Esthetic Outcomes Following Immediate and Early Implant Placement in the Anterior Maxilla—A Systematic Review

Stephen T. Chen, BDS, MDSc, PhD, FRACDS[1]/Daniel Buser, DMD, Prof Dr Med Dent[2]

Purpose: *The objectives of this systematic review are* (1) *to quantitatively estimate the esthetic outcomes of implants placed in postextraction sites, and* (2) *to evaluate the influence of simultaneous bone augmentation procedures on these outcomes.* ***Materials and Methods:*** *Electronic and manual searches of the dental literature were performed to collect information on esthetic outcomes based on objective criteria with implants placed after extraction of maxillary anterior and premolar teeth. All levels of evidence were accepted (case series studies required a minimum of 5 cases).* ***Results:*** *From 1,686 titles, 114 full-text articles were evaluated and 50 records included for data extraction. The included studies reported on single-tooth implants adjacent to natural teeth, with no studies on multiple missing teeth identified (6 randomized controlled trials, 6 cohort studies, 5 cross-sectional studies, and 33 case series studies). Considerable heterogeneity in study design was found. A meta-analysis of controlled studies was not possible. The available evidence suggests that esthetic outcomes, determined by esthetic indices (predominantly the pink esthetic score) and positional changes of the peri-implant mucosa, may be achieved for single-tooth implants placed after tooth extraction. Immediate (type 1) implant placement, however, is associated with a greater variability in outcomes and a higher frequency of recession of > 1 mm of the midfacial mucosa (eight studies; range 9% to 41% and median 26% of sites, 1 to 3 years after placement) compared to early (type 2 and type 3) implant placement (2 studies; no sites with recession > 1 mm). In two retrospective studies of immediate (type 1) implant placement with bone graft, the facial bone wall was not detectable on cone beam CT in 36% and 57% of sites. These sites had more recession of the midfacial mucosa compared to sites with detectable facial bone. Two studies of early implant placement (types 2 and 3) combined with simultaneous bone augmentation with GBR (contour augmentation) demonstrated a high frequency (above 90%) of facial bone wall visible on CBCT. Recent studies of immediate (type 1) placement imposed specific selection criteria, including thick tissue biotype and an intact facial socket wall, to reduce esthetic risk. There were no specific selection criteria for early (type 2 and type 3) implant placement.* ***Conclusions:*** *Acceptable esthetic outcomes may be achieved with implants placed after extraction of teeth in the maxillary anterior and premolar areas of the dentition. Recession of the midfacial mucosa is a risk with immediate (type 1) placement. Further research is needed to investigate the most suitable biomaterials to reconstruct the facial bone and the relationship between long-term mucosal stability and presence/absence of the facial bone, the thickness of the facial bone, and the position of the facial bone crest.* Int J Oral Maxillofac Implants 2014;29(Suppl):186–215. doi: 10.11607/jomi.2014suppl.g3.3

Key words: *bone grafts, CBCT, contour augmentation, early implant placement, esthetics, GBR, immediate implant*

Implant therapy is today widely regarded as a reliable treatment option to replace missing teeth, both for function and esthetics, as documented by recent 10-year studies conducted with current implant systems.[1–7] The original treatment protocols of the 1970s and 1980s required fully healed alveolar ridges before implants were placed.[8,9] In the 1990s, these protocols were modified to include implant placement in fresh extraction sockets[10,11] or in partially healed alveolar ridges[12] predominantly for implants in the esthetic zone.

At a consensus conference of the International Team for Implantology (ITI) in 2003, Belser et al concluded that although the use of dental implants in the esthetic zone was well documented, there was a lack of well-defined esthetic parameters to evaluate outcomes.[13]

[1]Senior Fellow, Periodontics, Melbourne Dental School, The University of Melbourne, Parkville, VIC, Australia.
[2]Professor and Chairman, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Bern, Switzerland.

Correspondence to: Dr Stephen Chen, 223 Whitehorse Road, Balwyn, VIC 3013, Australia. Email: schen@balwynperio.com.au

At the same conference, a classification system for the timing of implant placement after tooth extraction was developed, which was based on morphologic, histologic, and dimensional changes of the alveolar ridge.[14] The systematic review that formed the basis of this classification concluded that the evidence for esthetic outcomes in postextraction sites was insufficient for definitive conclusions to be drawn.[15] Postextraction implant placement in this context refers to immediate placement (type 1), early placement with soft tissue healing (type 2), early placement with partial bone healing (type 3), and late placement (type 4).

In the 10-year period since this consensus conference, there has been an increase in the reporting of esthetic parameters including changes in the position of the peri-implant mucosa[16] and esthetic indices based on ordinal scales.[17] Esthetic indices have provided clinicians and researchers with more objective tools to evaluate hard and soft tissue–related esthetic outcomes with implant-supported prostheses.

During the same period, it was recognized that the resorption and modeling of the alveolar ridge in postextraction sites has the potential to influence esthetic results.[18] The use of bone augmentation procedures using biomaterials with a low substitution rate has been proposed as a means to reduce these postextraction dimensional changes.[19] Technological advances in three-dimensional (3D) radiology have provided researchers with a noninvasive method to evaluate these bone augmentation procedures in relation to postextraction implants.[20,21]

The objectives of this systematic review are *(1)* to quantitatively estimate the esthetic outcomes of implants placed in postextraction sites, and *(2)* to evaluate the influence of simultaneous bone augmentation procedures on these outcomes.

MATERIALS AND METHODS

Search Strategy

The reporting of this systematic review is based on the PRISMA guidelines (http://www.prisma-statement.org). An electronic search of the literature was performed according to the criteria set out in Table 1.

Selection of Studies

Screening of the titles and selection of abstracts for potential inclusion in the review was undertaken independently by the two reviewers. The full texts of the shortlisted abstracts were reviewed independently, and articles for inclusion were selected on the basis of the criteria stipulated in Table 1. Any disagreement was resolved by discussion between the reviewers. The Kappa value for interassessor agreement during screening of title and abstract was 0.92 and 0.88 respectively, indicating excellent agreement.

Excluded Studies

Out of the 117 full-text articles assessed, 67 were excluded from the final analysis due to the following reasons:

- Review papers or papers of methodology
- Data for the same population duplicated in another study
- Insufficient data/lack of esthetic parameters to assess esthetic outcomes
- Unable to separate data for different placement time
- Unable to separate data for sites in the anterior maxilla (esthetic zone defined as the maxillary anterior and maxillary premolar teeth) from posterior and mandibular sites
- Data available only for implant placement in healed sites
- Case reports with less than 5 cases

Quality Assessment

Randomized controlled trials (RCTs) and cohort studies were assessed for bias using the Cochrane Collaboration tool, which consisted of six domains that addressed the adequacy of sequence generation, allocation concealment, blinding of participants, handling of incomplete outcome data, steps to minimize selective outcome reporting, and whether other sources of bias were identified (http://ohg.cochrane.org/sites/ohg.cochrane.org/files/uploads/Risk%20of%20bias%20assessment%20tool.pdf). According to the Cochrane Collaboration tool, a judgment of "risk of bias" was assigned if one or more key domains had a high risk of bias. Cohort studies were assessed for quality and reporting using the Newcastle-Ottawa scale, which provides for eight key domains (http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp). One star is awarded for each domain in which the criteria are fulfilled, with the exception of "comparability" which can be awarded two stars. A maximum of nine stars may be assigned to a study.

Data Extraction

From the included articles, data on timing of implant placement postextraction, simultaneous placement of bone grafts, connection of provisional crowns immediately after implant placement, peri-implant soft tissue dimensional changes, and esthetic indices were extracted and recorded on standardized forms. In addition, inclusion and exclusion criteria were recorded. Any disagreement between reviewers was resolved by discussion.

Table 1 Systematic Search Strategy

Focus question	What is the influence of implant placement timing and augmentation procedures on esthetic outcomes in the anterior maxilla?
Search strategy	
Population	1) Jaw, edentulous, partially[MeSH terms] OR partially edentulous OR partial edentulism
Intervention or exposure	2) Dental implantation, endosseous[MeSH terms] OR "dental implants, single tooth"[MeSH terms] OR endosseous implant* OR dental implant*
Comparison	3) Immediate implant OR immediate-delayed AND implant OR delayed-immediate AND implant OR early implant placement 4) Guided bone regeneration OR gbr OR bone substitute* OR bone filler* OR autogenous bone OR autologous bone OR allogenic graft* OR allograft* OR xenogenic graft* OR xenograft* OR freeze dried bone allograft OR fdba OR demineralized freeze dried bone allograft OR dfdba OR Bio-Oss OR Bio-Oss collagen OR tricalcium phosphate OR tricalciumphosphate OR xenogenic graft* OR alloplast 5) 3D imaging, computer generated[MeSH terms] OR cone beam ct OR cbct OR ct
Outcome	6) Esthetics[MeSH terms] OR esthetics OR esthetic indices OR esthetic index OR esthetic outcomes OR mucosal recession OR white esthetic score OR wes OR pink esthetic score OR pes OR implant crown esthetic index OR complex esthetic index OR copenhagen index score OR recession OR mucosal recession OR midfacial recession
Search combination	1 AND 2 AND (3 or 4 or 5) AND 6
Database search	
Language	English
Electronic	Medline (PubMed 1985 to August 2012), Cochrane Central Register of Controlled Trials (CENTRAL)
Journals	*Clinical Oral Implants Research, International Journal of Oral Maxillofacial Implants, Clinical Implant Dentistry and Related Research, Implant Dentistry, Journal of Implantology, Journal of Periodontology, Journal of Clinical Periodontology* (from 1985 to November 2012)
Selection criteria	
Inclusion criteria	Clinical studies on adults only Studies at all levels of evidence, except expert opinion Case reports must include at least five patients Implant placement in the esthetic zone defined as the maxillary anterior and premolar region of the dentition
Exclusion criteria	Insufficient information on timing of implant placement after tooth extraction Studies reporting on multiple placement times in which insufficient information is available to sort the data Absence of objective parameters: esthetic indices, soft tissue measurements Animal studies Multiple publications on the same patient population No author response to inquiry email for data clarification

Statistical Analysis

A preliminary analysis of the included studies showed that the majority of studies were case series studies. There were insufficient RCTs of similar design to permit a meta-analysis. Of the non-randomized studies (cohort, cross-sectional, and case series), it was noted that there was significant heterogeneity in study design, study population, follow-up times, and esthetic parameters reported. Therefore, descriptive methods were mainly used to present the data.

For non-randomized studies, a trend analysis was undertaken. Studies were included for this analysis if the subjects were consecutively enrolled, there was no deviation in the treatment protocol, and the follow-up period was between 1 and 3 years. Studies were grouped according to methodologic similarities based on timing of implant placement postextraction, use of bone graft, use of connective tissue (CT) graft, and use of immediate provisional crowns. The data were presented in forest plots with weights derived from random-effect analysis (Comprehensive Meta Analysis v2.2.064). Data from randomized studies were not included in this part of the analysis (http://handbook.cochrane.org/chapter_13/13_including_non_randomized_studies.htm). Overall effects were not calculated due to the high risk of bias with case series studies and significant heterogeneity. Statistical homogeneity was determined using Cochran *Q* and its associated *P* value, and the *I*-squared statistic. Clinical implications of data heterogeneity were reviewed when the *P* value was less than 0.1, and the *I*-squared statistic became increasingly higher. The random-effects model was used to weight studies on the forest plots. All data are presented in mm as means ± standard deviations.

Table 2 Included Studies

	Number	Studies
Randomized controlled studies (RCTs)	6	Lindeboom et al,[22] Palattella et al,[23] De Rouck et al,[24] Block et al,[25] Chen et al,[26] Felice et al[27]
Cohort studies	6	Gotfredsen,[28] Cangini and Cornelini,[29] Juodzbalys and Wang,[30] Grunder,[31] Raes et al,[32] De Bruyn et al[33]
Cross-sectional studies	5	Evans and Chen,[34] Buser et al,[35] Belser et al,[36] Miyamoto and Obama,[37] Cosyn et al[38]
Case series studies	33	Grunder,[39] Kan et al,[40] Cornelini et al,[41] Juodzbalys and Wang,[42] Kan et al,[43] Canullo and Rasperini,[44] Noelken et al,[45] De Rouck et al,[46] Buser et al,[47] Kan et al,[48] Pirker and Kocher,[49] Redemagni et al,[50] Tortamano et al,[51] Chen et al[52] Cosyn and De Rouck,[53] Cooper et al,[54] Cosyn et al,[55] Brown and Payne,[56] Tsuda et al,[57] Buser et al,[58] Chung et al,[59] Cosyn et al,[60] Kan et al,[61] Malchiodi et al,[62] Mangano et al,[63] Noelken et al,[64] Benic et al,[20] Cabello et al,[65] Lee et al,[66] Buser et al,[21] Cosyn et al,[67] Furze et al,[68] Noelken et al[69]
Total	50	

RESULTS

Following the systematic search strategy (Fig 1), a total of 50 studies were included in this systematic review of esthetic outcomes with postextraction implants (Table 2). These 50 studies were comprised of 6 RCTs,[22–27] 6 cohort studies,[28–33] 5 cross-sectional studies,[34–38] and 33 case series studies.[20,21,39–69] There were 7 studies.[21,33,38,58,60,61,69] that were identified as follow-up reports of previous publications.[35,40,45–47,54,55] One paper[36] presented data on esthetic outcomes on the patient pool of a previous paper.[35] Data were extracted from the more recent publications and tabulated. Any missing data were obtained from the earlier publications. The list of excluded studies,[45,70–132] including reasons for exclusion may be found in Table 3.

Of the six included RCTs, four were judged to be at risk of bias mainly due to nonconcealment and nonblinding of the examiners (Table 4).[22,23,25,26] The majority of the included cohort studies were of sufficient quality (Table 5).[28,29,32,33] For the case series studies, the majority were prospective in design with consecutively enrolled subjects. All the included studies assessed outcomes following placement of single-tooth implants in postextraction sites adjacent to natural teeth.

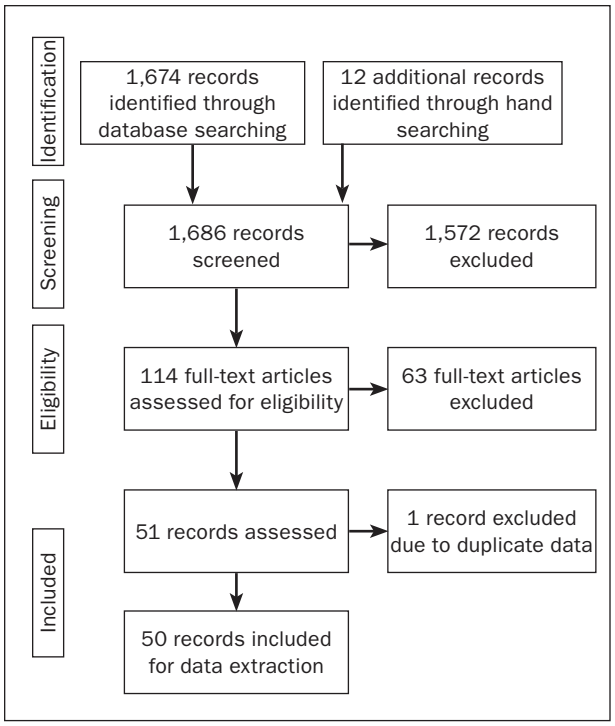


Fig 1 Search results.

Change in Position of the Peri-implant Mucosa

Study Characteristics. There were 5 RCTs,[22–26] 5 cohort studies,[28–31,33] 3 cross-sectional studies,[21,34,37] and 25 case series studies[20,21,30,39–41,44,46,48–53,56–62,65–72,92] that provided data on change in position of the peri-implant mucosa following implant placement. The majority of studies were prospectively designed, with only two studies identified as retrospective reports.[20,53] The data are summarized in Table 6 for studies with comparative data (RCT and cohort studies) and Table 7 for cross-sectional and case series studies.

Study Duration. For studies with comparative data, four studies provided short-term data with observation periods of 6[31] and 12 months.[22,24,29] Three studies reported on 2-year outcomes[23,25,37] and one study provided 3-year data.[26] One study reported on outcomes after a follow-up period of 5 years.[28]

Most of the case series were short-term, with a follow-up period of 12 months reported in 13 studies,[30,39–42,46,47,56,57,59,65,67,92] 13 to 24 months in 7 studies[34,44,49–51,53,66] and 25 to 36 months in 6 studies.[36,48,52,58,60,62] There was 1 study with an observation

Table 3 Excluded Studies

Reason for exclusion	Number	Studies
Review papers or papers of methodology	4	Kan and Rungcharassaeng,[71] Den Hartog et al,[97] Grutter and Belser,[108] Freitas et al[111]
Data for the same population reported in a later study	1	Raes et al[132]
Insufficient data and/or lack of parameters to evaluate esthetic outcomes	31	Handelsman,[70] Hui et al,[72] Proussaefs et al,[73] Saadoun,[74] Kan and Rungcharassaeng,[75] Covani et al,[77] Doring et al,[78] Locante,[79] Norton,[80] Dhanrajani and Al-Rafee,[82] Barone et al,[85] De Kok et al,[86] Steigmann and Wang,[88] Calvo Guirado et al,[89] Covani et al,[90] Kan et al,[92] Sammartino et al,[93] Siepenkothen,[94] Fagan et al,[98] Lops et al,[100] Mankoo,[101] Romeo et al,[103] Avvanzo et al,[105] Del Fabbro et al,[107] Crespi et al,[110] Shibly et al,[115] Balshi et al,[119] Grunder et al,[121] Kehl et al,[123] Lops et al,[126] Fugazzotto[130]
Data for different placement times could not be separated	9	Vanden Bogaerde et al,[84] Noelken et al,[45] Degidi et al,[96] Kollar et al,[99] Stein et al,[109] Juodzbalys and Wang,[113] Siebers et al,[114] Di Alberti et al,[129] Schwarz et al[131]
Data for maxillary anterior sites could not be separated from posterior and mandibular sites	6	Bianchi and Sanfilippo,[76] Cordaro et al,[106] Schropp and Isadore,[104] van Kesteren et al,[117] De Angelis et al,[120] Covani et al[128]
Data available only for implant placement in healed sites or sites that underwent ridge preservation prior to implant placement	11	Van der Zee et al,[81] Hall et al,[91] Lindeboom et al,[87] Cannizzaro et al,[95] Meijndert et al,[102] Aldredge and Nejat,[118] Hof et al,[122] Tymstra et al,[116] Fu et al,[112] Lee et al,[124] Schneider et al[127]
Case reports with less than 5 cases	2	Testori et al,[83] Levin[125]
Total	64	

Table 4 Quality Assessment and Risk of Bias of Included RCTs

Study	Adequate sequence generation?	Allocation concealment?	Blinding of participants?	Incomplete outcome data addressed?	Free of selective outcome reporting?	Other sources of bias?
Lindeboom et al[22]	Yes	Yes	No	Yes	Yes	No
Chen et al[26]	Yes	No	No	Yes	Yes	No
Palattella et al[23]	Yes	Yes	No	Yes	Yes	No
De Rouck et al[24]	Yes	Yes	Yes	Yes	Yes	No
Block et al[25]	Yes	No	Yes	Yes	Yes	No
Felice et al[27]	Yes	Yes	Yes	Yes	Yes	No

A "no" response in any of the first 5 domains indicates a high risk of bias.

Table 5 Quality Assessment and Risk of Bias of Included Non-Randomized Studies

Study	Representative of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Outcome of risk not present at commencement of study	Comparability of cases and controls (maximum 2 stars)	Assessment of outcome	Sufficient follow-up time for outcomes to occur	Adequacy of follow-up	Total
Gotfredsen[28]	*	*	*	*	*		*	*	7
Cangini and Cornelini[29]	*	*	*	*	*		*	*	7
Grunder[31]	*	*	*	*				*	5
Juodbalys and Wang[30]	*	*	*	*			*	*	6
Raes et al[32]	*	*	*	*	*	*	*	*	8
De Bruyn et al[33]	*	*	*	*	*		*	*	7

period of 48 months[61] and 2 long-term studies with 84 month follow-up.[20,21] Four studies[21,58,60,61] were follow-up reports of previous studies.[36,40,46,47]

Outcomes from Randomized Studies. Palattella and coworkers compared immediate (type 1) and early (type 2) implant placement in a RCT in which provisional restorations were connected within 48 hours of the implants being placed.[23] Each group comprised eight patients and nine single-tooth implants in the maxillary anterior region. Recession of the midfacial mucosa occurred in both groups without statistically significant difference between the groups after 2 years (type I group, –0.8 ± 0.7 mm vs type 2 group, –0.6 ± 0.6 mm; $P > .05$).

In a RCT that compared type 1 and type 3 implant placement at single-tooth sites with radiographic evidence of chronic periapical lesions, no difference in the level of the midfacial mucosa was observed between the two placement protocols.[22] The frequency of mucosal recession, however, was slightly greater in type 1 placement sites (0 to 1 mm in 7 of 23 sites; 1 to 2 mm in 2 of 23 sites) compared to type 3 placement sites (0 to 1 mm in 4 of 25 sites; 1 to 2 mm in 0 of 25 sites).

Immediate versus delayed restoration of immediately placed implants was compared in a RCT which combined implant placement and grafting of the periimplant defect with DBBM.[24] After 1 year, significantly less recession of the midfacial mucosa ($P = .005$) was observed in the immediate restoration group (25 implants in 25 patients; 1 early failure; –0.41 ± 0.75 mm) compared to the delayed restoration group (25 implants in 25 patients; –1.16 ± 0.66 mm). No differences were observed in recession of the mesial and distal papillae between the immediate restoration group and delayed restoration group (mesial papilla –0.41 ± 0.77 mm vs 0.43 ± 0.42 mm, respectively; distal papilla –0.31 ± 0.81 mm vs –0.53 ± 0.55 mm, respectively).

Three bone augmentation methods with type 1 implant placement were compared in a RCT.[26] A high proportion of sites across all three groups (10 of 30) demonstrated recession of the midfacial mucosa of greater than 1 mm. Implants placed buccally in the extraction sockets were significantly associated with recession.

Outcomes from Non-randomized Studies. Four cohort studies provided comparative data on timing of implant placement after extraction.[28,30,33,37] In a prospective cohort study, 25 consecutively enrolled patients received implant placement after extraction according to a decision tree based on the morphology of the extraction socket.[30] Sockets that were considered adequate were treated by flapless type 1 implant placement with a non-submerged approach. Compromised sockets were treated with one of the following techniques: Flapless type 1 implant placement with a non-submerged approach, type 2 placement 6 weeks after tooth extraction with simultaneous soft and/or hard tissue augmentation, or type 1 implant placement with simultaneous soft and/or hard tissue augmentation. Deficient sockets were reconstructed with GBR and soft tissue grafting procedures prior to implants being placed. After 12 months, all "adequate" sockets achieved satisfactory esthetic outcomes. Compromised sockets treated with type 1 implant placement showed initially adequate esthetic results, but 50% were downgraded to compromised after 1 year. On the other hand, compromised sockets with type 2 placement showed better results, initially 87.5% satisfactory at prosthesis placement and 62.5% after 1 year.

Miyamoto and Obama in a retrospective cohort study reported significantly greater recession at the 2-year follow-up visit with type 1 placement compared to type 2 placement.[37] There were three treatment groups: type 1 placement combined with autogenous bone graft (5 patients and 7 implants), type 2 placement in which guided bone regeneration (GBR) was performed with nonresorbable membranes (8 patients and 16 implants), and type 2 placement combined with GBR using resorbable membranes (3 patients and 8 implants). The implants were conventionally loaded. Recession of the midfacial mucosa of 0.85 ± 0.79 mm, 0.06 ± 0.25 mm, and 0.50 ± 0.53 mm was observed for the three groups, respectively. The differences were significant between the type 1 placement group and the type 2 placement with nonresorbable membrane group ($P < .05$). Cone beam computed tomography (CBCT) data indicated that vertical resorption of the facial bone occurred, with dimensions of 3.25 ± 4.68 mm, 0.13 ± 0.36 mm, and 0.70 ± 1.02 mm recorded, respectively.

Gotfredsen compared outcomes between type 2 and type 3 implant placement in a prospective cohort study.[28] Single-tooth implants were placed in 10 patients 4 weeks after extraction (type 2 group) and 10 patients 12 weeks after extraction (type 3 group). After 5 years, the difference in crown length between implants and control teeth was 0.6 ± 0.7 mm in the type 2 placement group and 0.7 ± 1.4 mm in the type 3 placement group (no significant difference; $P > .05$). Recession of the papillae 0.3 ± 0.5 mm and 1.0 ± 0.7 mm occurred in the type 2 and type 3 placement groups, respectively.

Type 1 and type 4 implant placement were compared in a prospective cohort study.[33] In the type 1 placement group, 55 patients received 55 single-tooth implants. In the type 4 placement group, 58 patients received 58 single-tooth implants. All implants had provisional crowns with no occlusal contacts connected immediately after placement. In the type 1 placement group, two early failures (3.6%) were recorded and one patient was lost to follow-up. In the type 4 placement group, one early failure (1.7%) was noted.

Table 6 Studies with Comparative Data on Different Implant Placement Times that Report on Dimensional Changes of the Peri-implant Mucosa

Study	Study design	Placement time (n patients/n implants)	Location	Simultaneous bone grafting	Time from surgery to evaluation	Healing protocol (time from surgery to loading in months)
Gotfredsen[28]	Cohort study	Group A: Type 2 at 4 weeks (10/10) Group B: Type 3 at 12 weeks (10/10)	Maxillary anterior and premolar sites	Nonresorbable ePTFE membrane	5 y	Conventional
Cangini and Cornelini[29]	Cohort study	Teeth with periodontal defects requiring extraction Type 1: EMD group (18/18) Membrane group (14/14)	Maxillary anterior and premolar sites	Enamel matrix derivative or resorbable collagen membrane	1 y	Conventional
Lindeboom et al[22]	RCT	Type 1 (25/25) Type 3 (25/25)	Maxillary anterior and premolar sites	Milled autogenous bone from the mandibular retromolar or symphyseal region and covered with a resorbable collagen membrane	1 y	Conventional
Chen et al[26]	RCT	Type 1 with 3 augmentation techniques: Control group no and graft no membrane (10/10) BG group DBBM only (10/10) BG+M group DBBM and collagen membrane (10/10)	Maxillary anterior and premolar sites	DBBM	3 y	Conventional
Palattella et al[23]	RCT	Type 1 (8/9) Type 2 (8/9) Immediate provisional non-loaded restorations attached within 48 hours of implant placement	Maxillary anterior teeth	No	2 y	Immediate provisional prosthesis (no occlusal contacts)
De Rouck et al[24]	RCT	Type 1: IRG group immediate restoration (24/24) DRG group delayed restoration (25/25)	Maxillary anterior teeth	IRG group DBBM only DRG group DBBM and collagen membrane	1 y	IRG group immediate provisional prosthesis (no occlusal contacts) DRG group conventional loading
Block et al[25]	RCT	Type 1 (26/26) Ridge preservation (29/29)	Maxillary anterior and premolar teeth	DFDB	2 y	Immediate provisional prosthesis (no occlusal contacts)
Juodzbalys and Wang[30]	Cohort study	Type 1 (9/9) Type 2 (10/10)	Maxillary anterior and premolar sites	DBBM and collagen membrane	1 y	Immediate provisional prosthesis (no occlusal contacts)
Grunder[31]	Cohort study	Type 1 no CT graft (12/12) Type 1 with CT graft (12/12)	Maxillary incisors and canines	No	6 mo	

Midfacial mucosal margin Mean (SD)	Mesial papilla Mean (SD)	Distal papilla Mean (SD)	Other findings
Change from baseline to 5 years: Group A: 0.3 (0.5) mm Group B: –0.3 (0.6) mm Difference between implant crown and contralateral control tooth: Group A: 0.6 (1.2) mm Group B: 0.7 (1.4) mm 9/10 Group A and 8/10 Group B implant crowns were longer than the natural control tooth crown No significant difference between groups	Mesial and distal papillae combined Change from baseline to 5 years: Group A: –0.3 (0.5) mm Group B: –1.0 (0.7) mm No significant difference between groups		Patient centered esthetic assessment using a 10 point VAS: Group A: 9.4 (range, 7.1–9.9) Group B: 8.8 (range, 5.1–10.0) Dentist esthetic assessment using a 10 point VAS: Group A: 5.9 (range, 2.9–9.5) Group B: 8.4 (range, 6.1–9.7)
Distance between mucosal margin and submucosally placed implant shoulder: EMD group, 0.90 (1.29) mm Membrane only group, 0.22 (1.47) mm (significant difference between groups; $P < .05$)	Mesial and distal papillae combined Distance between proximal soft tissue level and submucosally placed implant shoulder: EMD group, 1.30 (2.37) mm Membrane only, group 1.16 (1.0) mm (significant difference between groups; $P < .05$)		
Compared to the adjacent control tooth: No difference in mucosal level: Type 1, 14/23, Type 3, 21/25 0–1 mm difference: Type 1, 7/23 Type 3, 4/25 1–2 mm difference: Type 1, 2/23 Type 3, 0/25	Jemt Papilla Index mesial and distal papillae combined: Score 2: Type 1 group 5/23 Type 3 group 18/25 Score 3: Type 1 group 18/23 Type 2 group 18/25		All sites had radiographic evidence of chronic periapical lesions Implant failures: 2/25 in Type I group 0/25 in Type 3 group
10/30 sites exhibited recession of 1 to 3 mm (3 in BG group, 3 in control group, 4 in BG+M group)			Implants placed in a buccal in the socket were significantly associated with recession of the mucosa Midfacial mucosal margin and papillae were stable between 1 and 3 years.
Change from baseline Type 1 group: –0.8 (0.7) mm Type 2 group: –0.6 (0.6) mm No significant difference between groups	NR	NR	Jemt Papilla Index (mesial and distal papillae combined) Type 1 group: Score 0, 0; Score 1, 3/18; Score 2, 8/18; Score 3, 7/18; Score 4, 0 Type 2 group: Score 0, 0; Score 1, 2/18; Score 2, 7/18; Score 3, 9/18; Score 4, 0
Baseline to 1 year: IRG group, –0.41 (0.75) mm DRG group, –1.16 (0.66) mm Significant difference between groups ($P = .005$)	Baseline to 1 year: IRG group, –0.41 (0.77) mm DRG group, –0.43 (0.42) mm No significant difference between groups	Baseline to 1 year: IRG group, –0.31 (0.81) mm DRG group, – 0.53 (0.55) mm No significant difference between groups	Excluded patients: 2 with partial loss of facial bone after extraction; 1 in the IRG was excluded because insertion torque was only 20 Ncm Most dimensional change took place in the first 3 months Patient's esthetic satisfaction: IRG, 93% (range, 92%–100%) DRG, 91% (range, 80%–96%)
Length of implant crowns at 2 years Type I group, 7.4 (2.42) mm Ridge preservation group, 8.6 (2.63) mm Groups were significantly different			21/76 patients lost to follow-up
	Nordland and Tarnow classification: Mesial papilla: Adequate: Type 1, 7/9; Type 2, 6/10 Compromised: Type 1, 2/9; Type 2, 4/10	Nordland and Tarnow classification: Distal papilla: Adequate: Type 1, 8/9; Type 2, 8/10 Compromised: Type 1, 1/9; Type 2, 2/10	Type 1: 0% recession ≥ 1 mm Type 2: 20% recession ≥ 1 mm
			Changes in orofacial dimension of the ridge: Type 1 no CT graft, –1.06 mm (range –0.25 to –2.0) Type 1 with CT graft, 0.34 mm (range 0 to 1.5)

Table 6 *continued* **Studies with Comparative Data on Different Implant Placement Times that Report on Dimensional Changes of the Peri-implant Mucosa**

Study	Study design	Placement time (n patients/n implants)	Location	Simultaneous bone grafting	Time from surgery to evaluation	Healing protocol (time from surgery to loading in months)
Miyamoto and Obama[37]		Type 1 with autogenous bone graft (5/7) Type 2 GBR with DBBM and nonresorbable membrane (8/16) Type 2 GBR with DBBM and resorbable membrane (3/8)	Maxillary incisors and canines	Autogenous bone, DBBM, resorbable and non-esorbable membrane	Mean 28 (SD 15.8) mo	Early and conventional
De Bruyn et al[33]	Cohort study	Type 1 (55/55) Type 4 (58/58)	Maxillary anterior and premolar teeth	No	3 y	Immediate provisional prosthesis (no occlusal contacts)
Raes et al[32]	Cohort study	Type 1 (16/39) Type 4 (23/39) Failures: 1 in Type 1 group	Single-tooth maxillary anterior and premolar sites	No	1 y	Immediate provisional prosthesis

A slight positive change in the mucosal level was observed from final crown placement to the 3-year recall in both type 1 and type 4 placement groups (0.23 ± 0.87 mm vs 0.27 ± 1.03 mm). Similarly, a slight gain in papilla height (mesial and distal papillae combined) was observed between final crown insertions to the three-year recall in both groups (0.29 ± 1.08 mm vs 0.53 ± .07 mm, respectively). The difference between groups for midfacial mucosa and papillae were not significant. In a RCT comprising 55 implants and 55 patients, type 1 placement (26 patients) was compared to placement in sites that had undergone ridge preservation (29 patients) using demineralized freeze-dried bone allograft.[25] Implants were immediately restored with provisional crowns. After 2 years, the lengths of the implant crowns were significantly longer in the ridge preservation group (8.6 ± 2.6 mm) compared to the type 1 placement group (7.4 ± 2.4 mm).

In a prospective cohort study, enamel matrix derivative (EMD) was compared to resorbable collagen membrane in conjunction with type 1 implant placement.[29] Significantly less recession of the midfacial mucosa was observed in the EMD-treated sites compared to the membrane-treated sites.

The majority of the case series studies with data on dimensional changes of the peri-implant mucosa were reports on type 1 implant placement. Four studies reported on type 2 implant placement, two of which were follow-up reports on the same patient population.[21,36,47,58] The remaining 24 studies reported on type 1 placement, 18 of which combined immediate implant placement with connection of an immediate

Midfacial mucosal margin Mean (SD)	Mesial papilla Mean (SD)	Distal papilla Mean (SD)	Other findings
Type 1 group 0.85 (0.79) mm * Type 2 group with non-resorbable membrane 0.06 (0.25) mm * Type 2 group with resorbable membrane 0.50 (0.53) mm * P < .05 between these 2 groups			CBCT obtained at least 6 months after abutment connection Vertical bone resorption: Type 1 group 3.25 (4.68) mm * Type 2 group with nonresorbable membrane 0.13 (0.36) mm * Type 2 group with resorbable membrane 0.70 (1.02) mm * P < .05 between these 2 groups Width of labial bone at cervical section: Type 1 group 0.48 (0.67) mm (4/7 implant had no bone visible) Type 2 group with non-esorbable membrane 2.22 (0.81) mm Type 2 group with resorbable membrane 1.15 (0.82) mm (2/8 implants had no bone visible) P < .01 between Type 1 groups and both Type 2 groups
Final crown to 1 year: Type 1 group 0.35 (0.89) mm range –1.0 to 2.5 Type 4 group 0.29 (0.76) mm range –2.0 to 2.0 Final crown to 3 years: Type 1 group 0.23 (0.87) mm range –2.0 to 2.0 Type 4 group 0.27 (1.03) mm range –3.0 to 2.0 No significant differences between groups	Mesial and distal papillae combined: Final crown to 1 year: Type 1 group 0.34 (0.95) mm range –1.8 to 2.3 Type 4 group 0.58 (0.94) mm range –2.8 to 2.5 Final crown to 3 years: Type 1 group 0.29 (1.08) mm range –2.0 to 2.0 Type 4 group 0.53 (1.07) mm range –2.8 to 2.8 No significant differences between groups		Failure rate after 1 year: Type 1 group 3/54 (one patient lost to follow-up) Type 4 group 1/58 (no significant differences between groups) Type 1 cases had intact facial bone or clinically insignificant dehiscences and fenestrations
Type 1 group –0.12 (0.78) mm Type 4 group –1.00 (1.15) mm	Type 1 group 0.07 (0.99) mm Type 4 group 0.30 (1.38) mm	Type 1 group –0.38 (1.21) mm Type 4 group 0.60 (0.87) mm	11/16 implants in the Type 1 group were placed flapless Less recession observed with flapless placement

provisional crown.[30,41,44,46,48–51,56,57,59–62,65,67,92] Type 1 placement using a flapless surgical approach was reported in 13 studies.[44,48–52,56,57,59,61,62,65,92] Various bone and soft tissue augmentation methods were used at the time of implant placement, including autogenous bone graft alone,[62] deproteinized bovine bone mineral (DBBM) alone,[44,46,60,67] resorbable membrane alone,[41] DBBM particles and/or autogenous bone chips covered by a resorbable collagen membrane,[20,21,30,53,58] and DBBM alone combined with a connective tissue (CT) graft.[42,48,50,57,59,92,124]

The predominant finding was that recession of the midfacial mucosa and papillae occurred with postextraction implant placement. In most studies, the mean recession of the midfacial mucosa and tooth-implant papillae was less than 1 mm.[39,41,46,48,49,53,56-–59,62,65,67] There were five studies that reported no change[50] or a gain in mucosal height.[44,48,51,66] Four of these studies were of type 1 placement using a flapless approach and immediate provisional prosthesis,[44,51] as well as incorporation of a connective tissue graft at the same time.[48,50] One study combined CT graft and coronal flap advancement to correct preexisting gingival recession at sites in which the extracted teeth were periodontally compromised.[66] A significant mean gain of 2.1 ± 0.7 mm of the midfacial mucosa was reported in this study.

Non-randomized studies that fulfilled the criteria of consecutively enrolled patients, nondeviation of the treatment protocol, and follow-up time of 1 to 3 years were analyzed for trends in outcomes.[34,35,39–41,44,48,51,53,56–60,62,65]

Table 7 Case Series Studies Reporting on Change in Position of the Peri-implant Mucosa at Postextraction Implants in the Maxillary Esthetic Zone

Study	Study Design	Patients (implants)	Placement time	Healing protocol	Loading protocol	Augmentation technique	Follow-up period
Grunder[39]	Prospective case series	10 (10)	Type 1	Submerged	Delayed	No augmentation	12 mo
Cornelini et al[41]	Prospective case series	22 (22)	Type 1	Transmucosal	Immediate provisional restoration	Collagen membrane	12 mo
Juodzbalys and Wang[42]	Prospective case series	12 (14)	Type 1	Submerged	Delayed	DBBM and collagen membrane; CT graft to correct soft tissue deficiencies	12 mo
Kan et al[43]	Prospective case series	23 (23)	Type 1 flap and flapless	Transmucosal	Immediate provisional restoration	Autogenous bone or DBBM and collagen membrane; CT graft in 11/23 cases in which tissue biotype was thin	12 mo
Canullo and Rasperini[44]	Prospective case series	9 (10)	Type 1 flapless	Transmucosal	Immediate provisional restoration	DBBM if defect > 1 mm in orofacial dimension	Mean 22 mo (range, 18 to 36)
Evans and Chen[34]	Cross-sectional	42 (42)	Type 1	NR	Conventional	Not stated	Mean 19 mo
De Rouck et al[46]	Prospective case series	29 (29)	Type 1	Transmucosal	Immediate provisional restoration	DBBM	12 mo
Kan et al[48]	Prospective case series	20/20	Type 1 flapless	Transmucosal	Immediate provisional restoration	DBBM and CT graft	Mean 26 mo (range, 12 to 48)
Pirker and Kocher[49]	Prospective case series	12/12	Type 1 flapless	Transmucosal	Immediate provisional restoration	No augmentation	Mean 18 mo (SD 10; range, 6–34)
Redemagni et al[50]	Retrospective case series	28 (33)	Type 1 flapless	Transmucosal	Immediate provisional restoration	DBBM + CT graft	Mean 20.4 mo (range, 6 to 50)
Chen et al[52]	Retrospective case series	85 (85)	Type 1 flapless	Transmucosal	Early	No augmentation	Mean 26 mo
Cosyn and De Rouck[53]	Prospective case series	27 (27)	Type 2	Submerged	Conventional	DBBM + collagen membrane	Mean 21 mo
Tortamano et al[51]	Prospective case series	12 (12)	Type 1 flapless	Transmucosal	Immediate provisional restoration	Not stated	18 months

Change in midfacial mucosa*			
Frequency	Mean (SD)	Change in papillae height	Additional comments
NR	–0.6 (0.39) mm (median –0.5 mm; range 0 to –1.5 mm)	Mesial –0.5 (0.33) mm Distal –0.25 (0.26) mm Papillae combined –0.375 (0.32) mm (median –0.5 mm; range 0 to –1 mm)	
NR	Mean recession 0.75 mm	Jemt Papilla Index[138]: Score 2, 61% of papillae Score 3, 39% of papillae No scores of 0, 1, and 4	
21.4% with recession of 1 to 2 mm	NR	Jemt Papilla Index[138]: Score 2, 64.3% of papillae Score 3, 35.7% of papillae No scores of 0, 1, and 4	
34.8% - recession ≥ 1.5 mm 8.3% of sites with V-shaped defects of the facial bone 42.8% of sites with U-shaped defects of the facial bone 100% of sites with UU-shaped defects of the facial bone	NR	NR	CT graft was used in 4/8 with gingival recession of ≥ 1.5 mm
	0.2 (0.42) mm	Mesial, 0.4 (0.52) mm Distal, 0.1 (0.32) mm	
45.2%, recession 0.5 mm; 21.4%, recession 1.0 mm; 19.1%, recession ≥ 1.5 mm	–0.9 (0.78) mm	Mesial, –0.5 (0.52) mm Distal, –0.5 (1.0) mm	Subjective Esthetic Score (SES)[34] 82% satisfactory (score I and II) 18% unsatisfactory (score III and IV)
	–0.53 (0.76) mm Significantly different from baseline	Mesial, –0.41 (0.71) mm Distal, –0.31 (0.83) mm Mesial was significantly different from baseline	Patient's esthetic evaluation (VAS) Mean 93% (range 82 to 100%) The largest dimensional changes took place in the first 3 mo of implant placement
	+0.13 (0.61) Thick biotype: +0.23 (0.82) Thin biotype: +0.06 (0.45) No significant differences between thin and thick biotype cases	Jemt Papilla Index[138]: Score 2, 20% of papillae Score 3, 80% of papillae	
	–0.5 (0.7) mm Range 0-1.5 mm		58% cases had no discernible mucosal recession
	Mean 0 Range –1 to +0.5 mm	Mesial papilla: –0.21 (range 2 to –0.5) mm Distal papilla: –0.02 (range 1 to –0.5) mm	
At 44 sites with initial gingival margins level with adjacent maxillary central incisor: 20.5% recession 5% to 10%; 18% recession of >10%	–4.6 (6.6)% of length of the reference tooth	Mean change of papillae: Mesial, –6.2 (6.8)% Distal, –7.4 (7.5)% of length of the reference tooth	
	–0.3 (1.2) mm	Mean change of papillae: Mesial: –0.4 (0.9 mm) Distal: –1.0 (1.0) Significant difference between groups	
	+0.03 mm	Mesial, +0.14 mm Distal, +0.03 mm	Only cases with intact facial bone were included

Table 7 *continued* **Case Series Studies Reporting on Change in Position of the Peri-implant Mucosa at Postextraction Implants in the Maxillary Esthetic Zone**

Study	Study Design	Patients (implants)	Placement time	Healing protocol	Loading protocol	Augmentation technique	Follow-up period
Kan et al[61]	Prospective case series	35 (35)	Type 1 flapless	Transmucosal	Immediate provisional restoration	No augmentation	Mean 48 mo (range, 2 to 8.2 y)
Brown and Payne[56]	Prospective case series	27 (28)	Type 1 flapless	Transmucosal	Immediate provisional restoration	Not stated	12 mo
Tsuda et al[57]	Prospective case series	10 (10)	Type 1 flapless	Transmucosal	Immediate restoration	DBBM + CT graft	12 mo
Buser et al[58]	Prospective case series	20 (20)	Type 2	Submerged	Conventional	Autogenous bone chips + DBBM + collagen membrane	36 mo
Chung et al[59]	Prospective case series	10 (10) 1 failure	Type 1 flapless	Transmucosal	Immediate restoration	DBBM and CT graft	12 mo
Malchiodi et al[62]	Prospective case series	58 (64)	Type 1 flapless	Transmucosal	Immediate provisional restoration	Autogenous bone chips	36 mo
Benic et al[20]	Cross-sectional	14 (14)	Type 1	Transmucosal	Conventional	DBBM + collagen membrane in 11 cases	Mean 84 mo
Cabello et al[65]	Prospective case series	13 (13)	Type 1 flapless	Transmucosal	Immediate provisional restoration	No augmentation	12 mo
Lee et al[66]	Prospective case series	10 (11)	Type 1	Transmucosal	Conventional	DBBM + CT graft	24 mo
Buser et al[21]	Prospective case series	41 (41)	Type 2	Submerged	Early	Autogenous bone chips + DBBM + collagen membrane	Mean 84 mo (range 5–9 y)
Cosyn et al[67]	Prospective case series	22 (22)	Type 1	Transmucosal	Immediate provisional restoration	DBBM Some cases required CT grafts at a later stage to correct soft tissue deficiencies	12 mo

* Negative value indicates recession of the mucosa; DBBM = deproteinized bovine bone mineral; CT = connective tissue.

Change in midfacial mucosa*			
Frequency	**Mean (SD)**	**Change in papillae height**	**Additional comments**
	Baseline to 1-year: Thin biotype –0.75 (0.59) mm Thick biotype –0.25 (0.33) mm All –0.53 (0.23) mm Baseline to last follow-up: Thin biotype –1.50 (0.88) mm Thick biotype –0.56 (0.46) mm All –1.13 (0.87) mm	Baseline to last follow-up: Mesial papilla: Thin biotype, –0.18 (0.36) mm; Thick biotype, –0.27 (0.30) mm; All, –0.22 (0.34) mm Distal papilla: Thin biotype, –0.21 (0.46) mm; Thick biotype, –0.21 (0.32) mm; All, –0.21 (0.41) mm	All cases had intact facial bone 4 patients (11%) required adjunctive treatment including CT graft, autograft or xenograft to treat mucosal recession Patient evaluation of esthetic outcome (Rating 0 to 10; 0 = totally unsatisfied, 10 = totally satisfied): 33/35 patients were totally satisfied with the esthetic outcome (rated 10) 2/35 patients rated the outcome as 9 Mean patient rated esthetic outcome 9.9
	–0.2 (0.99) mm	Jemt Papilla Index[138]: Score 1, 7% of papillae Score 2, 58% of papillae Score 3, 37% of papillae No scores of 0, 1, and 4	
	–0.05 mm	Jemt Papilla Index[138]: Mesial papilla: Score 0, 20%; Score 1, 10% Score 2, 20%; Score 3, 50% Distal papilla: Score 0, 10%; Score 2, 10% Score 3, 80%	Necrosis of the CT graft in 2 patients resulted
Recession < 1 mm in 1/20	Length compared to control tooth (negative value indicates recession) 1 y: –0.18 (0.58) mm 3 y: –0.09 (0.33) mm		
	–0.05 mm	Jemt Papilla Index[138]: Mesial papilla: Score 2, 11%; Score 3, 89% Distal papilla: Score 0, 11%; Score 1, 11% Score 2, 11%; Score 3, 67%	
46.9% sites had no recession 21.9% recession of 0.5 mm 18.8% recession of 1.0 mm 12.5% recession ≥ 1.5 mm	–0.5 (0.6) mm	Distance between contact point to tip of papilla: Mesial, 0.6 (0.5) mm; Distal, 0.8 (0.6) mm	Significant relationship between crestal bone levels and papilla volume and midfacial mucosal level
At implants with no detectable facial bone on CBCT (5/14) there was 1 mm more recession of the facial mucosa (4/5 received GBR)	–1.5 mm (extrapolated by authors)		Implant shoulder submucosally positioned (tissue level implants) in 12/14 cases
	–0.45 (0.25) mm	Mesial, –0.38 (0.60); Distal, –0.80 (0.96)	No correlation between tissue biotype and dimensional changes of the mucosa between baseline and 12 months
	+2.1 (0.7) mm	Mesial, –0.1 (0.5) mm; Distal, –0.3 (0.5) mm	All cases had preexisting soft tissue recession
	No sig difference between implant crown and control tooth crown Implant crown length at 2006 9.48 (1.09) mm Implant crown length at 2010 9.47 (1.22) mm		CBCT measurement of facial bone thickness at 2010 examination: In relation to implant shoulder: 2 mm level, 1.58 (1.0) mm; 4 mm level, 2.22 (0.98) mm; 6 mm level, 2.33 (1.14) mm; In 2 implants (4.9%) no facial bone was detected
At 3 months: 9% > 1 mm recession At 12 months: 0% > 1 mm recession	At 3 months: –0.3 (0.8) mm range –2.0 to 1.5 At 12 months: –0.2 (0.4) mm range –1.0 to 0.5)	At 12 mo: Mesial papilla, –0.2 (0.5) mm, range –1.0 to 1.0 Distal papilla, –0.5 (0.5) mm, range –1.5 to 0	1 failure, 1 drop out Severe recession (1.5 mm and 2.0 mm) noted in 2 patients at 3 months. A further 5 patients had noticeable recession. 7 patients required adjunctive CT graft at 3 months to correct recession of the midfacial mucosa

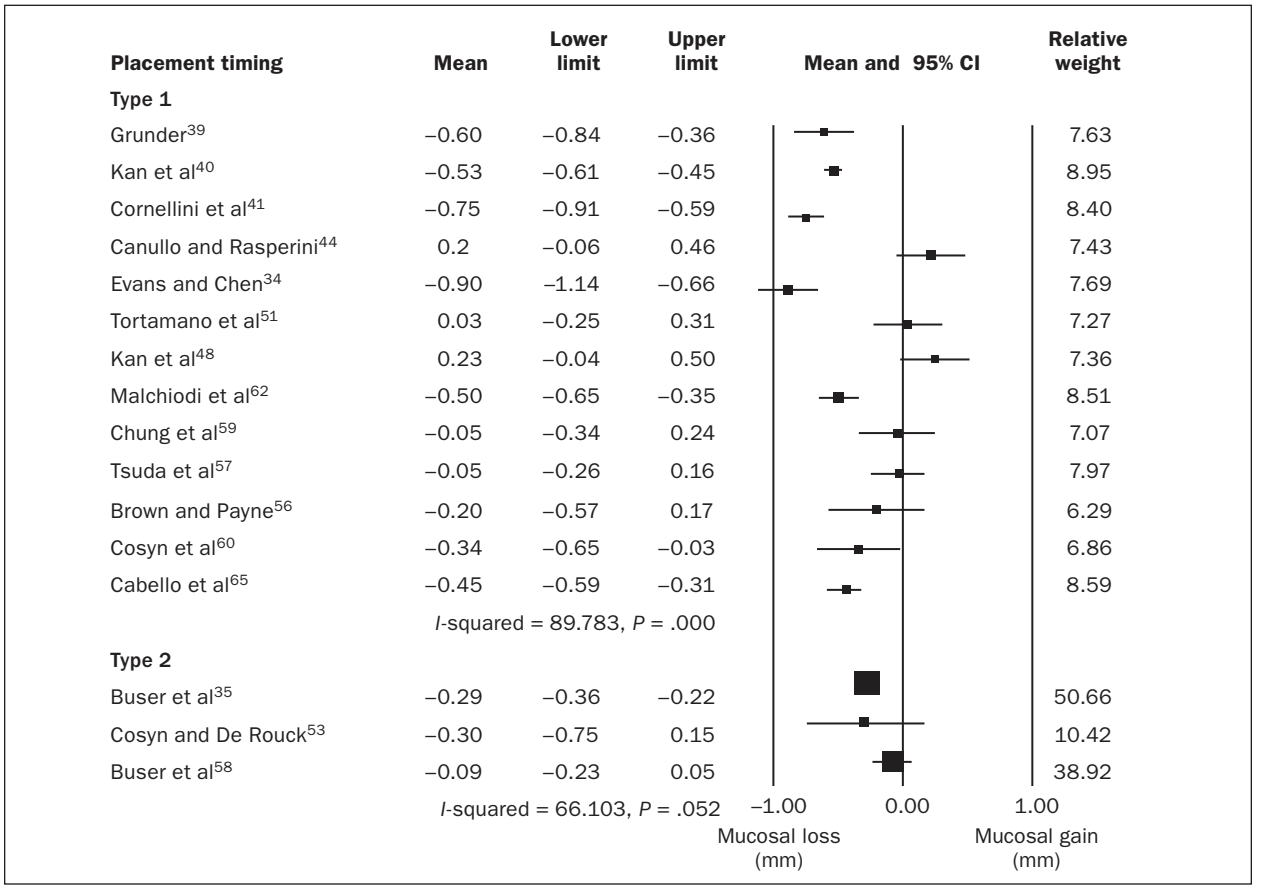


Fig 2 Mean change in midfacial mucosal position reported in studies grouped by timing of implant placement. NB weights are from random-effects analysis.

Studies were grouped according to placement timing (Fig 2). A greater variation in results was noted for type 1 placement (13 studies; *I*-squared = 89.783, *P* = .000) compared to type 2 placement (3 studies; *I*-squared = 66.103, *P* = .062). These studies varied in surgical protocol (flap vs flapless elevation), hard and soft tissue grafting, and loading protocols. Further stratification of studies on type 1 placement was made according to treatment methodology (use of bone graft, flapless surgery, provisional crown, and CT graft) (Fig 3). From the forest plots, less variation in results was seen for the combination on bone graft, flapless surgery, provisional crown, and CT graft at the time of type 1 implant placement (3 studies; *I*-squared = 33.74, *P* = .223).

There was one study of type 2 implant placement[53] and eight studies of type 1 implant placement[34,39,40,44,51,53,60,62,65] that provided data on change in position of the mesial and distal papillae (Fig 4). Significant heterogeneity between studies was noted which generally indicated that recession of the papillae occurred with both placement timings. Grouping of type 1 placement studies according to use of provisional crown and surgical approach (flap versus flapless surgery) revealed a homogeneity between two studies[34,39] in which implants were placed with conventional flap surgery and no provisional crowns connected immediately (mesial papilla: *I*-squared = 0.000, *P* = .999; distal papilla: *I*-squared = 51.089, *P* = .153) (Fig 5). Examination of the forest plots yielded no distinct trend in change of papilla position based on surgical approach and use of immediate provisional crowns.

Frequency of Recession. In addition to reporting mean values, several studies also reported on the frequency of recession of the midfacial mucosa. In a RCT, Lindaboom and coworkers reported a higher frequency of recession at the type 1 placement group (0 to 1 mm in 7 of 25 sites and 1 to 2 mm in 2 of 25 sites) compared to type 3 placement group (0 to 1 mm in 4 of 25 sites and 1 of 2 mm in 0 to 25 sites) when compared to the adjacent control teeth.[22] In another RCT, 10 of 30 sites exhibited recession of the midfacial mucosa of 1 to 3 mm following type 1 implant placement and transmucosal healing.[26] In two studies of type 1 placement using a conventional surgical approach and conventional loading protocol, the frequency of recession of the midfacial mucosa of 1 mm or more was

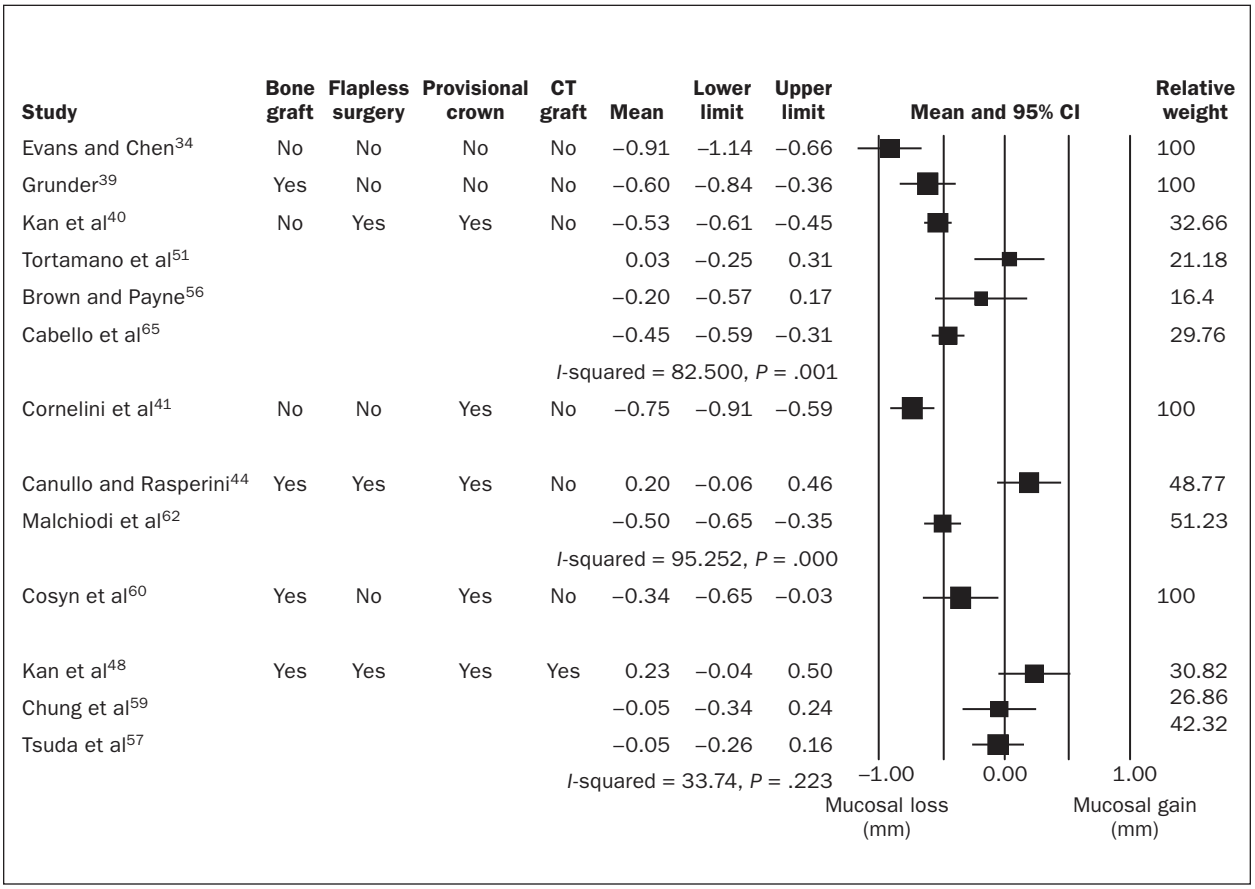


Fig 3 Mean change in midfacial mucosa reported in studies on immediate (type 1) placement grouped by treatment method. NB weights are from random-effects analysis.

reported to be 21.4%[42] and 40.5%.[34] Two studies of type 1 placement with immediate provisional restoration of the implants reported on the frequency of recession of the midfacial mucosa. In one study, implants were placed in extraction sites with thick tissue biotype using a minimal flap elevation. Recession of the midfacial mucosa of 1 mm or more was noted in 9% of sites within 3 months of the implants being placed.[67] In the other study, implants were placed with a flapless surgical technique. After 3 years, recession of the midfacial mucosa of 1 mm or more was observed in 31.3% of sites.[62] In contrast, one study of type 2 implant placement using conventional flap elevation, GBR with autogenous bone chips and DBBM and a submerged healing protocol reported 1 out of 20 sites with recession (0.5 to 1 mm) after 3 years.[58]

In a study of type 1 placement in the presence of defects in the facial bone of varying size, recession of the midfacial mucosa of 1.5 mm or more was reported in 34.8% of sites.[92] The defects were grafted with autogenous bone chips or DBBM combined with a resorbable collagen membrane. In the presence of thin periodontal tissue biotype, additional grafting with CT was carried out. The implants were provisionally restored following placement. It was noted that the frequency of recession increased with correspondingly larger defects in the facial bone.

In contrast, one study of type 2 placement reported a relatively low incidence of recession of the midfacial mucosa.[58] Type 2 implant placement was combined with GBR using autogenous bone chips and DBBM and resorbable collagen membrane. After 3 years, 1 of 20 sites (5%) demonstrated recession, which was in the range of 0.5 to 1 mm.

Outcomes from CBCT. Three studies provided data on CBCT reconstructed images of the bone on the facial aspect of maxillary anterior implants. In the study of Miyamoto and Obama, type 1 placement sites were grafted with autogenous bone to fill the peri-implant defect. Type 2 placement sites were grafted with DBBM and either a resorbable or nonresorbable barrier membrane.[37] Significantly greater recession of the midfacial mucosa occurred at type 1 placement sites compared to type 2 placement sites after a mean of 28 months (SD, 15.8 months). There was correspondingly greater vertical crestal bone

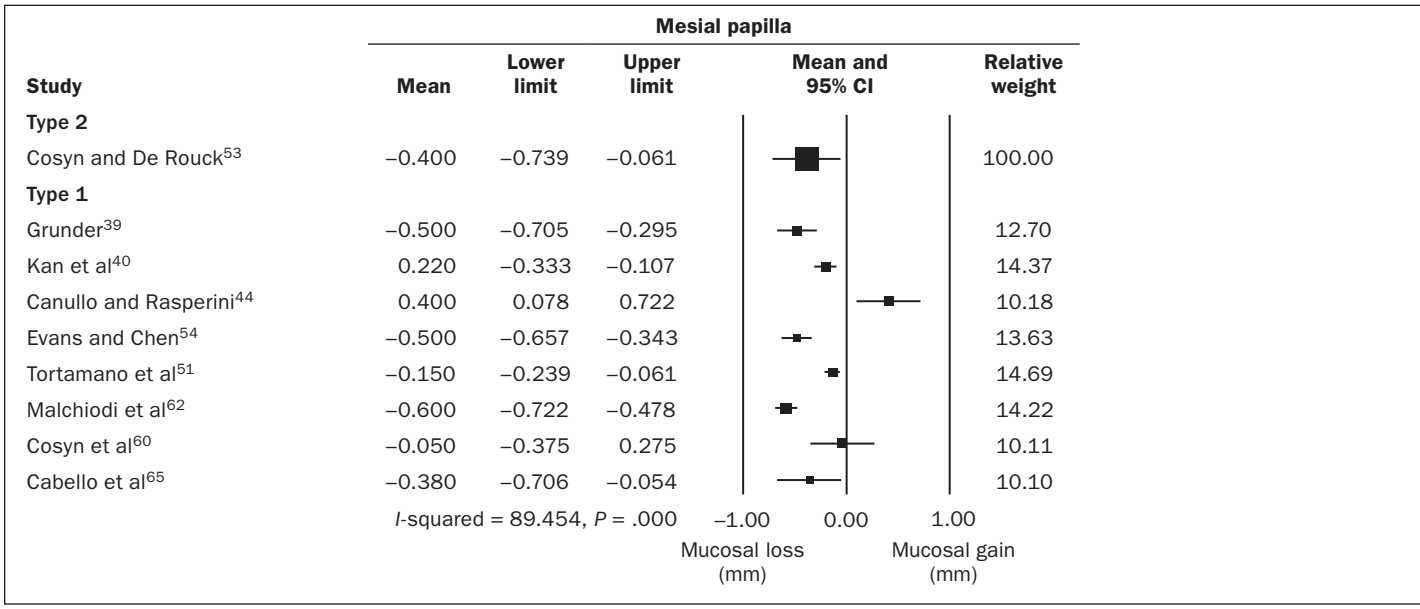


Fig 4 Mean change in position of the mesial and distal papilla reported in studies grouped by timing of implant placement. NB weights are from random-effects analysis.

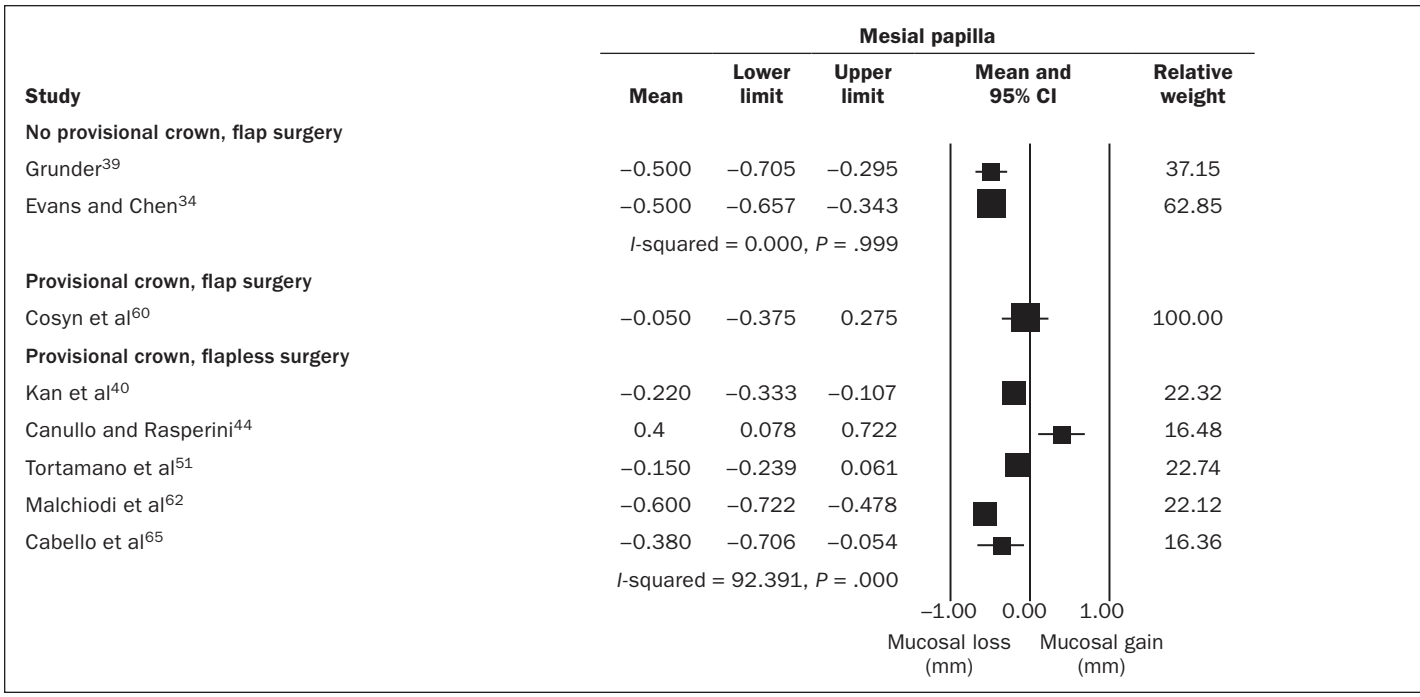
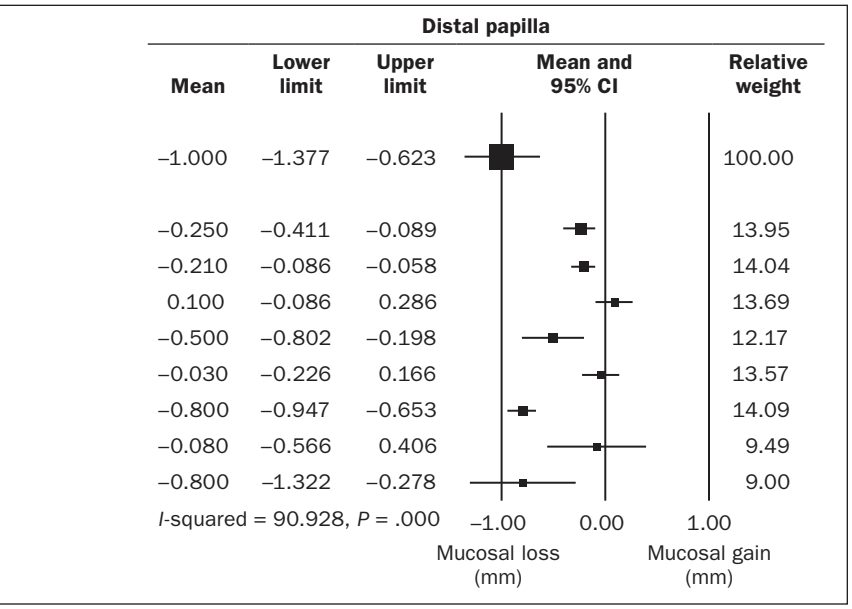
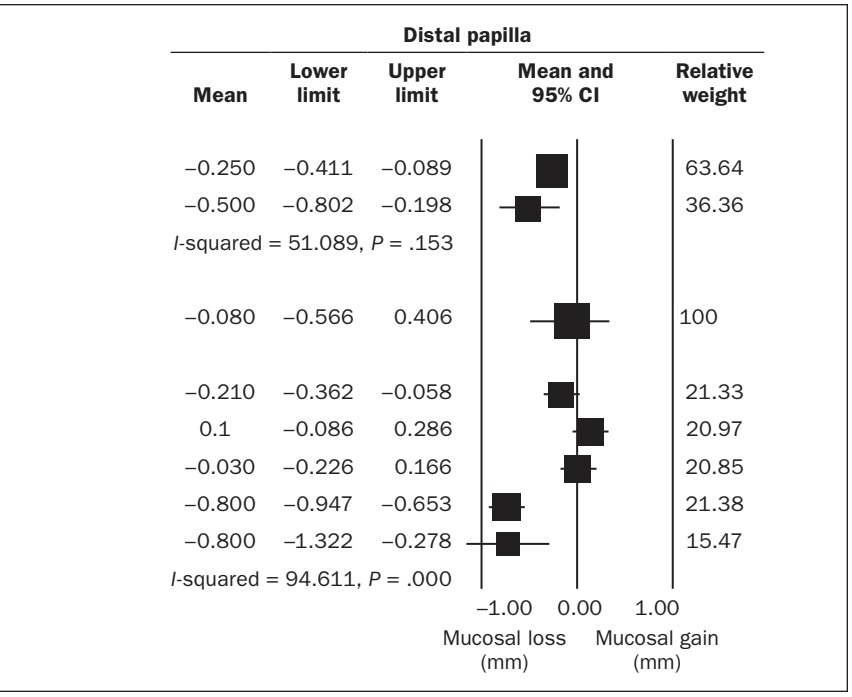


Fig 5 Mean change in position of the mesial and distal papilla reported in studies of type 1 implant placement grouped by treatment method. NB weights are from random-effects analysis.

resorption at type 1 placement sites (3.25 ± 4.68 mm) compared to type 2 placement sites (0.13 ± 0.36 mm for nonresorbable membrane and 0.70 ± 1.02 mm for resorbable membrane) which suggests that dimensional change in crestal bone influences the position of the peri-implant mucosa. From reformatted images of the scans, the orofacial thickness of the facial bone was measured at various points along the implants. At the cervical region of the implants, type 1 placement sites grafted with autogenous bone had a mean bone thickness of 0.48 ± 0.67 mm; 4 of 7 (57.1%) sites had no detectable bone on the facial surface of the implants. Type 2 placement sites grafted with DBBM had bone thickness of 2.22 ± 0.81 mm for the sites treated with





nonresorbable membrane and 1.15 ± 0.82 for sites treated with resorbable membrane. Two of eight (25%) of the type 2 sites treated with resorbable membrane had no detectable facial bone on the scans. The risk of resorption of the facial bone crest in type 1 placement was also identified in a recent retrospective study.[20] In 14 patients with 14 single-tooth type 1 implant placements, CBCT data were obtained 7 years after implant placement. At 11 sites, the peri-implant defects were grafted with DBBM and collagen membrane. The remaining three sites were not grafted. The authors reported an average of 1.5 mm of recession of the midfacial mucosa. There was no detectable facial bone on the reformatted CBCT images in 5 of 14 sites (35.7%). At sites with no radiographically detectable facial bone, recession of the midfacial mucosa was 1 mm greater than at sites with detectable facial bone.

A recent follow-up study of type 2 implant placement reported stable facial bone conditions.[21] Out of the original 45 patients who received single-tooth implants combined with GBR using autogenous bone chips, DBBM and resorbable collagen membrane and were examined in 2006,[35] 41 were able to be recalled 4 years later in 2010 (5 to 9 years after implant placement).[21] Clinical data were recorded and CBCT scans were obtained. There was no change in the length of the implant crowns between the 2 time points (9.48 ± 1.09 mm at the first examination and 9.47 ± 1.22 mm at the second examination). From reformatted CBCT images, the orofacial thickness of the facial bone wall was measured at three levels. At 2 mm from the implant shoulder, the mean orofacial thickness was 1.58 ± 1.00 mm. The corresponding measurements at 4 mm and 6 mm levels were 2.2 ± 0.98 mm and 2.33 ± 1.14 mm, respectively. In 2 of 41 implants (4.9%), no facial bone wall was detectable radiographically.

Factors Associated with Risk for Recession. From the included studies, factors associated with risk for recession of the midfacial mucosa were identified as pre-existing defects of the facial bone, tissue biotype, implant malposition, stability, and thickness of the facial bone and biomaterials used.

The influence of pre-existing defects in the facial bone on recession of the midfacial mucosa was identified in a study of type 1 placement.[43] In this study, all extraction sites presented with varying degrees of damage to the facial socket wall. Following implant placement, the defects were grafted with autogenous bone or DBBM combined with a resorbable collagen membrane. In the presence of thin periodontal tissue biotype, additional grafting with CT was carried out in 11 of 23 (47.8%) sites. The implants were provisionally restored immediately following implant placement. After 1 year, recession of the facial mucosa of 1.5 mm or more was observed in 34.8% of sites. At sites with minor defects in the facial bone, 8.3% of sites developed

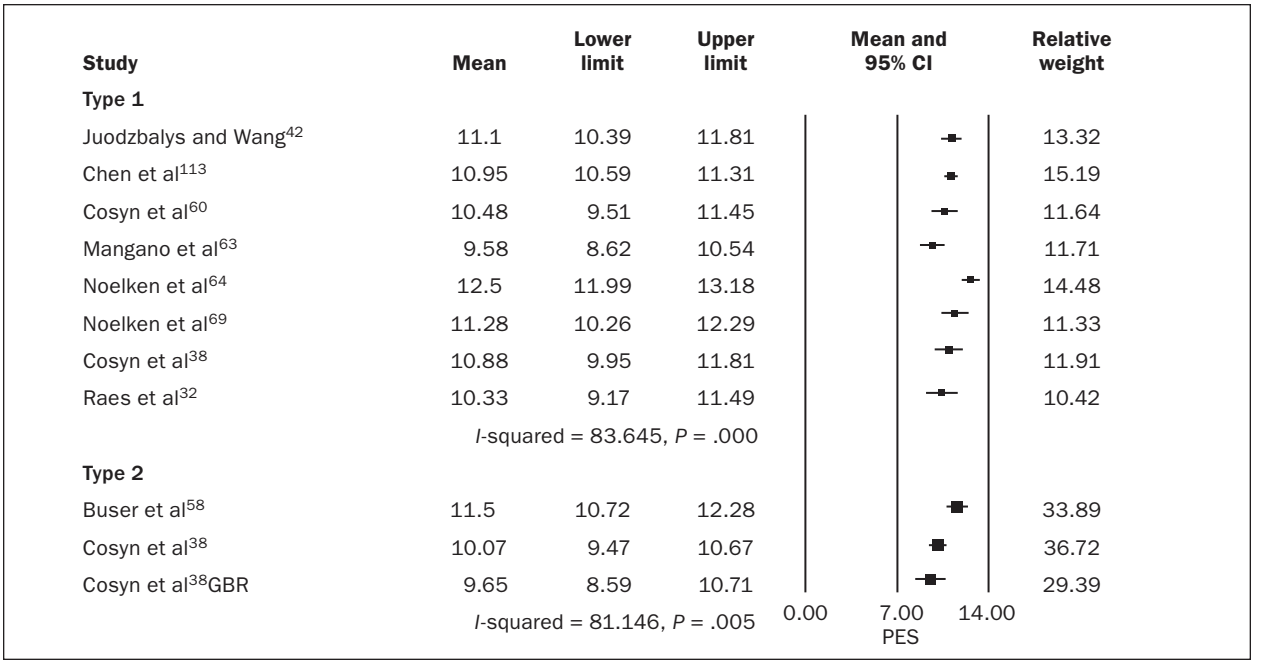


Fig 6 Esthetic outcomes based on pink esthetic score (PES) reported in studies grouped by timing of placement. NB weights are from random-effects analysis.

recession. At sites with larger defects, 42.8% of sites demonstrated recession of the mucosa. In extraction sites with a complete loss of the facial bone wall, recession of the mucosa occurred in 100% of sites.

Thin tissue biotype was identified as a risk factor for mucosal recession. In a study of type 1 implant placement using a flapless surgical approach and immediate provisional restoration, thin biotype sites had significantly more recession than thick biotype sites after 1 year (0.75 ± 0.59 mm vs 0.25 ± 0.33 mm, respectively). In a retrospective study of type 1 placement using a conventional surgical approach and loading protocol, a higher frequency of recession of the midfacial mucosa of 1 mm or more was observed for thin biotype sites (11 of 24 sites) compared to thick biotype sites (6 of 18).[34] Of the sites that developed recession, 6 of the 11 thin biotype sites showed severe recession of more than 2 mm. In contrast to these observations, Kan et al reported no differences between thick and thin tissue biotype sites when CT grafts were incorporated in the surgical protocol of flapless implant placement and immediate restoration.[48]

Two studies reported that the position of the implant in the extraction socket at type 1 placement sites was an important risk factor for mucosal recession.[26,34] Implants that were malpositioned facially in the extraction sockets were significantly associated with an increased risk for mucosal recession.[2] Recession of the mucosa was three times greater in facially malpositioned implants (1.8 ± 0.83 mm) compared to implants placed more orally in the socket (0.6 ± 0.55 mm); the difference was statistically significant.[34]

Based on the studies with CBCT data, type 1 implant placement was associated with significant vertical resorption of the crestal bone and recession of the midfacial mucosa irrespective of the grafting material used (autogenous bone versus DBBM).[20,37] A significant proportion of type 1 placement sites did not have a detectable bone wall on the facial aspect of the implants.[20] In contrast, type 2 placement sites grafted with autogenous bone chips and/or DBBM were associated with less recession of the mucosa[21,37] and a much higher proportion of sites retained detectable bone on the facial aspect of the implants after 7 years.[21]

Mucosal Stability. Several studies of type 1 implant placement reported that the greatest dimensional change took place within the first 3 months of surgery.[24,26,46,65,67] In two studies, mucosal recession was severe enough to require intervention with CT grafts.[26,67] In the study of Chen et al, recession of the midfacial mucosa of 1 to 3 mm occurred in 10 of 30 sites within the first 12 months of surgery. Several sites required corrective treatment using CT grafts.[26] Cosyn and coworkers reported that with type 1 placement combined with immediate provisional restoration and grafting of the peri-implant defect with DBBM, 9% of sites had recession of 1 mm or more within 3 months of implant placement.[67] Severe recession of 1.5 to 2 mm was noted in two patients. Overall, seven patients (seven implants or 31.8% of cases) required adjunctive CT grafts to correct the recession of the midfacial mucosa.

Between 1 to 3 years, the mucosa was reported to be stable in two studies.[26,33] In contrast, Kan and

co-workers reported that after initial recession of the peri-implant mucosa, ongoing changes took place between the first examination at 1 year and the follow-up of examination that took place 2 to 8.2 years later (mean 4 years).[61] Patients had received type 1 placement implants with connection of immediate provisional restorations. Bone grafts were not placed. At 1 year, mean recession of the midfacial mucosa was 0.53 ± 0.23 mm. Recession at the follow-up examination had increased to 1.13 ± 0.87 mm. There was a corresponding increase in the recession of the tooth-implant papillae. Thin biotype sites receded three times more than thick biotype sites. Four patients (11%) expressed concern about the mucosal recession, and three underwent hard and soft tissue grafting procedures to repair the recession. Studies of type 2 placement showed stable mucosal conditions after 3 years[58] and after an average of 7 years in another study from the same group.[21] In both studies, GBR using autogenous bone chips, DBBM, and resorbable collagen membrane was performed. Gotfredsen and coworkers observed stable peri-implant mucosal conditions following type 2 and type 3 implant placement after 5 years.[28] Non-resorbable e-PTFE membranes were used for bone augmentation in this study.

Outcomes Based on Esthetic Indices

Study characteristics. One RCT,[27] one cohort study,[32] one cross-sectional study,[38] and 13 case series studies[21,36,42,47,52,55,58,60,63,64,67–69] reported on esthetic outcomes based on esthetic indices (Tables 8 and 9). Three studies[21,38,58] were follow up reports of previous studies.[36,47,55] All papers were recent publications, the majority having been published since 2009. The majority of studies that fulfilled the inclusion criteria for this systematic review reported on outcomes using the Pink Esthetic Score (PES) in which scores of 0,1, and 2 are assigned to seven soft tissue esthetic parameters to reach a maximum score of 14.[21,27,32,36,38,42,47,52,58,60,63,64,67–69] In five of the studies, a modified version of the PES was used, in which scores of 0, 1, and 2 are assigned to five soft tissue esthetic parameters to reach a maximum score of 10.[21,36,58,63,68] The authors of two of the studies, when contacted, provided the full PES.[58,63] The White Esthetic Score (WES), which assigns scores of 0, 1, and 2 to 5 prosthesis-related parameters (to reach a maximum score of 10) was reported in five studies.[21,58,60,67,68] The Subjective Esthetic Score (SES), which ranks soft tissue related outcomes according to the degree of mucosal recession and volume of the soft tissues on a categorical scale of 1 to 4, was reported in two papers.[34,52]

Outcomes from Randomized Studies. One RCT reported on outcomes using an esthetic index. In this study, type 1 placement with DBBM graft was compared to implant placement in sites that had been grafted with DBBM 4 months previously (ridge preservation group).[27] Provisional restorations were connected to the implants in both groups immediately following their placement. There were 54 patients in the type 1 placement group and 52 patients in the ridge preservation group. Short-term data at 4 months from the time of provisional prosthesis insertion were reported. The authors reported that 35% and 75% of implants in the type 1 placement and ridge preservation groups respectively did not have the provisional restorations connected immediately due to lack of sufficient implant stability. The PES for the type 1 placement and ridge preservation groups were 12.75 ± 0.25 and 12.62 ± 1.05, respectively, with no significant difference between groups.

Outcomes from Non-randomized Studies. In a cohort study that involved single-tooth implants with immediate provisional restorations, type 1 placement was compared to type 4 placement after 1 year. No bone grafts were placed at the time of implant insertion. After 1 year, the PES was 10.33 ± 2.04 for the type 1 placement group and 10.35 ± 1.58 for the type 4 group. The difference was not significantly different. The WES was similar between the type 1 placement (WES 7.20 ± 2.04) and type 4 placement (WES 7.00 ± 2.37) groups.

In a cross-sectional study in which patients were examined on average 33 months from the time of implant placement, 4 treatment modalities were identified in relation to timing of implant placement.[38] For type 1 placement, DBBM was grafted to the gap between the implant and socket wall (28 patients and 30 implants). There were two treatment modalities for type 2 placements—49 implants in the 44 patients were placed without augmentation procedures and at 19 implants in 18 patients, GBR using DBBM and resorbable collagen membrane was used. A staged bone graft and late placement group was also identified, in which block bone grafts had been placed to augment deficient sites prior to implant insertion (14 implants in 14 patients). At type 1 placement sites, all cases had thick gingival biotype, intact facial bone, and ideal soft tissue levels. For the type 2 without GBR group, a minimum of 1.5 mm of bone thickness was present on the facial aspect of the implants. Both thin and thick tissue biotype cases were treated in this group. For the type 2 group with GBR, less than 1.5 mm of bone thickness was present on the facial aspect of the implant. Both thin and thick biotype cases were treated in this group. There were two early failures in the type 1 placement group, five in the type 2 placement group (three in the non-grafted group, and one in the GBR group) and one failure in the staged block graft group. Esthetic outcomes were assessed using PES. Similar results were achieved

Table 8 Studies with Comparative Data on Different Implant Placement Times That Report on Outcomes Using Esthetic Indices

Study	Study design	Placement time (patients/implants)	Location	Simultaneous bone augmentation	Time from surgery to evaluation	Healing protocol (time from surgery to loading in mo)
Raes et al[32]	Cohort study	Type 1 (16/39) Type 4 (23/39) Failures: 1 in Type 1 group	Single-tooth maxillary anterior and premolar sites	No augmentation	52 weeks from connection of the provisional restoration	Immediate provisional prosthesis
Felice et al[27]	Multi-center RCT	Type 1 (54/54) Type 4 after ridge preservation (52/52) Failures: 2 in the Type 1 group	Single-tooth maxillary anterior and premolar sites	Yes DBBM grafted to the horizontal gap between the facial bone and implant (Type 1) or into the socket (Type 4)	4 months from provisional prosthesis insertion	Immediate provisional prosthesis 35% of Type 1 group and 75% of Type 4 ridge preserved group were not immediately loaded due to lack of sufficient insertion torque (at least 35 Ncm)
Cosyn et al[38]	Cohort study	Type 1 (28/30) Type 2 (no GBR) (44/49) Type 2 + GBR (19/18) Type 4 block graft (14/14) Failures: 2 in Type 1 group, 3 in Type 2 (no GBR) group, 1 in Type 2 + GBR group, 1 in staged bone graft group	Single-tooth maxillary anterior and premolar sites	Type 1 DBBM applied to gap between implant and socket wall Type 2 + GBR grafted with DBBM and collagen membrane Type 4 bone graft group had block grafts placed derived from the chin	Type 1 33 months (SD 8; range 17–41) Type 2 (no GBR) 30 months (SD 8; range 17–41) Type 2 + GBR 30 months (SD 9; range 17–42) Staged bone graft 31 months (SD 6; range 19–40)	Type 1 group immediate provisional; All other groups early or conventional loading

PES = pink esthetic score, WES = white esthetic score, DBBM = deproteinized bovine bone mineral, GBR = guided bone regeneration, NR = not reported. NS = not significant ($P > .05$).

with type 1 and type 2 placements (type 1 group 10.88 ± 2.41, type 2 no GBR group 10.07 ± 1.96, type 2 with GBR group 9.65 ± 2.23). The worst esthetic outcomes were observed in the staged bone graft group (9.00 ± 1.73), the difference with the type 1 placement group approaching statistical significance ($P = .045$).

The overall esthetic outcomes reported in the case series studies were good, with average PES ranging from 10.48 to 12.5 in six studies[42,52,60,64,67,69] and modified PES ranging from 7.0 to 8.1 in four studies.[21,58,63,68] From selected studies, the forest plots showed no clear trend to indicate a difference between placement times (Fig 6). Prosthesis related esthetic outcomes using WES was reported in five studies with mean scores ranging 7.0 to 8.65.[21,58,60,67,68]

Ranking of Esthetic Outcomes. Several studies (Table 8) presented data that allowed esthetic outcomes to be ranked according to the criteria proposed by Cosyn et al[60] and Belser et al.[36] There were two studies of type 1 placement that reported excellent soft tissue esthetic outcomes (PES 12 to 14) in 29% to 36% of cases.[30,60] Acceptable outcomes (PES 8 to 11) were achieved in 56% to 71% of sites and poor outcomes (PES 0 to 7) were found in 8% of cases in one study. In two studies of type 2 placement using the modified PES, excellent esthetic outcomes (modPES 9 to 10) were achieved in 22% to 45% of sites, acceptable outcomes (modPES 6 to 8) in 50% to 78% of sites and poor outcomes (modPES < 6) in 1 of 20 cases (5%) in one study.[58] When PES and WES were considered together in determining esthetic outcomes, between 8% to 21% achieved excellent outcomes (PES ≥ 12, WES ≥ 9), 58% to 68% achieved acceptable outcomes (PES 8 to 11, WES 7 to 8), and 21% to 24% resulted in poor outcomes (PES < 8, WES < 6).[32,60] These results suggest that prosthesis related factors may contribute significantly to poorer outcomes when soft tissue and hard tissue related esthetic parameters are combined.

In two reports of type 1 placement using SES to evaluate esthetic outcomes, about 80% of implants had satisfactory esthetic outcomes, whereas 20% were found to be unsatisfactory.[34,52]

Inclusion and Exclusion Criteria

A number of systemic, oral, and site-related factors were listed as inclusion and exclusion criteria in the studies included in this review.

Systemic Factors. Medical conditions or medications that could compromise wound healing or osseointegration were common exclusion criteria.[22,24–26,33,35,38,40,47,51,56,60,62,65,67,68] Conditions such as uncontrolled diabetes,[23,25,27,32,33,41,44,69] coagulation disorders,[41] psychological conditions,[26,27,40] immunosuppressive medications,[25,27,64,69] irradiation therapy to the

Mean PES (SD; range)	Mean WES (SD; range)	Ranking of esthetic outcomes	Other findings
Type 1 = 10.33 (2.29; 6–14) Type 4 = 10.35 (1.58; 7–13) ns	Type 1 = 7.20 (2.04; 3–10) Type 4 = 7.00 (2.37; 2–10) ns	8 % were excellent (PES ≥ 12, WES ≥ 9) 68% were acceptable (PES 8–11, WES 7–8) 24% were poor (PES < 8, WES < 6)	Only cases with intact socket walls and a thick gingival biotype were included in the immediate implant group
Type 1 = 12.75 (1.25) Type 4 = 12.62 (SD 1.05) ns	NR	NR	To be included for immediate implant placement, sites had to have no more than 4 mm loss of buccal bone height (assessed using the highest peak of palatal wall as the reference) Sites with missing facial bone judged to be sufficient to comprise esthetic results were excluded
Type 1 group: 10.88 (2.41; 6–14) Type 2 (no GBR) group: 10.07 (1.96; 6–13) Type 2 + GBR group: 9.65 (2.23; 4–13) Type 4 bone graft group: 9.00 (1.73; 5–11) *P* = .045 (staged bone graft significantly less than Type 1 group)	NR	NR	For Type 1 placement, all cases had thick gingival biotype, intact facial bone and ideal soft tissue levels For Type 2 with GBR < 1.5 mm bone thickness present on facial aspect of implant, thin and thick biotype

head and neck region,[27,56,59,64,69] systemic bone diseases,[64,69] history of intravenous bisphosphonates,[27,56] osteoporosis,[25] and systemic corticosteroid therapy[33] were listed. Some studies specifically excluded pregnant and lactating individuals.[27,33,44,47,68] One study excluded individuals with incomplete skeletal growth.[28] Another study excluded patients with known allergies to the materials used.[41] Patients with alcohol or drug dependence were also excluded in a number of studies.[23,25,27,33,40,41]

The criteria applied to cigarette smoking varied between studies. In some studies, smokers were excluded[22,32,33,40,57,59,67] whereas smokers were not excluded in other studies[35] or only excluded if subjects were heavy smokers.[23] A number of studies provided specific exclusion thresholds for cigarette smoking. A threshold of 10 cigarettes a day was commonly applied.[24,42,44,47,56,60,68] A threshold of 15 cigarettes a day was applied in one study[63] and 20 cigarettes a day was applied in another study.[62]

Oral Factors. Untreated or uncontrolled periodontal disease was a common exclusion criteria.[22,24–28,31,32,51,56,60,63,65,67,68] In addition, untreated caries was an exclusion criteria in several studies.[22,25,32,33]

Site-Related Factors. For type 1 placement, acute infection at the site was a consistent exclusion criteria across the studies reviewed.[23–27,32,40,41,44,51,56,57,59,60,65,67] A number of studies of Type 1 placement only included cases that presented with intact bone walls after tooth extraction[23–25,38,40,41,44,51,60,63,65,67,121] or cases with minimal loss of the facial bone wall.[27,41,56] Some studies stipulated a minimum distance from the midfacial gingival margin to crestal bone of 3 mm,[40] 4 mm,[51] and 5 mm[26] or pre-extraction probing pockets of 3 mm or less.[25] A minimum distance from the gingival margin to the proximal bone of 4 to 6 mm was a requirement in one study[40] and 5 mm in another study.[51] One study included cases with varying degrees of damage to the facial bone wall.[48] Another study was designed specifically to include cases with complete loss of the facial bone wall.[64]

There were a number of studies of type 1 placement that specifically excluded sites with thin tissue biotype, accepting cases with normal to thick tissue biotypes.[24,32,60,62,63] Two studies specifically included cases with thick tissue biotype only.[38,67]

In studies reporting on type 1 placement with connection of immediate provisional restorations, a high degree of stability of the implant was a strict requirement.[24,25,32,38,40,44,51,57,59,60,62–65,67,69] The majority of these studies stated that they excluded subjects with bruxism or cases where it was determined that the posterior occlusion lacked stability.[24,25,40,56,57,59,60,62,63] Some studies specified a minimum height of 4 to 5 mm of bone apical to the extraction socket for stability of the implants to be achieved.[24,38,41,56,60,67]

Table 9 Case Series Studies of Esthetic Outcomes at Postextraction Implants in the Maxillary Esthetic Zone Using Objective Indices

Study	Study Design	Patients (implants)	Placement time	Healing protocol	Loading protocol	Augmentation technique
Juodzbalys and Wang[42]	Prospective case series	12 (14)	Type 1	Submerged	Conventional	DBBM + collagen membrane, CT graft to correct soft tissue deficiencies
Evans and Chen[34]	Retrospective case series	42 (42)	Type 1	NR	Conventional	NR
Chen et al[52]	Retrospective case series	85 (85)	Type 1 flapless	Transmucosal	Conventional	No augmentation performed
Mangano et al[63]	Retrospective case series	26 (26)	Type 1	Transmucosal	Immediate provisional restoration	Biphasic calcium phosphate + tetracycline powder
Cosyn et al[60]	Prospective case series	25 (25)	Type 1	Transmucosal	Immediate provisional restoration	DBBM
Noelken et al[64]	Prospective case series	16 (18)	Type 1 flapless	Transmucosal	Immediate provisional restoration	Autogenous bone
Buser et al[58]	Prospective case series	20 (20)	Type 2		Early	Autogenous bone chips + DBBM + collagen membrane
Buser et al[21]	Prospective case series	41 (41)	Type 2		Early	Autogenous bone chips + DBBM + collagen membrane
Furze et al[68]	Prospective case series	10 (10)	Type 2	NR	Early	DBBM + collagen membrane
Noelken et al[69]	Prospective case series	9 (15) Data for only maxillary anterior and pre-molar sites derived from the paper	Type 1 flapless	Transmucosal	Immediate provisional restoration	Autogenous bone
Cosyn et al[67]	Prospective case series	22 (22)	Type 1	Transmucosal	Immediate provisional	DBBM

PES = pink esthetic score; modPES = modified pink esthetic score; WES = white esthetic score; SES = subjective esthetic score; DBBM = deproteinized bovine bone mineral; GBR = guided bone regeneration.

An additional criterion was identified for flapless type 1 implant placement in conjunction with immediate provisional restoration. In five studies, cases with pre-extraction soft tissue contours that were in harmony with the surrounding teeth were included.[24,32,38,60,67] In contrast, one study of type 1 placement included sites in which the extracted teeth were periodontally involved and had pre-existing gingival recession.[66] In this study, CT grafts were placed in conjunction with coronally advanced flaps to correct the recession. Two studies, both of type 1 placement with immediate restoration, required that at least 2 mm of keratinized gingiva was present facially at the extraction site.[25,62]

Time from surgery to evaluation	Esthetic Index			Other comments
	PES	WES	SES	
1 y	11.1 (1.35) range 10–14			Excellent (PES 12–14) 29% Acceptable (PES 9–11) 71% Poor (PES 0–8) 0%
Mean 19 mo (range 6–50 months)				Subjective Esthetic Score (SES) 82% satisfactory (score I and II) 18% unsatisfactory (score III and IV)
Mean 26.2 mo (range 10.3–46.7 mo)	10.95 (1.68) range 8–14			Subjective Esthetic Score: 81% satisfactory (score I and II) 19% unsatisfactory (score III and IV) PES outcomes: Excellent (PES 12–14) 39% Acceptable (PES 9–11) 52% Poor (PES 0–8) 9%
2 y	7.30 (1.78) range 4–10			
3 y	10.48 (2.47) range 5–14	8.17 (1.52) Range 5–10		Excellent (PES 12–14) 36% Acceptable (PES 9–11) 56% Poor (PES 0–8) 8% Combined PES/WES: Excellent (PES ≥ 12, WES ≥ 9) 21% Acceptable (PES 8–11, WES 6–8) 58% Poor (PES < 8, WES < 6) 21%
Median 22 mo (range 13 to 36 mo)	Preop PES 12.2 (1.77) range 8–14 Final PES 12.5 (1.10) range 10–14			All sites had loss of facial bone; grafted with autogenous bone derived from the mandibular ramus 5/18 sites showed a slight deterioration in PES from baseline to final examination; 5/18 were unchanged and 8/18 showed improvement
3 years	PES (modified) 8.1 at y 1 8.1 at y 3	8.65 at y 1 8.65 at y 3		Excellent (modPES 9–10) 45% Acceptable (modPES 6–8) 50% Poor (modPES < 6) 5%
Mean 7 years (range 5-9 years)	PES (modified) 7.78 at 2006 7.49 at 2010	6.95 at 2006 6.88 at 2010		Excellent (modPES 9–10) 22% Acceptable (modPES 6–8) 78% Poor (modPES < 6) 0%
1 y	PES (modified) 7.9 (1.7)	7.0 (1.5)		
Mean 65 mo (range 55.4 to 77.6)	Baseline PES 12.14 (1.65) Final PES 11.28 (1.93)			
1 y	At 3 mo: 11.86 (1.61) range 8–14 At 12 mo: 12.15 (0.99) range 10–13	8.63		I failure, 1 drop-out Severe recession (1.5 mm and 2.0 mm) noted on 2 patients at 3 months. A further 5 patients had noticeable recession. 7 patients required adjunctive CT graft at 3 months to correct recession of the midfacial mucosa

For type 2 placement, there were no specific site related criteria imposed in studies in relation to tissue biotype, condition of bone walls, or presence of acute infection at the time of extraction,[35,47,68] except in one study which excluded cases where there was apical pathology at neighboring teeth.[68] Thin and thick biotypes for type 2 placement were specifically mentioned for inclusion in one study.[38]

DISCUSSION

Implant placement in postextraction sites has been a subject of great interest over the last 15 years and was included as a major topic in the two previous ITI Consensus Conferences of 2003 and 2008. In the first systematic review in 2003, the focus was on survival outcomes and the success of bone augmentation

procedures.[15] The second systematic review in 2008 centered on clinical and esthetic outcomes.[133] In this third systematic review, the main focus was on esthetic outcomes for the various treatment options in postextraction implant placement based on objective esthetic criteria. The two esthetic parameters identified were *(1)* changes in the position of the peri-implant mucosa, and *(2)* two esthetic indices, predominantly the PES index. The studies included in this systematic review were found to have reported on single-tooth implant replacements adjacent to intact natural teeth. No papers dealing with multiple missing teeth were identified in the search.

In the present systematic review, the search was limited to publications in the English language from two databases. It is possible that relevant articles were missed thereby undermining the internal validity of the systematic review.

The majority of included studies in this review were case series studies. The evidence from the pooled cases series studies should be evaluated with caution, as significant heterogeneity between studies was observed. This was most likely due to differences in study populations, surgical and grafting techniques, and loading protocols used. Grouping of studies according to the different clinical techniques used provides an insight into trends, but should not be regarded as strong evidence.

Concerning positional changes of the midfacial peri-implant mucosa, there were two RCTs and one cohort study, which compared outcomes following different implant placement timings. These studies showed no differences between immediate (type 1) and early implant placement (type 2). The majority of included studies were case series studies, which predominantly reported on type 1 placement.

For changes in the midfacial mucosal position, the studies were heterogeneous and showed a wide variation in results. Although case series studies on type 2 placement appeared more homogenous, the analysis was based on a small number of studies (3) and should be interpreted with care. Stratification of the type 1 placement studies according to similarity in treatment protocols revealed more homogenous results in relation to changes in the midfacial mucosal level when flapless implant placement was combined with bone graft, CT graft, and connection of an immediate provisional crown. It should be noted that this finding is based on only three case series studies and should be interpreted with caution. For change in position of the papillae, the results between studies were highly variable. No trend was observed for differences in outcomes when studies were stratified according to surgical approach (flap vs flapless placement) and use of immediate provisional crowns.

For outcomes based on esthetic indices, most studies used the PES index. One RCT and two cohort studies provided data on different placement timings. The RCT compared type 1 and type 4 placements; however, the follow-up time of 4 months from provisional prosthesis insertion was too short to make any meaningful conclusions. One cohort study provided evidence that PES was significantly higher for type 1 placement compared to sites that had received block bone grafts to correct significant ridge defects. Similar to the available data for change in peri-implant mucosal position, the majority of studies using esthetic indices were case series studies that predominantly reported on type 1 placement. The studies showed a high degree of heterogeneity.

In summary, the evidence to evaluate the esthetic outcomes with postextraction implants are based on a limited number of randomized and cohort studies, with the vast majority of evidence provided by cross-sectional and case series studies. Nevertheless, well-conducted cross-sectional and case series studies can provide meaningful data when interpreted carefully. Currently, the evidence suggests that acceptable esthetic outcomes can be achieved with type 1 and early implant placement (type 2 and type 3). For positional change of the peri-implant mucosa, it may be anticipated that on average, a small degree of recession of the midfacial mucosa of about 0.5 mm will occur following implant placement. When comparing treatment options, the outcomes for type 1 placement showed more variation compared to type 2 and 3 placements. There was also a higher frequency of recession of > 1 mm of the midfacial mucosa for type 1 placement compared to type 2 and 3 placements.

The analysis clearly shows the variability and potential risk for mucosal recession in the range of 20% to 30%, if no inclusion criteria are used for immediate implants (type 1 placement). This is in accordance with the findings of the previous ITI Consensus Conference in which the potential risk factors for recession with type 1 placement were identified as pre-existing defects of the facial bone, thin facial bone, thin soft tissue biotype, and facial malposition of the implant.[134] To reduce the risk of mucosal recession, the majority of studies published after 2008 on type 1 placement have imposed strict case selection criteria by only including sites with intact facial bone and medium to thick tissue biotype. It has also been recognized that ongoing resorption and modeling of the facial bone takes place following implant placement, with changes most notable after type 1 placement. To reduce the risk of recession of the mucosa with type 1 placement, clinicians have applied treatment strategies to counteract these changes, including the concomitant use of CT grafts, low-substitution bone fillers in the peri-implant defects, and flapless surgery.

Table 10a Ranking of Esthetic Outcomes: PES Score

Study	Placement time	Excellent PES 12–14 (%)	Acceptable PES 8–11 (%)	Poor PES 0–7(%)
Juodzbalys and Wang[42]	Type 1	29	71	0
Cosyn et al[60]	Type 1	36	56	8

PES = pink esthetic score; modPES = modified pink esthetic score; WES = white esthetic score.

Table 10b Ranking of Esthetic Outcomes: modPES Score

	Placement time	Excellent modPES 9–10(%)	Acceptable modPES 6–8 (%)	Poor modPES < 6 (%)
Buser et al[58]	Type 2	45	50	5
Buser et al[21]	Type 2	22	78	0

PES = pink esthetic score; modPES = modified pink esthetic score; WES = white esthetic score.

Table 10c Ranking of Esthetic Outcomes: Combined Score

	Placement time	Combined PES ≥ 12, WES ≥ 9 (%)	Combined PES 9–11, WES 7–8 (%)	Combined PES < 8, WES < 6 (%)
Raes et al[32]	Type 1 and 4	8	68	24
Cosyn et al[60]	Type 1	21	58	21

PES = pink esthetic score; modPES = modified pink esthetic score; WES = white esthetic score.

For papillae, the evidence shows that recession of the tooth-implant papillae of 0.5 to 1 mm may be anticipated following implant surgery irrespective of the timing of placement. Interestingly, there was little evidence to support flapless surgery or connection of an immediate provisional crown as a means to reduce papillary recession with type 1 placement.

The predominant index used to report on esthetic outcomes was the PES index. The esthetic outcomes for type 1 and type 2 placements were similar although significant heterogeneity between studies was noted. Mean scores reported were in a narrow range of 9.5 to 11.5. The strength of the PES is that it has been shown to be consistently reproducible in a number of studies[135–137] and provides a measure of symmetry of the peri-implant mucosa with the adjacent natural teeth. The PES, however, is a summation of seven soft tissue–related factors assigned scores on an ordinal scale. The weakness of the PES is that each factor is assumed to carry equal weight in contributing to the overall score; however, this has not been demonstrated in the literature. Indeed it may be argued that, for example, midfacial mucosal recession of 1 to 2 mm (assigned a score of 1) has more impact esthetically then the equivalent score of 1 for color or consistency of the peri-implant mucosa. The PES is therefore not sensitive to linear changes in soft tissue levels. A clinically more meaningful application of PES is to rank esthetic outcomes as shown in Table 10. The proportion of excellent, acceptable, and poor outcomes may provide the clinician with greater insight into the esthetic success of the clinical techniques under scrutiny rather than comparing the mean PES. Several studies reported on outcomes relating to the papillae using the Papilla Index of Jemt.[138] This index, however, was originally designed to monitor changes in the degree of soft tissue fill within the tooth-implant embrasure spaces after delivery of the definitive crowns. As it is neither a measure of symmetry nor a record of linear soft tissue changes, it is unsuitable as an esthetic index.

A critical determinant for stable esthetic outcomes long-term is the integrity and stability of the facial bone wall. Recently, 3D radiology predominantly using CBCT has provided a noninvasive method to assess the status of the facial bone. This technology does have limitations, as intact but thin facial bone may not always be detectable on the reformatted images.[139] However the strong correlation between the radiographic presence of the facial bone and a more coronal location of the midfacial mucosa[20] suggests that the thickness of the facial bone is an important outcome variable. The study of Buser and coworkers that reported on the dimensions of the facial peri-implant bone on CBCT images is worthy of particular note.[21,35] The facial bone walls that were reconstructed with a combination of autogenous bone chips and DBBM particles were largely intact at an average of 7 years following implant placement. Of clinical significance was the stability of the position of the peri-implant mucosa throughout the observation period, which, it may be

speculated, could be due to the underlying thick facial bone. A recent follow-up of a previous study[47] by the same group reported that all 20 implant sites had a detectable facial bone wall averaging 1.9 mm in thickness after 6 years. The timing of implant placement may also be an important consideration. The two CBCT studies of type 1 placement reported diminished bone thickness and increased mucosal recession even when the peri-implant defects were grafted with either autogenous bone or DBBM.[20,37] It may be speculated that the thin facial bone at the crestal region continued to resorb even in the presence of a bone graft, a phenomenon previously observed in a RCT with surgical reentry.[36] It is hypothesized that DBBM particles have only low substitution characteristics if the particles are embedded in bone. As shown in a recent preclinical study, DBBM particles embedded in soft tissue showed signs of resorption.[141] More research is needed to better understand these aspects. It also must be noted that the current evidence with CBCT data is limited, since some studies are based on small numbers of patients with rather short observation periods. It is anticipated that future studies using 3D radiologic imaging of the facial bone wall will provide further evidence for the relationship between the presence or absence of the facial bone, the thickness of the facial bone, the position of the bone crest, and the long-term stability of the peri-implant mucosa.

CONCLUSIONS

Six RCTs and six cohort studies provided high level evidence for the assessment of esthetic outcomes with postextraction implants.

The majority of included studies were cross-sectional and case series studies that allowed trends in esthetic outcomes with various surgical approaches to be explored.

Acceptable esthetic outcomes, determined by esthetic indices and positional changes of the peri-implant mucosa, may be achieved for single-tooth implants placed following tooth extraction.

Immediate (type 1) implant placement is associated with a greater variability in outcomes and a higher frequency of recession of > 1 mm of the midfacial mucosa (8 studies; range 9% to 41% and median 26% of sites; 1 to 3 years after placement) compared to early (type 2 and type 3) implant placement (two studies; no sites with recession > 1 mm).

In two retrospective studies of immediate (type 1) implant placement with bone graft, the facial bone wall was not detectable on cone beam CT in 36% and 57% of sites. These sites had more recession of the midfacial mucosa compared to sites with detectable facial bone.

Two studies of early implant placement (type 2 and 3) combined with simultaneous bone augmentation with GBR (contour augmentation) demonstrated a high frequency (above 90%) of facial bone wall visible on CBCT.

Further research is required to determine the effect of different surgical and loading protocols on esthetic outcomes.

Integrity of the facial bone may be an important factor for long-term stability of esthetic outcomes. Further research is needed to investigate the most suitable biomaterials to reconstruct the facial bone and the relationship between mucosal stability long-term and the presence or absence of the facial bone, the thickness of the facial bone, and the position of the facial bone crest.

ACKNOWLEDGMENTS

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

REFERENCES

1. Al-Nawas B, Kammerer PW, Morbach T, et al. Ten-year retrospective follow-up study of the TiOblast dental implant. Clin Implant Dent Relat Res 2012;14:127–134.
2. Buser D, Janner SF, Wittneben JG, et al. 10-Year survival and success rates of 511 titanium implants with a sandblasted and acid-etched surface: A retrospective study in 303 partially edentulous patients. Clin Implant Dent Relat Res 2012;14:839–851.
3. Fischer K, Stenberg T. Prospective 10-year cohort study based on a randomized controlled trial (RCT) on implant-supported full-arch maxillary prostheses. Part 1: Sandblasted and acid-etched implants and mucosal tissue. Clin Implant Dent Relat Res 2012;14:808–815.
4. Gotfredsen K. A 10-year prospective study of single tooth implants placed in the anterior maxilla. Clin Implant Dent Relat Res 2012;14:80–87.
5. Mertens C, Steveling HG, Stucke K, et al. Fixed implant-retained rehabilitation of the edentulous maxilla: 11-year results of a prospective study. Clin Implant Dent Relat Res 2012;14:816–827.
6. Ostman PO, Hellman M, Sennerby L. Ten years later. Results from a prospective single-centre clinical study on 121 oxidized (TiUnite) Branemark implants in 46 patients. Clin Implant Dent Relat Res 2012;14:852–860.
7. Degidi M, Nardi D, Piattelli A. 10-year follow-up of immediately loaded implants with TiUnite porous anodized surface. Clin Implant Dent Relat Res 2012;14:828–838.
8. Branemark PI, Hansson BO, Adell R, Breine U, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1–132.
9. Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
10. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: A literature review. J Periodontol 1997;68:915–923.
11. Mayfield LJA. Immediate, delayed and late submerged and transmucosal implants. In: Lang NP, Karring T, Lindhe J (eds). Proceedings of the 3rd European Workshop on Periodontology: Implant Dentistry. Berlin: Quintessence, 1999:520–534.
12. Nir-Hadar O, Palmer M, Soskolne WA. Delayed immediate implants: Alveolar bone changes during the healing period. Clin Oral Implants Res 1998;9:26–33.
13. Belser UC, Schmid B, Higginbottom F, Buser D. Outcome analysis of implant restorations located in the anterior maxilla: A review of the recent literature. Int J Oral Maxillofac Implants 2004;19(suppl):30–42.

14. Hammerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19 (suppl):26–28.
15. Chen ST, Wilson TG Jr, Hammerle CH. Immediate or early placement of implants following tooth extraction: Review of biologic basis, clinical procedures, and outcomes. Int J Oral Maxillofac Implants 2004;19(suppl):12–25.
16. Benic GI, Wolleb K, Sancho-Puchades M, Hammerle CH. Systematic review of parameters and methods for the professional assessment of aesthetics in dental implant research. J Clin Periodontol 2012;39(suppl 12):160–192.
17. Annibali S, Bignozzi I, La Monaca G, Cristalli MP. Usefulness of the aesthetic result as a success criterion for implant therapy: A review. Clin Implant Dent Relat Res 2012;14:3–40.
18. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: A clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 2003;23:313–323.
19. Buser D, Chen ST, Weber HP, Belser UC. Early implant placement following single-tooth extraction in the esthetic zone: Biologic rationale and surgical procedures. Int J Periodontics Restorative Dent 2008;28:441–451.
20. Benic GI, Mokti M, Chen CJ, et al. Dimensions of buccal bone and mucosa at immediately placed implants after 7 years: A clinical and cone beam computed tomography study. Clin Oral Implants Res 2012;23:560–566.
21. 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 Jan 24 [epub ahead of print].
22. Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: A prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:705–710.
23. Palattella P, Torsello F, Cordaro L. Two-year prospective clinical comparison of immediate replacement vs. immediate restoration of single tooth in the esthetic zone. Clin Oral Implants Res 2008;19: 1148–1153.
24. De Rouck T, Collys K, Wyn I, Cosyn J. Instant provisionalization of immediate single-tooth implants is essential to optimize esthetic treatment outcome. Clin Oral Implants Res 2009;20:566–570.
25. Block MS, Mercante DE, Lirette D, et al. Prospective evaluation of immediate and delayed provisional single tooth restorations. J Oral Maxillofac Surg 2009;67:89–107.
26. Chen ST, Darby IB, Reynolds EC. A prospective clinical study of non-submerged immediate implants: Clinical outcomes and esthetic results. Clin Oral Implants Res 2007;18:552–562.
27. Felice P, Soardi E, Piattelli M, et al. Immediate non-occlusal loading of immediate post-extractive versus delayed placement of single implants in preserved sockets of the anterior maxilla: 4-month post-loading results from a pragmatic multicentre randomised controlled trial. Eur J Oral Implantol 2011;4:329–344.
28. Gotfredsen K. A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: A pilot study. Clin Implant Dent Relat Res 2004;6:1–8.
29. Cangini F, Cornelini R. A comparison between enamel matrix derivative and a bioabsorbable membrane to enhance healing around transmucosal immediate post-extraction implants. J Periodontol 2005; 76:1785–1792.
30. Juodzbalys G, Wang HL. Socket morphology-based treatment for implant esthetics: A pilot study. Int J Oral Maxillofac Implants 2010;25:970–978.
31. Grunder U. Crestal ridge width changes when placing implants at the time of tooth extraction with and without soft tissue augmentation after a healing period of 6 months: Report of 24 consecutive cases. Int J Periodontics Restorative Dent 2011;31:9–17.
32. Raes F, Cosyn J, De Bruyn H. Clinical, aesthetic, and patient-related outcome of immediately loaded single implants in the anterior maxilla: A prospective study in extraction sockets, healed ridges, and grafted sites. Clin Implant Dent Relat Res 2012 Jan 17 [epub ahead of print].
33. 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.
34. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
35. Buser D, Bornstein MM, Weber HP, et al. Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: A cross-sectional, retrospective study in 45 subjects with a 2- to 4-year follow-up. J Periodontol 2008;79:1773–1781.
36. Belser UC, Grutter L, Vailati F, Bornstein MM, et al. 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.
37. Miyamoto Y, Obama T. Dental cone beam computed tomography analyses of postoperative labial bone thickness in maxillary anterior implants: Comparing immediate and delayed implant placement. Int J Periodontics Restorative Dent 2011;31:215–225.
38. Cosyn J, Eghbali A, Hanselaer L, et al. Four modalities of single implant treatment in the anterior maxilla: A clinical, radiographic, and aesthetic evaluation. Clin Implant Dent Relat Res 2013;15:517–530.
39. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. Int J Periodontics Restorative Dent 2000;20:11–17.
40. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.
41. Cornelini R, Cangini F, Covani U, Wilson TG, Jr. Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: A prospective clinical study. Int J Periodontics Restorative Dent 2005;25:439–447.
42. Juodzbalys G, Wang HL. Soft and hard tissue assessment of immediate implant placement: A case series. Clin Oral Implants Res 2007;18:237–243.
43. Kan JY, Rungcharassaeng K, Sclar A, Lozada JL. Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. J Oral Maxillofac Surg 2007;65:13–19.
44. Canullo L, Rasperini G. Preservation of peri-implant soft and hard tissues using platform switching of implants placed in immediate extraction sockets: A proof-of-concept study with 12- to 36-month follow-up. Int J Oral Maxillofac Implants 2007;22:995–1000.
45. Noelken R, Morbach T, Kunkel M, Wagner W. Immediate function with NobelPerfect implants in the anterior dental arch. Int J Periodontics Restorative Dent 2007;27:277–285.
46. De Rouck T, Collys K, Cosyn J. Immediate single-tooth implants in the anterior maxilla: A 1-year case cohort study on hard and soft tissue response. J Clin Periodontol 2008;35:649–657.
47. 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.
48. Kan JY, Rungcharassaeng K, Morimoto T, Lozada J. Facial gingival tissue stability after connective tissue graft with single immediate tooth replacement in the esthetic zone: Consecutive case report. J Oral Maxillofac Surg 2009;67:40–48.
49. Pirker W, Kocher A. Immediate, non-submerged, root-analogue zirconia implants placed into single-rooted extraction sockets: 2-year follow-up of a clinical study. Int J Oral Maxillofac Surg 2009;38: 1127–1132.
50. Redemagni M, Cremonesi S, Garlini G, Maiorana C. Soft tissue stability with immediate implants and concave abutments. Eur J Esthet Dent 2009;4:328–337.
51. Tortamano P, Camargo LO, Bello-Silva MS, Kanashiro LH. Immediate implant placement and restoration in the esthetic zone: A prospective study with 18 months of follow-up. Int J Oral Maxillofac Implants 2010;25:345–350.
52. Chen ST, Darby IB, Reynolds EC, Clement JG. Immediate implant placement postextraction without flap elevation. J Periodontol 2009;80:163–172.
53. Cosyn J, De Rouck T. Aesthetic outcome of single-tooth implant restorations following early implant placement and guided bone regeneration: Crown and soft tissue dimensions compared with contralateral teeth. Clin Oral Implants Res 2009;20:1063–1069.
54. 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.

55. Cosyn J, Eghbali A, De Bruyn H, Dierens M, De Rouck T. Single implant treatment in healing versus healed sites of the anterior maxilla: An aesthetic evaluation. Clin Implant Dent Relat Res 2012;14:517–526.
56. Brown SD, Payne AG. Immediately restored single implants in the aesthetic zone of the maxilla using a novel design: 1-year report. Clin Oral Implants Res 2011;22:445–454.
57. Tsuda H, Rungcharassaeng K, Kan JY, Roe P, et al. Peri-implant tissue response following connective tissue and bone grafting in conjunction with immediate single-tooth replacement in the esthetic zone: A case series. Int J Oral Maxillofac Implants 2011;26:427–436.
58. Buser D, Wittneben J, Bornstein MM, et al. Stability of contour augmentation and esthetic outcomes of implant-supported single crowns in the esthetic zone: 3-year results of a prospective study with early implant placement postextraction. J Periodontol 2011;82:342–349.
59. Chung S, Rungcharassaeng K, Kan JY, et al. Immediate single tooth replacement with subepithelial connective tissue graft using platform switching implants: A case series. J Oral Implantol 2011;37:559–569.
60. Cosyn J, Eghbali A, De Bruyn H, et al. Immediate single-tooth implants in the anterior maxilla: 3-year results of a case series on hard and soft tissue response and aesthetics. J Clin Periodontol 2011;38:746–753.
61. Kan JY, Rungcharassaeng K, Lozada JL, Zimmerman G. Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: A 2- to 8-year follow-up. Int J Oral Maxillofac Implants 2011;26:179–187.
62. Malchiodi L, Cucchi A, Ghensi P, Nocini PF. Evaluation of the esthetic results of 64 nonfunctional immediately loaded postextraction implants in the maxilla: Correlation between interproximal alveolar crest and soft tissues at 3 years of follow-up. Clin Implant Dent Relat Res 2013;15:130–142.
63. Mangano F, Mangano C, Ricci M, Sammons RL, Shibli JA, Piattelli A. Single-tooth Morse taper connection implants placed in fresh extraction sockets of the anterior maxilla: An aesthetic evaluation. Clin Oral Implants Res 2012;23:1302–1307.
64. Noelken R, Kunkel M, Wagner W. Immediate implant placement and provisionalization after long-axis root fracture and complete loss of the facial bony lamella. Int J Periodontics Restorative Dent 2011;31:175–183.
65. Cabello G, Rioboo M, Fabrega JG. Immediate placement and restoration of implants in the aesthetic zone with a trimodal approach: Soft tissue alterations and its relation to gingival biotype. Clin Oral Implants Res 2012 July 9 [epub ahead of print].
66. Lee YM, Kim DY, Kim JY, et al. Peri-implant soft tissue level secondary to a connective tissue graft in conjunction with immediate implant placement: A 2-year follow-up report of 11 consecutive cases. Int J Periodontics Restorative Dent 2012;32:213–222.
67. Cosyn J, De Bruyn H, Cleymaet R. Soft tissue preservation and pink aesthetics around single immediate implant restorations: A 1-year prospective study. Clin Implant Dent Relat Res 2012 Feb 29 [epub ahead of print].
68. Furze D, Byrne A, Donos N, Mardas N. Clinical and esthetic outcomes of single-tooth implants in the anterior maxilla. Quintessence Int 2012;43:127–134.
69. Noelken R, Kunkel M, Jung BA, Wagner W. Immediate nonfunctional loading of NobelPerfect implants in the anterior dental arch in private practice—5-year data. Clin Implant Dent Relat Res 2012 Feb 29 [epub ahead of print].
70. Handelsman M. Treatment planning and surgical considerations for placement of wide-body implants. Compend Contin Educ Dent 1998;19:507–514.
71. Kan JY, Rungcharassaeng K. Immediate placement and provisionalization of maxillary anterior single implants: A surgical and prosthodontic rationale. Pract Periodontics Aesthet Dent 2000;12:817–824.
72. Hui E, Chow J, Li D, et al. Immediate provisional for single-tooth implant replacement with Branemark system: Preliminary report. Clin Implant Dent Relat Res 2001;3:79–86.
73. Proussaefs P, Kan J, Lozada J, et al. Effects of immediate loading with threaded hydroxyapatite-coated root-form implants on single premolar replacements: A preliminary report. Int J Oral Maxillofac Implants 2002;17:567–572.
74. Saadoun AP. Immediate implant placement and temporization in extraction and healing sites. Compend Contin Educ Dent 2002;23:309–312, 314–306, 318 passim, quiz 326.
75. Kan JY, Rungcharassaeng K. Interimplant papilla preservation in the esthetic zone: A report of six consecutive cases. Int J Periodontics Restorative Dent 2003;23:249–259.
76. Bianchi AE, Sanfilippo F. Single-tooth replacement by immediate implant and connective tissue graft: A 1-9-year clinical evaluation. Clin Oral Implants Res 2004;15:269–277.
77. Covani U, Bortolaia C, Barone A, Sbordone L. Bucco-lingual crestal bone changes after immediate and delayed implant placement. J Periodontol 2004;75:1605–1612.
78. Doring K, Eisenmann E, Stiller M. Functional and esthetic considerations for single-tooth Ankylos implant-crowns: 8 years of clinical performance. J Oral Implantol 2004;30:198–209.
79. Locante WM. Single-tooth replacements in the esthetic zone with an immediate function implant: A preliminary report. J Oral Implantol 2004;30:369–375.
80. Norton MR. A short-term clinical evaluation of immediately restored maxillary TiOblast single-tooth implants. Int J Oral Maxillofac Implants 2004;19:274–281.
81. Van der Zee E, Oosterveld P, Van Waas MA. Effect of GBR and fixture installation on gingiva and bone levels at adjacent teeth. Clin Oral Implants Res 2004;15:62–65.
82. Dhanrajani PJ, Al-Rafee MA. Single-tooth implant restorations: A retrospective study. Implant Dent 2005;14:125–130.
83. Testori T, Bianchi F, Del Fabbro M, et al. Implant aesthetic score for evaluating the outcome: Immediate loading in the aesthetic zone. Pract Proced Aesthet Dent 2005;17:123–130.
84. Vanden Bogaerde L, Rangert B, Wendelhag I. Immediate/early function of Branemark System TiUnite implants in fresh extraction sockets in maxillae and posterior mandibles: An 18-month prospective clinical study. Clin Implant Dent Relat Res 2005;7(suppl 1):s121–s130.
85. Barone A, Rispoli L, Vozza I, Quaranta A, et al. Immediate restoration of single implants placed immediately after tooth extraction. J Periodontol 2006;77:1914–1920.
86. De Kok IJ, Chang SS, Moriarty JD, Cooper LF. A retrospective analysis of peri-implant tissue responses at immediate load/provisionalized microthreaded implants. Int J Oral Maxillofac Implants 2006;21:405–412.
87. Lindeboom JA, Frenken JW, Dubois L, et al. Immediate loading versus immediate provisionalization of maxillary single-tooth replacements: A prospective randomized study with BioComp implants. J Oral Maxillofac Surg 2006;64:936–942.
88. Steigmann M, Wang HL. Esthetic buccal flap for correction of buccal fenestration defects during flapless immediate implant surgery. J Periodontol 2006;77:517–522.
89. Calvo Guirado JL, Saez Yuguero MR, Pardo Zamora G, Munoz Barrio E. Immediate provisionalization on a new implant design for esthetic restoration and preserving crestal bone. Implant Dent 2007;16:155–164.
90. Covani U, Marconcini S, Galassini G, et al. Connective tissue graft used as a biologic barrier to cover an immediate implant. J Periodontol 2007;78:1644–1649.
91. Hall JA, Payne AG, Purton DG, et al. Immediately restored, single-tapered implants in the anterior maxilla: Prosthodontic and aesthetic outcomes after 1 year. Clin Implant Dent Relat Res 2007;9:34–45.
92. Kan JY, Rungcharassaeng K, Liddelow G, et al. Periimplant tissue response following immediate provisional restoration of scalloped implants in the esthetic zone: A one-year pilot prospective multicenter study. J Prosthet Dent 2007;97:s109–s118.
93. Sammartino G, Marenzi G, di Lauro AE, Paolantoni G. Aesthetics in oral implantology: Biological, clinical, surgical, and prosthetic aspects. Implant Dent 2007;16:54–65.
94. Siepenkothen T. Clinical performance and radiographic evaluation of a novel single-piece implant in a private practice over a mean of seventeen months. J Prosthet Dent 2007;97:s69–s78.
95. Cannizzaro G, Leone M, Torchio C, Viola P, Esposito M. Immediate versus early loading of 7-mm-long flapless-placed single implants: A split-mouth randomised controlled clinical trial. Eur J Oral Implantol 2008;1:277–292.
96. Degidi M, Nardi D, Piattelli A. Peri-implant tissue and radiographic bone levels in the immediately restored single-tooth implant: A retrospective analysis. J Periodontol 2008;79:252–259.
97. den Hartog L, Slater JJ, Vissink A, et al. 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. J Clin Periodontol 2008;35:1073–1086.
98. Fagan MC, Owens H, Smaha J, Kao RT. Simultaneous hard and soft tissue augmentation for implants in the esthetic zone: Report of 37 consecutive cases. J Periodontol 2008;79:1782–1788.

99. Kollar A, Huber S, Mericske E, Mericske-Stern R. Zirconia for teeth and implants: A case series. Int J Periodontics Restorative Dent 2008;28:479–487.
100. Lops D, Chiapasco M, Rossi A, et al. Incidence of inter-proximal papilla between a tooth and an adjacent immediate implant placed into a fresh extraction socket: 1-year prospective study. Clin Oral Implants Res 2008;19:1135–1140.
101. Mankoo T. Maintenance of interdental papillae in the esthetic zone using multiple immediate adjacent implants to restore failing teeth—A report of ten cases at 2 to 7 years follow-up. Eur J Esthet Dent 2008;3:304–322.
102. 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.
103. Romeo E, Lops D, Rossi A, Storelli S, et al. Surgical and prosthetic management of interproximal region with single-implant restorations: 1-year prospective study. J Periodontol 2008;79:1048–1055.
104. Schropp L, Isidor F. Clinical outcome and patient satisfaction following full-flap elevation for early and delayed placement of single-tooth implants: A 5-year randomized study. Int J Oral Maxillofac Implants 2008;23:733–743.
105. Avvanzo P, Ciavarella D, Avvanzo A, Giannone N, et al. Immediate placement and temporization of implants: Three- to five-year retrospective results. J Oral Implantol 2009;35:136–142.
106. Cordaro L, Torsello F, Roccuzzo M. Clinical outcome of submerged vs non-submerged implants placed in fresh extraction sockets. Clin Oral Implants Res 2009;20:1307–1313.
107. Del Fabbro M, Boggian C, Taschieri S. Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: Preliminary results of single-cohort study. J Oral Maxillofac Surg 2009;67: 2476–2484.
108. Grutter L, Belser UC. Implant loading protocols for the partially edentulous esthetic zone. Int J Oral Maxillofac Implants 2009; 24(suppl):169–179.
109. Stein AE, McGlmphy EA, Johnston WM, Larsen PE. Effects of implant design and surface roughness on crestal bone and soft tissue levels in the esthetic zone. Int J Oral Maxillofac Implants 2009;24:910–919.
110. Crespi R, Cappare P, Gherlone E. A 4-year evaluation of the periimplant parameters of immediately loaded implants placed in fresh extraction sockets. J Periodontol 2010;81:1629–1634.
111. Freitas AC Jr, Goiato MC, Pellizzer EP, et al. Aesthetic approach in single immediate implant-supported restoration. J Craniofac Surg 2010;21:792–796.
112. Fu JH, Yeh CY, Chan HL, et al. Tissue biotype and its relation to the underlying bone morphology. J Periodontol 2010;81:569–574.
113. Juodzbalys G, Wang HL. Esthetic index for anterior maxillary implant-supported restorations. J Periodontol 2010;81:34–42.
114. Siebers D, Gehrke P, Schliephake H. Delayed function of dental implants: A 1- to 7-year follow-up study of 222 implants. Int J Oral Maxillofac Implants 2010;25:1195–1202.
115. Shibly O, Patel N, Albandar JM, Kutkut A. Bone regeneration around implants in periodontally compromised patients: A randomized clinical trial of the effect of immediate implant with immediate loading. J Periodontol 2010;81:1743–1751.
116. Tymstra N, Meijer HJ, Stellingsma K, et al. Treatment outcome and patient satisfaction with two adjacent implant-supported restorations in the esthetic zone. Int J Periodontics Restorative Dent 2010; 30:307–316.
117. van Kesteren CJ, Schoolfield J, West J, Oates T. A prospective randomized clinical study of changes in soft tissue position following immediate and delayed implant placement. Int J Oral Maxillofac Implants 2010;25:562–570.
118. Aldredge WA, Nejat R. Delayed implant procedure using deproteinized bovine bone mineral: A report of 109 consecutive cases. Compend Contin Educ Dent 2011;32:66–71.
119. Balshi TJ, Wolfinger GJ, Wulc D, Balshi SF. A prospective analysis of immediate provisionalization of single implants. J Prosthodont 2011;20:10–15.
120. De Angelis N, Felice P, Pellegrino G, et al. Guided bone regeneration with and without a bone substitute at single post-extractive implants: 1-year post-loading results from a pragmatic multicentre randomised controlled trial. Eur J Oral Implantol 2011;4:313–325.
121. Grunder U, Wenz B, Schupbach P. Guided bone regeneration around single-tooth implants in the esthetic zone: a case series. Int J Periodontics Restorative Dent 2011;31:613–620.
122. Hof M, Pommer B, Strbac GD, et al. Esthetic evaluation of single-tooth implants in the anterior maxilla following autologous bone augmentation. Clin Oral Implants Res 2013;24(suppl A100):88–93.
123. Kehl M, Swierkot K, Mengel R. Three-dimensional measurement of bone loss at implants in patients with periodontal disease. J Periodontol 2011;82:689–699.
124. Lee DH, Choi BH, Jeong SM, et al. Effects of flapless implant surgery on soft tissue profiles: A prospective clinical study. Clin Implant Dent Relat Res 2011;13:324–329.
125. Levin BP. Immediate temporization of immediate implants in the esthetic zone: Evaluating survival and bone maintenance. Compend Contin Educ Dent 2011;32:52–56, 58–60, 62.
126. Lops D, Mosca D, Muller A, Rossi A, et al. Management of peri-implant soft tissues between tooth and adjacent immediate implant placed into fresh extraction single socket: A one-year prospective study on two different types of implant-abutment connection design. Minerva Stomatol 2011;60:403–415.
127. Schneider D, Grunder U, Ender A, et al. Volume gain and stability of peri-implant tissue following bone and soft tissue augmentation: 1-year results from a prospective cohort study. Clin Oral Implants Res 2011;22:28–37.
128. Covani U, Chiappe G, Bosco M, et al. A 10-year evaluation of implants placed in fresh extraction sockets: A prospective cohort study. J Periodontol 2012;83:1226–1234.
129. Di Alberti L, Donnini F, Di Alberti C, et al. Clinical and radiologic evaluation of 70 immediately loaded single implants in the maxillary esthetic zone: Preliminary results after 1 year of functional loading. Int J Oral Maxillofac Implants 2012;27:181–186.
130. Fugazzotto PA. A retrospective analysis of implants immediately placed in sites with and without periapical pathology in sixty-four patients. J Periodontol 2012;83:182–186.
131. Schwarz F, Sahm N, Becker J. Impact of the outcome of guided bone regeneration in dehiscence-type defects on the long-term stability of peri-implant health: Clinical observations at 4 years. Clin Oral Implants Res 2012;23:191–196.
132. Raes F, Cosyn J, Crommelinck E, et al. Immediate and conventional single implant treatment in the anterior maxilla: 1-year results of a case series on hard and soft tissue response and aesthetics. J Clin Periodontol 2011;38:385–394.
133. Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. Int J Oral Maxillofac Implants 2009; 24(suppl):186–217.
134. Chen ST, Beagle J, Jensen SS, et al. Consensus statements and recommended clinical procedures regarding surgical techniques. Int J Oral Maxillofac Implants 2009;24(suppl):272–278.
135. Gehrke P, Lobert M, Dhom G. Reproducibility of the pink esthetic score—Rating soft tissue esthetics around single-implant restorations with regard to dental observer specialization. J Esthet Restor Dent 2008;20:375–384.
136. Lai HC, Zhang ZY, Wang F, et al. Evaluation of soft-tissue alteration around implant-supported single-tooth restoration in the anterior maxilla: The pink esthetic score. Clin Oral Implants Res 2008;19: 560–564.
137. Luo Z, Zeng R, Chen Z. Single implants in the esthetic zone: Analysis of recent peri-implant soft tissue alterations and patient satisfaction. A photographic study. Int J Oral Maxillofac Implants 2011;26:578–586.
138. Jemt T. Regeneration of gingival papillae after single-implant treatment. Int J Periodontics Restorative Dent 1997;17:326–333.
139. Razavi T, Palmer RM, Davies J, et al. Accuracy of measuring the cortical bone thickness adjacent to dental implants using cone beam computed tomography. Clin Oral Implants Res 2010;21:718_725.
140. Buser D, Chappuis V, Kuchler U, et al. Long-term stability of early implant placement with contour augmentation. J Dent Res 2013; 92(12 suppl):176S–182S.
141. Busenlechner D, Tangl S, Arnhart C, et al. Resorption of deproteinized bovine bone mineral in a porcine calvaria augmentation model. Clin Oral Implants Res 2012;23:95–99.