Immediate Provisionalization of Dental Implants in Grafted Alveolar Ridges in the Esthetic Zone: A 5-Year Evaluation

Lyndon F. Cooper, DDS, PhD[1]/Glenn Reside, DDS[2]
Filiep Raes, DDS, MSc, PhD[3]/Joan Soliva Garriga, DDS, DMD[4]
Luís Giner Tarrida, DDS, DMD, PhD[5]/Jörg Wiltfang, MD, DMD[6]
Matthias Kern, DMD[7]/Hugo De Bruyn, DDS, PhD[8]

This clinical study assessed at 5 years both implant survival and peri-implant tissue architecture of immediately provisionalized implants placed 4 to 6 months following augmentation with demineralized bovine bone allograft and collagen membrane. Of 23 implants in 19 patients, one implant failed prior to loading (95.6% survival). Implant tissue relationships were stable following implant placement; marginal bone level changes from implant placement to 5 years (mean ± SD: –0.18 ± 0.79 mm, range: –1.6 to 1.4 mm, P = .51), the mesial and distal papilla length changes (mesial mean ± SD: 1.14 ± 0.92 mm, P < .001; distal mean ± SD: 0.74 ± 1.46 mm, P = .04), and the unchanged mucosal zenith location (mean ± SD: 0.24 ± 0.93 mm, P = .15) were recorded. There were no major surgical complications during the 5-year period. When augmentation is required, subsequent dental implant placement in the anterior maxilla may be achieved using immediate placement and provisionalization protocol to attain osseointegration success and stable peri-implant tissue responses.
(Int J Periodontics Restorative Dent 2014;34:477–486. doi: 10.11607/prd.2022)

[1]Stallings Distinguished Professor and Chairman, Department of Prosthodontics, University of North Carolina, Chapel Hill, North Carolina, USA.
[2]Associate Professor, Department of Oral and Maxillofacial Surgery, University of North Carolina, Chapel Hill, North Carolina, USA.
[3]Assistant Professor, Department of Periodontology and Oral Implantology, Dental School, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium.
[4]Professor, Department of Prosthodontics, Dentistry School, Universitat Internacional de Catalunya, Barcelona, Spain.
[5]Vice Dean, Research Department, Dentistry School, Universitat Internacional de Catalunya, Barcelona, Spain.
[6]Professor and Head, Department of Oral and Maxillofacial Surgery, University of Schleswig-Holstein, Kiel, Germany.
[7]Department of Prosthodontics, Propaedeutics and Dental Materials; School of Dentistry; Christian-Albrechts University at Kiel; Kiel, Germany.
[8]Professor and Chairman, Department of Periodontology and Oral Implantology, Dental School, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium; Visiting Professor, Department of Prosthodontics, University of Malmö, Malmö, Sweden.

Correspondence to: Dr Lyndon F. Cooper, 330 Brauer Hall, CB#7450, University of North Carolina, Chapel Hill, NC 27518-7450; email: lyndon_cooper@unc.edu

The replacement of a single anterior maxillary tooth is predictably achieved using endosseous dental implants.[1,2] Recent investigations have extended reported outcomes from implant survival data to include important information about esthetic outcomes using objective scoring of soft tissues (pink esthetic score or PES[3]) and supported crowns.[4] In addition, interest is emerging about patient-based outcomes related to satisfaction.[5] Several systematic reviews indicate high implant survival and short-term esthetic success associated with high patient satisfaction.

The replacement of a failing or missing anterior tooth may be a consequence of trauma, caries, periodontal disease, or anodontia. The clinical presentation of the tooth or the residual alveolar ridge strongly influences the procedural course of therapy, and different protocols, including immediate placement and provisionalization, immediate provisionalization, early placement, or conventional placement in healed alveolar ridges, have been advocated. Several investigators reported that high implant survival and

esthetic success may be achieved for either immediate placement with provisionalization or immediate provisionalization of implants placed in healed ridges.[6,7] An early placement protocol has been alternatively advocated.[4,8] In the anterior maxillary alveolar ridge, the local conditions for esthetic implant placement and restoration are often unfavorable because of multiple architectural factors.[9] Irrespective of the clinician's preference, when considering implant placement into extraction sockets or alveolar ridges, there will be situations when bone grafting is required.

Alveolar bone grafting and socket preservation procedures are commonly performed, and many different methods for bone augmentation have been evaluated. The use of autogenous bone, allogeneic bone substitutes, and recombinant osteoinductive agents with or without occlusive membranes have been illustrated and are supported by case series. When considering prospective, comparative studies, Esposito et al[10] concluded that there was little data to distinguish the outcomes of one or another material or technique. In a separate review[11] it was concluded that there is merit in selecting procedures that are simpler and less invasive, involve less risk of complications, and reach their goals most expeditiously. A recent systematic review suggested that adequate alveolar bone augmentation may be achieved using particulate xenograft or allograft materials beneath barrier membranes.[12]

Following healing and initial consolidation of the grafted alveolar ridge, the eventuality of implant placement can be met by different clinical approaches that include two-stage, one-stage, and immediate provisionalization protocols. Expedited therapies often appeal to patients. When implants cannot be placed in extraction sockets or healed ridges and bone augmentation is required, the subsequent placement of the implant may be achieved using an immediate provisionalization procedure. The outcomes of immediate provisionalization of implants placed into recently grafted bone have not been fully investigated. As part of a larger, prospective study of immediate provisionalization of implants placed in extraction sockets and healed ridges, several patients required bone grafting to support future implant placement. Here, the 5-year outcome of immediately provisionalized implants placed in recently grafted bone is reported. Implant survival, marginal bone level, and soft tissue architectural changes were evaluated.

Method and materials

This data is a subset of data representing patients enrolled in a four-center investigation comparing immediate placement and provisionalization with immediate provisionalization of maxillary implants in the esthetic zone. The details of this investigation are reported elsewhere.[6,13]

According to an institutional review board–approved protocol, 139 patients were recruited for implant placement. At the time of surgery, anatomical or volumetric conditions that precluded implant placement for immediate placement and/or provisionalization were identified in 21 patients. A guided bone regeneration (GBR) procedure was performed using anorganic bovine bone (Bio-Oss, Geistlich) and a resorbable collagen membrane (Bio-Gide or Bio-Mend, Geistlich). Primary closure was obtained, and the sites were left to heal for a period of 4 to 6 months, after which implant placement was performed.

Implant placement and restoration

Briefly, following uneventful healing of the grafted alveolus, 3.5- to 5.0-mm wide and 11- to 17-mm long implants (OsseoSpeed, Dentsply) were placed under local anesthesia using a modified protocol. Preoperative analgesics (eg, 800 mg ibuprofen) and antibiotics (1 g amoxicillin or 600 mg clindamycin) were prescribed. Transmucosal punches were used for flapless access in the majority of cases; however, conventional flaps were performed in seven of the patients. Osteotomies were created to depth but undersized with respect to diameter (3.2-mm diameter for 3.5- and 4.5-mm implants or 3.7-mm diameter for 4.0- and 5.0-mm implants). For 4.5- and 5.0-mm implants, conical tapered drills were required. The stability of the implant was visually and tactilely assessed at the time of placement. Immediate provisionalization

procedures were performed using Direct Abutment or Profile BiAbutment (Dentsply) and acrylic crowns. Abutments were placed with finger pressure (approximately 15 to 20 Ncm). The crowns were adjusted to be free of centric or eccentric contacts. A periapical radiograph was taken to *(1)* evaluate implant placement, *(2)* ensure abutment placement, *(3)* discover residual cement, and *(4)* serve as a baseline for evaluation of marginal bone level changes. Postoperative prescriptions for analgesics, antimicrobial mouthrinse (0.12% chlorhexidine gluconate), and antibiotics (amoxicillin 500 mg, three times daily for 5 to 7 days) were given to all patients. Instructions for oral hygiene included the maintenance of conventional toothbrushing and flossing, with local restrictions around the provisional crown for the first 7 to 10 days. Eight weeks after implant, abutment, and provisional crown placement, the provisional crown was removed, and the abutment was retightened to 25 Ncm. An impression was taken of the abutment, and a definitive all-ceramic (Procera [Nobel Biocare] or Lava [3M Espe]) crown was fabricated using conventional prosthodontic procedures. At 11 to 12 weeks, the definitive crown was cemented, and a periapical radiograph was taken.

Follow-up evaluation

Individuals were evaluated at 26 weeks and annually for 5 years following provisional crown placement. The initial clinical treatment and follow-up evaluation are illustrated longitudinally in Fig 1. Implant immobility was assessed clinically. Implant failure was indicated by pain, peri-implant radiolucency, and/or mobility. Abutment and crown complications and failures were recorded. Plaque and bleeding scores were recorded at four points for each crown (mesiolingual, distolingual, mesiobuccal, and distobuccal). The gingival zenith score (linear distance from the gingival zenith to the incisal edge reference) and the papilla score (linear distance from the papilla tip to the incisal edge reference of adjacent tooth) were recorded to the nearest 0.5 mm. Periapical radiographs were taken by a long cone paralleling technique at implant placement, definitive crown cementation, and at 6 months and yearly for the 5-year follow-up period (Fig 2). A radiologist, independent from the group of investigators, performed all the radiographic interpretations. The distance of the mesial and distal interproximal bone to the reference point (the outer aspect of the implant bevel) was measured to the nearest 0.1 mm. A mean of these two measurements was calculated for each implant, and the changes from baseline, ie, implant placement, were calculated for each subsequent time point.

Statistical analysis

Descriptive statistics were used in analyzing patient group and implant characteristics. A nonparametric test, Wilcoxon signed rank test, was used to analyze differences between visits or time intervals in terms of hard and soft tissue parameters. The level of significance was set at 0.05 for each test.

Results

Among the 21 patients, 19 had 23 implants placed with primary stability that were included in this 5-year evaluation. Two implants did not achieve primary stability, were not immediately provisionalized, and therefore were not included in the subsequent analyses. Of the 23 implant sites, 16 were placed in sites developed from extraction sockets and 7 were placed in augmented healed ridges. After the 4- to 6-month graft healing period, 23 implants were placed with acceptable primary stability and were restored with provisional crowns.

The study cohort included 7 women (mean ± SD age: 41 ± 19 years) and 12 men (mean ± SD age: 39 ± 16 years). Among these, all were nonsmokers, with three reporting previous tobacco use. The bone quality estimates included 9 (39%) type 2 and 12 (52%) type 3. Bone quantity was high (91% types A and B). No canine sites were represented among the patients; the 23 implants were widely distributed among incisor and premolar sites (Table 1). One implant was determined to be mobile at the time of definitive crown impression (67 days following placement) and was removed. One implant was lost to follow-up after the 6-month evaluation as a result of patient relocation. The calculated implant survival at 5 years was 95.6%.

Fig 1 *Longitudinal photographic documentation of peri-implant mucosal conditions illustrating the present investigation of implants placed into grafted alveolar bone.*

Fig 1a *Preoperative condition of the dentition, with a resin-bonded fixed dental prosthesis replacing the maxillary left and right lateral incisors.*

Figs 1b to 1d *Grafting of the alveolar ridge at the maxillary lateral incisor positions using demineralized bovine bone mineral and a collagen membrane. Note the substantial defect present.*

Fig 1e *Alveolar ridges and mucosa 4 months following ridge augmentation procedure.*

Figs 1f and 1g *Left and right lateral incisor provisional crowns and mucosal tissues 8 weeks following implant placement.*

Figs 1h and 1i *One week following definitive crown placement.*

Figs 1j and 1k *One year following placement of definitive crowns.*

Figs 1l and 1m *Three years following definitive crown placement.*

Figs 1n and 1o *Five years following placement of definitive crowns.*

Fig 2 *Longitudinal radiographic assessment of implant therapy illustrating the present investigation of implants placed in grafted alveolar bone.*

Figs 2a and 2b *Preoperative condition of implant sites.*

Figs 2c and 2d *Implant placement: 3.5-mm MicroThread implants (AstraTech Dental Implant System, Dentsply Implants) placed within the available alveolar bone in the maxillary left and right lateral incisor positions. The interproximal subcrestal positioning is consistent with crestal placement at the buccal bone crest.*

Figs 2e and 2f *Crestal bone level at abutment tightening, prior to final impression. Note the approximation of the bone to the implant-abutment interface.*

Figs 2g and 2h *One-year radiographic evaluation of the all-ceramic restorations and abutments on implants. Note that abutments of different heights were utilized to accommodate the differences in tissue height.*

Figs 2i and 2j *Three-year radiographic evaluation.*

Table 1 Implant positions

	Central incisor	Lateral incisor	Canine	First premolar	Second premolar	Total
n	5	8	0	5	5	23
%	22	35	0	22	22	100

Table 2 **Marginal bone level values (mm) at the various examinations**

	IP	DR (IP + 12 weeks)	IP + 1 year	IP + 3 years	IP + 5 years
n	19	13	19	21	21
Mean	0.57	0.84	1.09	0.65	0.67
SD	0.73	0.69	1.11	0.67	0.90
Maximum	2.3	1.9	3.6	2.0	3.6
Minimum	0.0	0.0	0.0	0.0	0.0
Median	0.2	0.6	0.5	0.3	0.5
P value*		.76	.35	.57	.51

IP = implant placement; DR = definitive restoration.
*Wilcoxon signed rank test.

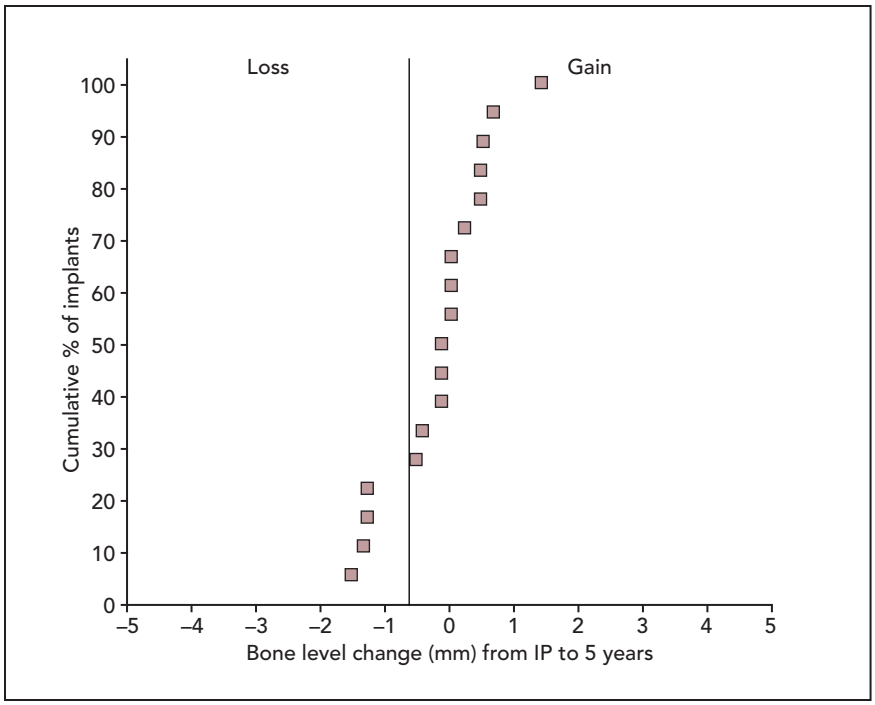

Fig 3 *Cumulative graph illustrating interproximal bone level changes between implant placement (IP) and the 5-year follow-up.*

In this study, the relationship of the reference point (the outer aspect of the implant bevel) to the interproximal crest at implant placement was reported by the investigator as supracrestal (concave), crestal (flat), or subcrestal (convex) and was most frequently flat (20/23), indicating that clinicians achieved crestal implant placement. Marginal bone levels were measured from implant placement to 5 years. The position of the average marginal bone level (mesial and distal) over the 5-year follow-up period is presented in Table 2. As noted, the marginal bone levels were stable over the 5 years. The mean ± SD marginal bone level change after 5 years was –0.18 ± 0.79 mm (range: –1.6 to 1.4 mm). The distribution of marginal bone level changes is presented in Fig 3. Half of the sites (9/18) recorded no bone loss or bone gain, while only four sites displayed more than 1 mm of interproximal marginal bone loss after 5 years.

The affiliated peri-implant coronal plaque and bleeding indices were consistently 15% or lower (Table 3). The direct intraoral measurement of papillae revealed the increased interproximal dimension of approximately 1 mm within the first year following implant and crown placement. This increase in interproximal soft tissue remained throughout the 5-year period (Table 4). Regarding the buccal soft tissues, the direct measurement of the distance from the incisal edge to the peri-implant mucosal zenith demonstrated minor reductions (mean ± SD tissue growth: 0.24 ± 0.93 mm) in this dimension over the 5-year period (Table 5). When comparing the change in the peri-implant mucosal zenith location for implants placed in grafted bone using a flapped versus flapless procedure, minor tissue recession occurred at implants placed using flaps (−0.21 mm ± 1.07) versus flapless procedures (+0.46mm ± −0.80).

Table 3 Percentage of surfaces exhibiting bleeding on gentle probing and plaque

	IP + 2 weeks	IP + 8 weeks	DR (IP + 12 weeks)	IP + 1 year	IP + 3 years	IP + 5 years
Bleeding	1.1	4.6	2.5	2.4	15.5	10.7
Plaque	0.0	3.4	2.5	4.8	14.3	3.6

IP = implant placement; DR = definitive restoration.

Table 4 Changes in papilla dimensions (mm) from implant and provisional crown placement*

	Impression (IP + 8 weeks)		DR (IP + 12 weeks)		IP +1 year		IP + 3 years		IP + 5 years	
Papillae	M	D	M	D	M	D	M	D	M	D
n	21	21	20	20	21	21	21	21	21	21
Mean	0.76	0.55	0.48	0.5	1.21	1.17	1.21	1.12	1.14	0.74
SD	0.97	0.79	1.03	1.25	1.02	1.0	1.11	1.11	0.92	1.46
Maximum	3.0	2.0	2.5	3.0	3.5	3.0	3.5	3.0	2.5	2.5
Minimum	–1.0	–1.0	–1.5	–1.5	–0.5	–0.5	–1.5	–1.0	–1.0	–3.0
Median	0.5	0.5	0.5	0.75	1.0	1.5	1.0	1.0	1.0	1.0
P value†	.002	.007	.07	.09	< .001	< .001	< .001	< .001	< .001	.04

IP = implant placement; DR = definitive restoration; M = mesial; D = distal.
*Positive values indicate gain; negative values indicate loss.
†Wilcoxon signed rank test.

Discussion

This study evaluated implant survival and peri-implant tissue response following immediate provisionalization of implants placed into recently grafted alveolar ridges and sockets. After a healing period of 4 to 6 months following augmentation using demineralized bovine bone mineral and a collagen barrier membrane, sufficient bone was available for placement of implants with primary stability in the majority of patients. However, initial primary stability was not achieved for 2 of 25 implants planned for the 21 patients. The immediate provisionalization of the implants resulted in one early implant loss without late failures and produced high implant survival after a 5-year follow-up period (95.6%). In the related prospective study comparing immediate provisionalization of implants placed into ungrafted sockets or healed ridges, the same high implant survival (96%) was recorded at 3 years.[13]

Table 5 Mean changes (mm) in gingival zenith location (relative to incisal edge) from definitive crown placement*

	IP + 1 year	IP + 3 years	IP + 5 years
n	20	21	21
Mean	0.70	0.45	0.24
SD	1.13	1.14	0.93
Maximum	3.0	2.5	2.0
Minimum	–1.0	–2.0	–2.0
Median	0.75	0.5	0.0
P value†	.02	.04	.15

IP = implant placement.
*Positive values indicate gain; negative values indicate loss.
†Wilcoxon signed rank test.

In a systematic review of alveolar augmentation and implant placement, Jensen and Terheyden[14] indicated that several combinations of bone grafting materials and procedures permit implant placement and are associated with high implant

survival. In another review,[15] it was concluded that bone grafting procedures as performed in this study are effective in promoting augmentation in postextraction sites. The authors concluded that survival rates over 95% may be expected for both immediate and early placement. The present investigation is in agreement with this review regarding implant survival and tissue stability associated with later implant placement. However, the related study involving immediate placement and provisionalization also demonstrated the same magnitude of tissue stability, calling in question the fundamental causes of tissue stability and the potential reasons for tissue instability.[16] The stated risk factors of thin tissue biotype, facial malposition of the implant, and a thin or damaged facial bone wall were averted by the present grafting of deficient alveolar ridges or sockets.

Jung et al[17] reported on the comparison of implant placement in alveolar ridges augmented using demineralized bovine bone allograft and collagen membranes with or without recombinant human bone morphogenetic protein 2. None of the 34 implants in 11 patients were lost in either grafting situation; there were insignificant changes in the marginal bone levels over the 5-year evaluation period. In a related work, Benić et al[18] demonstrated 100% implant survival for implants in concomitantly grafted bone and 94.1% implant survival for implants placed in native alveolar bone. They concluded that implants placed with concomitant bone regeneration did not perform differently from implants placed into native bone with respect to implant survival, marginal bone height, and peri-implant soft tissue parameters. The osseointegration of implants does not appear to be negatively impacted by the presence of healed or healing demineralized bone allograft. This may reflect the relative abundance of native alveolar bone supporting the implant and/or the integrity of the osseointegration process within regenerated bone. Importantly, the present study did not include any canine sites (or traumatically avulsed teeth), which may have required more significant alveolar reconstruction that could challenge optimal esthetic outcomes.

There is sufficient histologic evidence that titanium implants are integrated within regenerated bone. Bone-to-implant contact is not negatively impacted by the presence of residual xenograft or allograft particles in the augmented sites. In a canine model, implants placed in deproteinized bovine bone mineral (DBBM; BioOss) 3 months after grafting showed equivalent osseointegration to implants placed in healed ridges following a 4-month healing period.[19] In a primate model, osseointegration within tissues regenerated using DBBM and a collagen membrane was confirmed.[20] In a surgical defect model in dogs, histology revealed that DBBM grafts placed around implants at placement resulted in a normal range of bone-to-implant contact (30% to 40%). At 4 months, however, some of the newly formed bone resorbed.[21] Bio-Oss exhibited osteoconductive properties and was recommended for GBR procedures in dehiscence defects with respect to vertical and horizontal growth of bone. Norton et al[22] illustrated that the new bone volume created by augmentation procedures using this method was approximately 25% vital bone (with approximately 25% residual matrix), and this tissue supported the successful osseointegration of dental implants (97%).

It should be noted that some controversy remains regarding the value of graft material to the process of osseointegration at subsequent implant placement. In a canine buccal defect model, it was concluded that significant bone-to-implant contact was not achieved at DBBM-grafted sites.[23] In a recent consideration of the bone-to-implant contact achieved at microimplants placed into grafted sinuses, Browaeys et al[24] concluded that osseointegration in sinus bone grafts mixed with Bio-Oss was poor. This result may not be limited to the type of material: Spin-Neto et al[25] indicated similar limitations in osseointegration achieved clinically using an allogeneic bone graft. Rasmusson et al[26] directly compared the implant stability and survival of implants placed in grafted maxillary bone and intact maxillary bone and found no difference in implant performance. In the present scenario, the high implant survival may reflect that much of the implant was placed in native alveolar bone. Clinical alveolar regeneration and subsequent dental implant osseointegration can be achieved using the protocol utilized in this study.

The present investigation involved a relatively brief healing period of 4 to 6 months following augmentation. There is some evidence that longer healing periods may not be required for consolidation of xenogenic bone grafts. However, clearly this time frame does not permit complete integration or resorption of the xenograft. The clinical procedures reflect this; intact xenograft particles were occasionally displaced from the healing tissue sites during the preparation of the osteotomy for implant placement. A longer healing period could favor further graft consolidation and improve the intraoperative experience for the clinician. However, it is noted that high implant survival and 5-year peri-implant tissue stability suggests that sufficient consolidation occurred prior to or continued following implant placement, provisionalization, and function.

The logistical and temporal advantages of immediate provisionalization 4 to 6 months following ridge augmentation merit consideration. First, a decision to avoid implant placement in a socket or insufficient alveolar ridge in favor of augmentation should always be made where needed. Second, the augmentation prior to implant placement simplifies the procedure and permits soft tissue closure at the time of grafting. Third, immediate provisionalization within the recently grafted site accelerates treatment with apparently little added risk of implant failure or soft tissue complication. This approach is temporally equivalent to early placement procedures that involve tooth extraction followed by early implant placement concurrent with buccal bone augmentation utilizing demineralized bone xenograft and a collagen membrane without implant provisionalization.[4] Both approaches involve at least a 6-month period of partial edentulism that is followed by implant placement and restoration. Comparing the 5-year outcomes from the early placement protocol to the present approach, both provide high implant survival and buccal tissue stability. The increased interproximal soft tissue (papilla) dimensions recorded here were not observed for the early loading protocol. While both procedures require mucoperiosteal reflection involving the adjacent teeth, in the present investigation, both flapped (n = 7) and flapless (n = 16) procedures resulted in positive interproximal tissue changes. The interproximal tissue differences are minor and may not influence the reportedly high esthetic values recorded.[27] However, the time of provisionalization as a variable merits further investigation in terms of peri-implant mucosal architecture.

The restorative protocol utilized a titanium abutment that was retained from provisionalization as the final abutment. This required the use of cement-retained provisional crowns. The perils of cement-mediated inflammatory disease at implants, while identified nearly two decades ago by Walton and co-workers,[28] has become a recent prominent concern, although its impact remains debated.[29] The highest suspicion of cement retention must be adopted when cement-retained crowns are used for implant restorations. Every effort must be made to identify and remove excess cement. The present data set did not directly report on the occurrence of cement retention and removal, but the low incidence of inflammation (bleeding on probing) and absence of significant soft tissue complications suggest that efforts to control cement extrusion were carefully carried out. Although not adopted for this patient cohort, alveolar grafting can afford alternative implant orientation that favors screw retention, a therapeutic concept that offers several different advantages, including the elimination of cement from the protocol.

Conclusions

Alveolar bone augmentation required for implant placement within bound edentulous spaces can be performed using DBBM and a collagen membrane to create sufficient bone volume to permit subsequent implant placement and successful osseointegration. Alveolar ridge augmentation using DBBM and a collagen membrane supported the measured soft tissue architecture, including the buccal tissue levels, over a 5-year period. The immediate placement and provisionalization of implants into regenerated alveolar sites resulted in high implant survival and stability of both the interproximal papillae and buccal tissue architecture.

Acknowledgments

The authors reported no conflicts of interest related to this study.

References

1. den Hartog L, Slater JJ, Vissink A, Meijer HJ, Raghoebar GM. Treatment outcome of immediate, early and conventional single-tooth implants in the aesthetic zone: A systematic review to survival, bone level, soft-tissue, aesthetics and patient satisfaction. Clin Periodontol 2008;35:1073–1086.
2. Jung RE, Zembic A, Pjetursson BE, Zwahlen M, Thoma DS. Systematic review of the survival rate and the incidence of biological, technical and esthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. Clin Oral Implants Res 2012;23(suppl 6):2–21
3. Fürhauser R, Florescu D, Benesch T, Haas R, Mailath G, Watzek. Evaluation of soft tissue around single-tooth implant crowns: The pink esthetic score. Clin Oral Implants Res 2005;16:639–644.
4. Belser UC, Grütter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: a cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. J Periodontol 2009;80:140–151.
5. Raes F, Cooper LF, Tarrida LG, Vandromme H, De Bruyn H. A case-control study assessing oral-health-related quality of life after immediately loaded single implants in healed alveolar ridges or extraction sockets. Clin Oral Implants Res 2012; 23:602–608.
6. Cooper LF, Raes F, Reside GJ, et al. Comparison of radiographic and clinical outcomes following immediate provisionalization of single-tooth dental implants placed in healed alveolar ridges and extraction sockets. Int J Oral Maxillofac Implants 2010;25:1222–1232.
7. Cosyn J, Sabzevar MM, De Bruyn H. Predictors of inter-proximal and midfacial recession following single implant treatment in the anterior maxilla: A multivariate analysis. J Clin Periodontol 2012;39:895–903.
8. Buser D, Chappuis V, Bornstein MM, Wittneben JG, Frei M, Belser UC. Long-term stability of contour augmentation with early implant placement following single tooth extraction in the esthetic zone: A prospective, cross-sectional study in 41 patients with a 5- to 9-year follow-up. J Periodontol 2013;84:1517–1527.
9. Meijndert L, Raghoebar GM, Meijer HJ, Vissink A. Clinical and radiographic characteristics of single-tooth replacements preceded by local ridge augmentation: A prospective randomized clinical trial. Clin Oral Implants Res 2008;19:1295–1303.
10. Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. The efficacy of horizontal and vertical bone augmentation procedures for dental implants—A Cochrane systematic review. Eur J Oral Implantol 2009;2:167–184.
11. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants 2009;24(suppl):237–259.
12. Hämmerle CH, Araújo MG, Simion M; Osteology Consensus Group 2011. Evidence-based knowledge on the biology and treatment of extraction sockets. Clin Oral Implants Res. 2012;23:(suppl 5):80–82.
13. De Bruyn H, Raes F, Cooper LF, et al. Three-years clinical outcome of immediate provisionalization of single Osseospeed implants in extraction sockets and healed ridges. Clin Oral Implants Res 2013;24: 217–223.
14. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: Clinical results with different bone grafts and bone-substitute materials. Int J Oral Maxillofac Implants 2009; 24(suppl):218–236.
15. Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. Int J Oral Maxillofac Implants 2009;24(suppl):186–217.
16. Cosyn J, Hooghe N, De Bruyn H. A systematic review on the frequency of advanced recession following single immediate implant treatment. J Clin Periodontol 2012;39:582–589.
17. Jung RE, Windisch SI, Eggenschwiler AM, Thoma DS, Weber FE, Hämmerle CH. A randomized-controlled clinical trial evaluating clinical and radiological outcomes after 3 and 5 years of dental implants placed in bone regenerated by means of GBR techniques with or without the addition of BMP-2. Clin Oral Implants Res 2009;20:660–666.
18. Benić GI, Jung RE, Siegenthaler DW, Hämmerle CH. Clinical and radiographic comparison of implants in regenerated or native bone: 5-year results. Clin Oral Implants Res 2009;20:507–513.
19. Berglundh T, Lindhe J. Healing around implants placed in bone defects treated with Bio-Oss. An experimental study in the dog. Clin Oral Implants Res 1997;8: 117–124.
20. Hämmerle CHF, Chiantella GC, Karring T, Lang NP. The effect of a deproteinized bovine bone mineral on bone regeneration around titanium dental implants. Clin Oral Implants Res 1998;9:151–162.
21. De Santis E, Botticelli D, Pantani F, Pereira FP, Beolchini M, Lang NP. Bone regeneration at implants placed into extraction sockets of maxillary incisors in dogs. Clin Oral Implants Res 2011;22:430–437.
22. Norton MR, Odell EW, Thompson ID, Cook RJ. Efficacy of bovine bone mineral for alveolar augmentation: A human histologic study. Clin Oral Implants Res 2003; 14:775–783.
23. Carmagnola D, Berglundh T, Araújo M, Albrektsson T, Lindhe J. Bone healing around implants placed in a jaw defect augmented with Bio-Oss. An experimental study in dogs. J Clin Periodontol 2000;27: 799–805.
24. Browaeys H, Vandeweghe S, Johansson CB, Jimbo R, Deschepper E, De Bruyn H. The histological evaluation of osseointegration of surface enhanced microimplants immediately loaded in conjunction with sinuslifting in humans. Clin Oral Implants Res 2013;24:36–44.
25. Spin-Neto R, Stavropoulos A, Coletti FL, Faeda RS, Pereira LA, Marcantonio E Jr. Graft incorporation and implant osseointegration following the use of autologous and fresh-frozen allogeneic block bone grafts for lateral ridge augmentation. Clin Oral Implants Res 2014;25:226–233.
26. Rasmusson L, Thor A, Sennerby L. Stability evaluation of implants integrated in grafted and nongrafted maxillary bone: A clinical study from implant placement to abutment connection. Clin Implant Dent Relat Res 2012;14:61–66.
27. Buser D, Halbritter S, Hart C, et al. Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: 12-month results of a prospective study with 20 consecutive patients. J Periodontol 2009;80:152–162.
28. Pauletto N, Lahiffe BJ, Walton JN. Complications associated with excess cement around crowns on osseointegrated implants: A clinical report. Int J Oral Maxillofac Implants 1999;14:865–868.
29. de Brandão ML, Vettore MV, Vidigal Júnior GM. Peri-implant bone loss in cement- and screw-retained prostheses: Systematic review and meta-analysis. J Clin Periodontol 2013;40:287–295.