] Based on this, the mean PTV at T1 of −0.2 (range, −6 to +6) reported in this study suggested that the primary stability of some implants was not optimal. The high PTV may be related to the density/quality of the maxillary bone as well as immediate placement in an extraction site, where implant stability relies mainly on the engagement of the apical and palatal aspects of the anterior extraction socket.[5] Furthermore, the rotational instability of three implants, although eventually resolved, may also have contributed to the high PTV. Despite this, all implants fulfilled the manufacturer's recommended minimal insertion torque value (25 Ncm). In addition, a statistically significant lower mean PTV was noted at T3 (−2.6, range, −6 to +2), suggesting that osseointegration is a dynamic process and that the implants became more stable over time.

While it is generally agreed that plaque accumulation can potentially induce a negative mucosal response,[7] the relationship between compromised oral hygiene and implant failure has been contentious.[60–65]

The mPI scores observed throughout the duration of this study were either 0 or 1, implying that the patients were able to maintain a good level of oral hygiene (Table 3). To minimize peri-implant gingival tissue disturbance following immediate tooth replacement and SCTG, the patients were advised to refrain from brushing the surgical site for 1 month. Meanwhile, oral hygiene was maintained through light swabbing of the surgical area with a cotton-tipped applicator soaked in 0.12% chlorhexidine gluconate (Peridex).

The PIS in the present study ranged from 0 to 3 at T1, T2, T3, and T4. There were no statistically significant differences in the PIS at different time intervals (Table 4; $P = .87$) when immediate tooth replacement with SCTG was performed, even when necrosis of the SCTG was encountered in two patients. This validates the idea that peri-implant papilla levels are dictated by the proximal bone levels of the adjacent teeth[66,67] and that the best way to maintain the papilla is to provide hard tissue support immediately after tooth extraction.[4,5,7,68]

Although useful information was found in this study, because of the limited sample size, its limitations should be acknowledged. Future studies involving a larger sample size with a control group and long-term follow-up will undoubtedly provide more useful information on the viability of this particular procedure.

CONCLUSIONS

The results of this case series suggests that, in addition to a favorable implant success rate and peri-implant tissue response, the facial gingival level can also be maintained around postextraction immediate single-tooth implants treated with subepithelial connective tissue grafting when a proper three-dimensional implant position is achieved and bone grafting material is placed into the implant-socket gap.

ACKNOWLEDGMENTS

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