

Soft Tissue Augmentation Procedures for Mucogingival Defects in Esthetic Sites

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Purpose: This systematic review was performed to address the focus question: "In adult patients with soft tissue deficiencies around maxillary anterior implants, what is the effect on esthetic outcomes when a soft tissue procedure is performed?" In addition, this paper reviews the importance of presurgical esthetic risk assessment (ERA) starting with comprehensive team case planning prior to surgical intervention and a restorative-driven approach. **Materials and Methods:** A thorough Medline database search performed on related MeSH terms yielded 1,532 titles and selected abstracts that were independently screened. Out of the 351 abstracts selected, 123 full-text articles were obtained for further evaluation. At each level, any disagreements were discussed until a consensus was reached. **Results:** A total of 18 studies were included in this systematic review of esthetic outcomes following soft tissue procedures around implants with soft tissue deficiencies. A preliminary analysis of the included studies showed that the vast majority were case series studies with most not providing objective outcomes of their results. Moreover, only one randomized controlled trial was identified. Therefore, quantitative data analysis and subsequent meta-analysis could not be performed. The included studies were grouped according to the intervention on the peri-implant soft tissue performed and six groups were identified. The periodontal procedures performed around dental implants gave initial good results from the inflammation involved in wound healing, but in virtually all cases significant recession occurred as healing resolved and the tissues matured. **Conclusions:** Although success of implant therapy is similar in the anterior maxilla and other areas of the mouth, the majority of studies evaluating this therapy in the esthetic zone are lacking literature support, few in number, devoid of long-term follow-up and number of patients, and are subject to inclusion bias. The use of the ERA tool for all esthetic zone cases can benefit both the clinician and the patient to avoid any miscommunication and problems of expectation upon completion. All the available knowledge on this topic, including the approaches described in this paper, is based on a very limited literature support and thus should be addressed with caution. These concerns should encourage long-term good clinical trials for better assessment of those issues. *INT J ORAL MAXILLOFAC IMPLANTS* 2014;29(SUPPL):155–185. doi: 10.11607/jomi.2014suppl.g3.2

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Long-term clinical studies have shown that functional osseointegration is a predictable outcome when endosseous implants are placed in the treatment of missing teeth.¹⁻⁵ However, the success of dental implant therapy is no longer based only on functional osseointegration but positive patient outcomes of creating an illusion that the tooth replacement is in esthetic harmony with the remaining dentition upon smiling. Patients expect not only the ability to function long term with their restored implants but also to have a reasonable esthetic result. The knowledge base has significantly improved over the last two decades when it comes to clinicians' understanding of the biology and healing of the oral hard and soft tissues, with the esthetic zone being studied extensively over this time period. Although the success of dental implants is

Table 1 Implant Esthetic Risk Profile Assessment

Esthetic risk factors	Low	Medium	High
Medical status	Healthy patient, intact immune system	–	Reduced immune system
Smoking habit	Nonsmoker	Light smoker (< 10 cigarettes/d)	Heavy smoker (> 10 cigarettes/d)
Patient esthetic expectations	Low	Medium	High
Lip line	Low	Medium	High
Gingival biotype	Low scalloped, thick	Medium scalloped, medium thickness	High scalloped, thin
Shape of tooth crowns	Rectangular	Slightly triangular	Triangular
Infection at implant site	None	Chronic	Acute
Bone level at adjacent teeth	≤ 5 mm to contact point	5.5 to 6.5 mm to contact point	7 mm to contact point
Restoration status of neighboring teeth	Virgin	–	Restored
Width of edentulous span	1 tooth ≥ 7 mm	1 tooth ≤ 7 mm	2 or more teeth
Soft tissue anatomy	Intact soft tissue	–	Soft tissue defects
Bone anatomy of alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency

similar in the anterior maxilla to that of posterior areas, attaining predictable esthetic results are not.

The straightforward, advanced, and complex (SAC) classification was developed to aid in clinical decision-making for the benefit of the patient and to help avoid complications based on the experience level of the clinician and the potential difficulty of the treated implant site.⁶ The SAC classification system has both restorative and surgical categories that use a normative classification system, which can be influenced by modifying factors based on individual clinical situations. One area that can influence this classification—both from a surgical and restorative perspective—is found in the International Team for Implantology (ITI) esthetic risk assessment (ERA) analysis (Table 1). The ERA is a pretreatment assessment tool that uses clinical precursors to determine the risk of achieving an esthetic result based on known surgical and restorative approaches in given clinical situations.⁷ Esthetic risk factors (Table 1) should be addressed directly with the patient before the initiation of treatment to avoid any posttreatment misunderstandings that may result from unmet high expectations. The clinician can best avoid potential posttreatment complications and an unhappy patient by gathering information chairside with patients during their initial consultation visit and sharing it with them using aids such as the ERA form. This is also an excellent team (surgeon, restorative dentist, and patient) communication tool that can be used in all esthetic cases to help both the clinician and the patient achieve their esthetic goals.⁷

The SAC classification advises that the anterior maxillae is an advanced or complex treatment procedure and requires comprehensive preoperative planning

and precise surgical execution based on a restorative-driven approach.^{6–10} The goal of risk assessment is to identify patients whose implant therapy carries a high risk for a negative outcome. Avoidance of any potential postsurgical complication or misunderstanding on the patient's part is communicated prior to therapy, and based on the esthetic risk profile of the patient, an appropriate treatment plan is developed.^{7,10} The more high-risk categories the patient falls into, the more conservative the surgical and restorative approach should be. This will help avoid any potential esthetic problems later.

The ITI Treatment Guide 19 states, “An esthetic implant prosthesis is defined as one that is in harmony with the perioral facial structures of the patient. The esthetic peri-implant tissues, including health, height, volume, color, and contours, must be in harmony with the surrounding dentition. The restoration should imitate the natural appearance of the missing dental unit(s) in color, form, texture, size, and optical properties.”

In some cases of implants placed in esthetic areas of the mouth, conditions develop after implant placement where the implant restoration is no longer pleasing in appearance. In those cases, the important clinical question is whether or not a soft tissue procedure can restore the esthetic outcome of the restoration. The purpose of this paper was therefore to address a PICO (patient or population, intervention, control or comparison, outcome) question aimed at identifying literature that addresses this topic. In addition, this paper will review the literature on the role of keratinized gingiva in regards to maintaining periodontal health, the biologic differences in soft tissues between teeth and dental implants, and the timing and need for soft

Table 2 Systematic Search Strategy

Focus question In adult patients with soft tissue deficiencies around maxillary anterior implants, what is the effect on esthetic outcomes when a soft tissue procedure is performed?

Search strategy

Population	#1 – jaw, edentulous, partially[MeSH Terms] OR partially edentulous OR partial edentulism
Intervention or exposure	# 2 - soft tissue graft OR connective tissue graft OR subepithelial connective tissue graft OR alloplastic graft OR alloderm OR xenograft OR mucograft OR free gingival graft OR coronally positioned flap OR double papilla flap OR roll technique OR push back OR vestibuloplasty OR apligraf OR living cell construct
Comparison	N.A.
Outcome	#4 - papilla OR papilla index OR keratinized mucosa OR width of keratinized mucosa OR recession coverage OR PES/WES OR pink esthetic score OR white esthetic score OR esthetic outcome
Search combination	#1 AND (#2 OR #4)

Database search

Language	English
Electronic	PubMed
Journals	<i>Clinical Oral Implants Research, International Journal of Oral Maxillofacial Implants, Clinical Oral Implants and Related Research, Implant Dentistry, Journal of Implantology, Journal of Periodontology, Journal of Clinical Periodontology, Periodontology 2000, International Journal of Periodontics and Restorative Dentistry, Compendium of Continuing Education Dentistry, Practical Periodontics and Aesthetic Dentistry, Journal of Esthetic Dentistry</i> as well as bibliographies of articles and recent text books relevant to the topic. In addition, reference lists of recent review papers were searched for additional citations. ^{11–22}

Selection criteria

Inclusion criteria	Clinical studies only Studies at all levels of evidence Implant placement in the esthetic zone, defined as the maxillary anterior and premolar region of the dentition
Exclusion criteria	Studies without any soft tissue deficiency around the implant at baseline Studies reporting soft tissue procedure performed previous to and at implant placement Animal studies

tissue augmentation procedures in helping to achieve an improved long-term and stable esthetic result. Furthermore, recommendations will be made on the variables that can predict the need for augmentation procedures and possible ways to clinically avoid their need by proper treatment planning exercises PRIOR to any surgical intervention. Our therapeutic goal is to provide the patient the best evidenced-based therapy with the least risk of patient morbidity.

MATERIALS AND METHODS

Focus Question

The focus (PICO) question to be addressed was: “In adult patients with soft tissue deficiencies around maxillary anterior implants, what is the effect on esthetic outcomes when a soft tissue procedure is performed?”

Search Strategy

A search in the MEDLINE database was performed on 10/30/2012 using the following search query:

- (dental implants[MeSH Terms] OR oral implant OR endosseous implant) AND papilla OR papilla index OR keratinized mucosa OR width of keratinized mucosa OR recession coverage OR PES/WES OR pink esthetic score OR white esthetic score OR esthetic outcome OR soft tissue graft OR connective tissue graft (CTG)
- OR subepithelial connective tissue graft (SECTG) OR alloplastic graft OR alloderm OR xenograft OR mucograft OR free gingival graft OR coronally positioned flap (CPF) OR double papilla flap OR roll technique OR push back OR vestibuloplasty OR apligraf OR living cell construct. Further criteria are provided in Table 2.

Study Selection

This search yielded 1,532 titles that were independently screened by two reviewers (DLC and GH).

The two reviewers compared their respective selection and the calculated Kappa score for inter-examiner agreement indicated a “fair” agreement ($\kappa = 0.353$, 95% confidence interval [CI]: 0.303 to 0.403). Out of the initial 1,532 titles, 351 abstracts were obtained for further

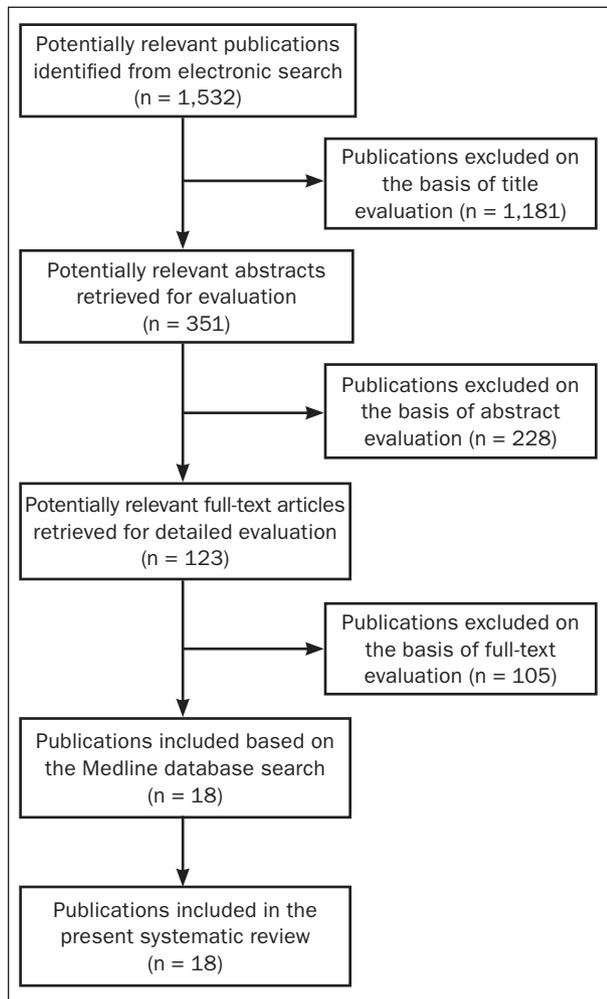


Fig 1 Selection process of the included publications.

evaluation. If article abstracts were not available, the reviewers included those articles to the next level, ie, full-text review.

Selected abstracts were independently screened by the same two reviewers (DLC and GH). The two reviewers compared their respective selection and the calculated Kappa score for inter-examiner agreement indicated a “good” agreement ($\kappa = 0.743$, 95% CI: 0.670 to 0.815).

Out of the 351 abstracts selected, 123 full-text articles were obtained for further evaluation. The same reviewers compared their respective independent selection (on February 5, 2013) and the calculated kappa score for inter-examiner agreement indicated a “very good” agreement ($\kappa = 0.833$, 95% CI: 0.692 to 0.975).

At each level, any disagreements were discussed until a consensus was reached. Finally, 18 full-text articles relevant to answer the PICO question formulated previously were included. The hand search did not yield any further articles to be included (Fig 1).

Excluded Studies

Out of the 123 full-text articles assessed, 105 were excluded from the final analysis due to the following reasons:

- Review article
- Article describing a technique without any case report
- No soft tissue deficiency around the implant present at baseline
- Sites were located in the mandible
- Unable to distinguish data for sites in the anterior maxilla from posterior nonesthetic sites

Quality Assessment and Data Extraction

From the included articles the following characteristics and data were extracted:

- Author
- Year
- Study design
- Number of patients
- Implant site
- Timing of implant placement (Type 1, 2, 3, or 4 according to Hämmerle et al)²³
- Patient age
- Smoking status
- Soft tissue defect treated
- Intervention
- Follow-up
- Qualitative assessment of outcome
- Quantitative assessment of outcome
- Outcome measurement
- Conclusion of the study as reported by the author(s)

Statistical Analysis

A preliminary analysis of the included studies showed that the vast majority of studies were case series studies. Moreover only one randomized controlled trial was identified. Therefore, quantitative data analysis and subsequent meta-analysis could not be performed.

RESULTS

A total of 18 studies were included in this systematic review of esthetic outcomes following soft tissue procedure around implants with soft tissue deficiencies. Of these, one study was a randomized controlled trial (RCT) (Basegmez et al²⁴). The remaining studies were case series with the vast majority including one to three patients (Hsu et al,²⁵ Hidaka and Ueno,²⁶ Cosyn et al,²⁷ Mareque-Bueno,²⁸ Lai et al,²⁹ Shibli and d’Avila,³⁰ Yan et al,³¹ Shibli et al,³² Matthews,³³ Block,³⁴ Price and Price,³⁵ Han et al,³⁶ Alpert,³⁷ and Silverstein and Lefkove³⁸).

The remaining three case series had either 10 (Becker et al³⁹ and Burkhardt et al⁴⁰) or 20 patients included (Zucchelli et al⁴¹). Since no meta-analysis was possible, the review of these studies will be descriptive in nature.

The included studies were grouped according to the intervention on the peri-implant soft tissue performed and six groups were identified:

- Connective tissue graft (CTG) with a coronally advanced flap (CAF): Seven studies (Zucchelli et al,⁴¹ Hidaka and Ueno,²⁶ Lai et al,²⁹ Burkhardt et al,⁴⁰ Shibli and d'Avila 2006,³⁰ Shibli et al,³² and Price and Price 1999³⁵)
- Connective tissue graft in combination with an envelope flap or pouch: Three studies (Hsu et al,²⁵ Cosyn et al,²⁷ and Silverstein and Lefkove³⁸)
- Free gingival graft (FGG): Three studies (Basegmez et al,²⁴ Yan et al,³¹ Han et al,³⁶ and Alpert³⁷)
- Acellular dermal matrix (ADM) with a coronally advanced flap (CAF): One study (Mareque-Bueno²⁸)
- Pediculated connective tissue graft (PCTG): Two studies (Matthews 2002³³ and Block³⁴)
- Injection of hyaluronic acid: One study (Becker et al³⁹)

Table 3 summarizes the included studies.

Connective Tissue Graft (CTG) and Coronally Advanced Flap (CAF)

Two studies,^{40,41} used this technique in case series including, respectively, 10 and 20 patients, with each patient having one implant presenting a mean buccal soft tissue recession of approximately 3 mm in both studies.

The technique used by Burkhardt et al⁴⁰ included the collection of a subepithelial CTG using a single incision harvesting technique,^{42,43} which was secured on the prepared connective tissue bed recipient site and over the implant-abutment junction. The partial thickness flap, which was mobilized beyond the mucosal-gingival junction (MGJ), was then coronally advanced and sutured to cover the graft. The mean initial recession depth reported was 3.0 ± 0.8 mm. The final position of the mucosal margin was located up to 1.2 mm more coronally (mean, 0.5 mm) than the margin on the contralateral natural tooth. Therefore, immediately after surgery, all sites presented recession coverage of $\geq 100\%$. Unfortunately, these positive outcomes were not maintained over the 6-month follow-up. One month after surgery, a significant decrease of coverage to 75% (SD, 17%) was observed. Further decreases, although statistically significant, were reported for the 3- and 6-month follow-up visits with, respectively, 70% (SD, 18%) and 66% (SD, 18%) of the initial recession covered. The same trend of healing was observed for all the treated sites. The authors concluded that a CTG in

conjunction with a CAF could improve the condition of the soft tissue recession around dental implants. However, complete coverage was not achieved.

In contrast, Zucchelli et al,⁴¹ with similar amount of soft tissue dehiscence at baseline (2.72 ± 0.68 mm), reported a mean coverage of 96.3% and complete coverage observed at 75% of the treated sites at the final follow-up visit, one year after final crown delivery. Moreover, the authors reported a significant increase in keratinized tissue height (0.57 ± 0.41 mm), in tissue thickness (1.54 ± 0.21), and patient satisfaction using a visual analog scale.

The discrepancy observed in the amount of recession coverage between the two studies was discussed by Zucchelli and coworkers.⁴¹ They speculated that the difference in outcome was probably due to the fact that 1 month prior to surgery they removed the implant crown and reshaped and polished the underlying abutment. Moreover, the newly fabricated provisional crown was removed at the time of surgery. As a consequence of these prosthetic procedures, more room was created for the soft tissue graft to be placed over the implant-abutment interface and a better adaptation between the graft and the smoothed abutment surface was obtained. This may have contributed to the better clinical outcomes reported.

The five remaining studies^{26,29,30,32,35} using a CTG and CAF to treat mucosal recession around implants included a total of six sites treated. Four studies did not report any objective outcome measurements but only a qualitative assessment of the coverage observed, such as "patient was pleased with the esthetics." Shibli et al³² reported on one treated site for which a complete 3-mm recession coverage was achieved following surgery and the use of two temporary crowns. The limited amount of cases treated in each of these reports combined with the fact that all but one study (Shibli et al³²) did not report any objective outcome measurements constitute anecdotal evidence that CTG and CAF may be able to improve soft tissue recession around dental implants.

Connective Tissue Graft (CTG) and Pouch or Envelope Flap

Hsu et al²⁵ reported on one case in which an immediately placed implant at the right maxillary central incisor presented with a facial mucosal recession 3 months after surgery. A CTG with an envelope flap was performed at the site in order to correct the level of the soft tissue. Moreover, the provisional crown was modified to sculpt the tissue. A final crown was delivered 2 months after the procedure, and the results at 3.5 years were stated to demonstrate "favorable esthetic outcomes." No quantitative measurements were reported.

Table 3 Details of Included Studies

Study	Year	Study design	Patients	Age	Smoking status	Implant site	Details on implant placement	Defect	Intervention
Zucchelli et al ⁴¹	2013	Case series	20 (14 F/6 M)	26–53	< 10 cigarettes/d	Esthetic area	NR	Buccal soft tissue dehiscence	CTG and CAF, abutment modification (if needed), new restoration
Hsu et al ²⁵	2012	Case series	1 F	53	NR	Implant #8 (11)	Type 1	Mucosa recession observed 3 mo after placement	CTG with envelope flap and modification of provisional prosthesis
Basegmez et al ²⁴	2012	RCT	64 (36 F/28 M; 32 FGG, 32 VP)	60 ± 11	NR	NR	NR	Inadequate attached mucosa (< 1.5 mm)	FGG or VP
Hidaka and Ueno ²⁶	2012	Case series	1 F	33	NR	Implant #9 (21)	NR	3 mm abutment exposure on the buccal mucosa (dehiscence)	2× at same site: subepithelial CTG with CAF with 1 y interval and new restoration
Cosyn et al ²⁷	2012	Case series	2	NR	NR	In the esthetic zone	Type 1 flapless	Midbuccal facial recession 1.5 and 2 mm, 3 mo after placement	CTG
Mareque-Bueno ²⁸	2011	Case series	1 F	41	Nonsmoker	Implant #7 (12)	Type 1	Midfacial mucosa recession, 3 mm	ADM graft and CAF
Lai et al ²⁹	2010	Case series	1 F	39	NR	Implant #9 (21)	Type 4 (staged approach)	1 mm gingival recession after 1 y orthodontic treatment with provisional implant-supported crown #9	Removal of provisional crown and abutment. Resubmerged implant with CTG and CAF for 2 mo before uncovering and abutment/provisional crown delivery. 6 mo later, final cemented crown delivery
Becker et al ³⁹	2010	Case series 10 implants in 10 patients	NR	NR	NR	7 cases: Implant #7 (12) 3 cases: Implant #10 (22)	NR	Deficient papillae characterized by dark deficiencies adjacent to implant site	Injection of hyaluronic-acid based gel 2–3 mm coronal to the tip of the deficient papillae at 3 wk interval up to 3×
Burkhardt et al ⁴⁰	2008	Case series	10	43–59	NR	Maxillary front	8 implants were two-stage (sumerged) and 2 implants were one-stage (transmucosal)	Soft tissue recession with unfavorable esthetics developed over 1-6 y (3 mm ± 0.8 SD)	CTG and CAF (covered graft + 2 mm)

Follow-up	Qualitative measurements	Quantitative measurements	Outcome measurements	Conclusion
1 y after final prosthesis	NR	Difference in clinical parameters between baseline and 1 year	Increase in keratinized tissue height, $0.57 \text{ mm} \pm 0.41$ ($P < .01$); Increase in soft tissue thickness, $1.54 \text{ mm} \pm 0.21$ ($P < .01$); Reduction in dehiscence, $2.62 \text{ mm} \pm 0.81$ ($P < .01$); Patient esthetic satisfaction improvement, VAS 4.2 ($P < .01$)	75% complete coverage (defined by comparison to contralateral tooth)
3.5 y after final prosthesis	Favorable esthetic outcome was maintained for 3.5 years after delivery of the final prosthesis	NR	NR	NA
1, 3, 6, 12 mo after procedure	NR	Width of attached mucosa	FGG vs VP: baseline, 0.75 ± 0.36 vs 0.67 ± 0.32 ($P = .37$); 1 mo, 5.11 ± 0.71 vs 4.89 ± 0.84 ($P = .27$); 3 mo, 3.54 ± 0.61 vs 2.92 ± 0.62 ($P < .05$); 6 mo, 3.26 ± 0.59 vs 2.06 ± 0.62 ($P < .05$); 12 mo, 3.11 ± 0.58 vs 1.83 ± 0.73 ($P < .05$)	Statistically significant improvement in attached mucosa width in both treatment groups and at all time points compared to baseline. FGG resulted in significantly more attached mucosa at 3, 6, 12 mo after surgery as compared to VP.
9 mo after second graft	Harmonious mucosa observed	NR	NR	Two-step split pouch technique with SCTG could achieve substantial soft tissue dehiscence coverage
6 and 12 mo after CTG	NR	Difference in recession	1 and 1.5 mm reduction of recession	Final recession, 0.5 mm in 2 cases
2, 4, 6 mo	Partial coverage was obtained	NR	NR	
3 y postgrafting	Soft tissue contour in the anterior region was harmonious	NR	NR	If peri-implant soft tissue recession occurs, the implant resubmergence technique with CTG can provide esthetic result.
6-25 mo after initial injection	At the final examination, none of the patients showed evidence of relapse	Percentage change of black triangle size	3 cases 100% (complete fill); 6 cases: 88%–97%; 1 case: 57% Mean \pm SD (calculated): $92.4\% \pm 13.0\%$	The use of an injectable hyaluronic gel to enhance papillary esthetics after implant treatment should be evaluated in a controlled clinical study. The results of this pilot study are promising.
6 mo	After 6 mo, only partial coverage	% coverage, width of keratinized mucosa	1) At surgery: 100% (8 out of 10 cases overcompensated up to 1.2 mm, mean 0.5 mm); 1.3 mm (SD 1 mm), contralateral tooth 2.3 mm (SD 1.6 mm) 2) At 1 mo: 75% (SD 17%) (Decrease is significant $P < .05$); 1.3 mm (SD 0.5 mm) 3) At 3 mo: 70% (SD 18%) (decrease not significant); 1.2 mm (SD 0.5 mm) 4) At 6 mo: 66% (SD 18%) (decrease not significant); 1.1 mm (SD 0.5 mm)	All sites clinically significant improvement but none had complete coverage at 6 mo.

Table 3 continued Details of Included Studies

Study	Year	Study design	Patients	Age	Smoking status	Implant site	Details on implant placement	Defect	Intervention
Shibli and d'Avila ³⁰	2006	Case series	1 M/1 F	26 (M), 25 (F)	NR	Implant #8 (11), #9 (21)	NR	#8: implant facial margin apical to adjacent natural central incisor #9: dehiscence showing healing abutment and non-keratinized mucosa	New abutment and crown, SECTG and CAF and antibiotics in both cases
Yan et al ³¹	2006	Case series	1 M	35	NR	Implants #7 to #10 (12 to 22)	NR	Insufficient keratinized tissue (≤ 1 mm)	28 × 11 mm FG and antibiotics
Shibli et al ³²	2004	Case series	1 F	37	NR	Implant #9 (22)	Type 1	3 mm midfacial gingival recession	CTG + CAF with a provisional crown, 6 wk after surgery, 2nd provisional crown, 4 months after surgery
Mathews ³³	2002	Case series	3 F	45, 35, 18	NR	1) Implant #8 (11) 2) Implant #7, 10 (12,22) 3) Implant #10,11 (22,23)	NR	1) Soft tissue profile deficient, platform fixture visible, black triangles visible with provisional prosthesis 2) Midfacial recession 3) Gingival disharmony due to soft tissue deficiency	Pediculated CTG rotated over implant and underneath a facial pouch
Block ³⁴	1999	Case series	1 F	40	NR	Implant #10 (22)	Type 2	Thin gingiva over implant with metal showing. Translucent thin gingiva prevented an esthetic restoration.	Palatal roll flap
Price and Price ³⁵	1999	Case series	1 F	41	NR	Implant #8 (11)	Type 1	Siebert class III defect and hard and soft tissue deficiencies in the apicocoronal and buccolingual directions.	1st surgery: free CTG with a 3-mm epithelial collar to increase soft tissue volume and keratinization 2nd surgery (17 days later): CAF
Han et al ³⁶	1995	Case series	1 F	50	NR	5 in anterior maxilla	NR	Lack of keratinized mucosa	Strips of FG covered by foil and periodontal dressing

Follow-up	Qualitative measurements	Quantitative measurements	Outcome measurements	Conclusion
2 y	Both patient "pleased with final esthetic result; mucosal margins 2-3 mm more coronal and at same level as adjacent central incisor	NR	NR	Modification of the peri-implant margin and repositioning of the abutment with a new abutment closer to adjacent tooth CEJ were important. Authors felt that the position of the implant shoulder in relation to the CEJ, the amount of keratinized tissue, and the implant buccolingual axis are important.
6 mo	Uneventful healing, best color blend 1 mo post-op, complete keratinization and maturation at 3 mo	Width of keratinized tissue	Baseline, mean 0.5 mm; 3 mo, mean 8 mm (net gain 7.5 mm, 30.5% shrinkage); 6 mo, mean 7.8 mm (net gain 7.3 mm, 32.4% shrinkage)	The FGG gave a patchlike appearance, achieved satisfactory result, and increased the width of keratinized tissue.
18 mo recall	Peri-implant soft tissues were stable and patient was pleased with esthetic results.	Recession difference	Mucosal margin was 3 mm more coronal. No recession in comparison to adjacent contralateral central incisor.	The use of a subepithelial c tissue graft to restore the labial margin discrepancy of a single implant-supported crown in the anterior maxilla was described. The procedure was successful and demonstrated esthetic improvement and stability of peri-implant tissue over a follow-up period of 18 mo.
1) Final restoration 7 mo after surgery 2) Final restoration 11 mo after surgery 3) Final restoration 8 mo after surgery	1) Esthetic integration of the definitive restorations 2) Improved tissue condition and esthetics 3) Definitive restoration demonstrated harmonious integration during natural smile	NR	NR	The pediculated CTG is an excellent technique that can be used for vertical and labial augmentation of soft tissue. It can be employed to improve unesthetic soft tissue structures around implants and can also be used to augment deficient ridges where pontics are scheduled.
NR	Healthy soft tissue appearance around implant	NR	–	NR
6 wk after 2nd surgery and 3 y after crown delivery	6 wk after surgery: adequate apicocoronal tissue height and buccolingual width; 3 y after: patient very pleased with esthetics, soft tissue defect corrected	NR	NR	A subepithelial CTG with an emergence-profile provisional crown and final restoration may be used to successfully restore the gingival papillae and augment ridge soft tissue adjacent to a dental implant.
2 wk	Increased attached keratinized gingiva and presence of firm keratinized tissue provided a tighter seal around implant, resulting in easier maintenance of oral hygiene for patient. Inflammation, bleeding on probing, probing depths decreased.	NR	NR	With the strip gingival autograft, extended areas with mucogingival problems can be treated in one appointment, which makes it a very practical technique. This technique consistently provides a wider zone of keratinized gingiva and promotes a tight seal of firm tissue around implants for improved health.

Table 3 continued Details of Included Studies

Study	Year	Study design	Patients	Age	Smoking status	Implant site	Details on implant placement	Defect	Intervention
Alpert ³⁷	1994	Case series	2 F	64, 17	NR	1st case: Implant #13 (24) 2nd case: Implant #7 (12)	NR	Case 1: Lack of keratinized gingiva, Case 2: Soft tissue concavity and blue appearance	FGG
Silverstein and Lefkove ³⁸	1994	Case series	1 M	40 y	NR	Implant #10 (22)	NR	Concavity and gum with gray appearance	SECTG underneath partial thickness flap

FGG = free gingival graft; VP = vestibuloplasty procedure; NR = not reported; CTG = connective tissue graft; CAF = coronally advanced flap; ADM = acellular dermal matrix; SECTG = subepithelial connective tissue graft.

Cosyn et al²⁷ reported on the outcomes of 22 immediately placed implants in a 1-year prospective study. At 3 months, two cases demonstrated advanced mid-facial recession of 1.5 and 2 mm, which were corrected by means of a connective tissue graft. The recession measured at the 1-year time point was 0.5 mm for both cases.

Silverstein and Lefkove³⁸ also presented one case in which a gray peri-implant mucosal appearance and a concavity were observed around an implant at the left maxillary lateral incisor. However, no recession was reported at the baseline. The soft tissue deficiencies were corrected by a subepithelial CTG placed over the dental implant underneath a partial thickness flap. This procedure resulted in a desired soft tissue prominence and masking of the gray color.

Free Gingival Grafts (FGG)

Four publications^{24,31,36,37} have reported on the use of an autogenous free gingival graft (FGG) in mucogingival surgeries to augment implant esthetic soft tissue defects. Most of these procedures were used to increase the amount of keratinized tissue around an implant; however, the need for such tissue remains controversial. Only one of the studies involved more than one or two cases using a FGG. That study²⁴ described a randomized controlled clinical trial around implants to augment the amount of keratinized tissue using a FGG versus a vestibuloplasty procedure (VP). In this 1-year study 64 patients with less than 1.5 mm of keratinized tissue were randomized between the groups. Study criteria included mobile mucosa but no recession or radiographic bone resorption. Smokers were excluded. Each site demonstrated inflammation with signs of bleeding on probing, hyperemia, or swelling. Measurements (made by an independent examiner) at baseline, 1, 3, 6, and 12 months included Plaque Index (PI), Gingival Index (GI), probing

depth (PD), and the width of attached mucosa (WAM). The FGG procedure was performed following the techniques described by Bjorn⁴⁴ and as followed by Sullivan and Atkins.⁴⁵ The VP was performed as described by Edlan and Mejchar.⁴⁶ Healing was uneventful and no patients experienced any complications. The change in WAM from baseline at all time points was significant for both techniques ($P = .000$). The 3-, 6-, and 12-month WAM gains were significantly greater ($P = .000$) in the FGG group compared to the VP group, with the 1-year gain in the FGG group being 2.36 mm compared to the VP group with 1.15 mm.

A critical finding in many of these soft tissue procedures is relapse after healing. In this study, the amount of relapse at one year was significantly less ($P = .000$) in the FGG group (2.00 mm) compared to the VP group (3.06 mm). It is important to note that both procedures resulted in large amounts of relapse in WAM. In addition, pocket depth values were significantly greater ($P = .02$, $P = .024$ and $P = .000$, respectively) in the VP group at 3, 6, and 12 months in this study. Plaque accumulation and gingival inflammation at all measurement points were not significantly different between test (FGG) and control (VP) groups. Although the patients reported no significant complications, the FGG group participants did complain about the donor site, reporting moderate to severe pain in that area. The examiner in this study could not be blinded due to the clear differences clinically when using a FGG tissue graft compared to a VP. One criticism of this report is that the location and number of each type of tooth treated was not reported. The authors concluded that in spite of the observed relapse that occurred using both procedures, that the use of a FGG to augment the amount of keratinized tissue around implants is more effective than a VP.

Follow-up	Qualitative measurements	Quantitative measurements	Outcome measurements	Conclusion
NR	Case 1: excellent zone of keratinized gingiva. Case 2: improvement of contour and decrease in blue appearance	NR	NR	NR
8 wk	Successful soft tissue root prominence and masked gray color.	NR	NR	NR

In one of the three papers involving a single case report,³¹ a patient received an autogenous FGG and an acellular dermal matrix (ADM) allograft in the maxillary and mandibular anterior areas respectively (randomly allocated) to augment keratinized mucosa around multiple implants. The patient was 35 years old and did not smoke. Measurements were made at baseline, 3, and 6 months postsurgery. These measurements (all made by one examiner) included Plaque and Gingival Index, probing depth, and gingival recession on the facial aspect with the implant shoulder as the reference point. At baseline, no more than 1 mm of keratinized tissue was found on the facial aspect of the implants. The ADM allograft was placed with the basement membrane side exposed and the connective tissue facing the periosteal recipient bed and was not covered by the mucosal flap. Antibiotics were prescribed for 2 weeks. Both recipient sites healed uneventfully but postoperative bleeding did occur at the palatal donor site. The FGG was best color-matched 1 month after surgery and at 3 months was reported to be completely keratinized with mature healing. At 6 months there was an increase in keratinized tissue. The authors felt that the ADM allograft took approximately 2 weeks longer to heal than did the FGG with surface necrosis occurring at 2 weeks. Graft shrinkage was noted at 1 month with keratinization occurring by 2 months. Epithelialization and color blend was found at 3 months with maturation and stability of the tissue at 6 months. The width of keratinized tissue increased significantly with both procedures. The FGG graft at baseline had a mean of 0.5 mm and increased to 7.8 mm at 6 months. The ADM allograft had 0.6 mm at baseline and 2.4 mm at 6 months. Shrinkage occurred at both 3 and 6 months, and for the ADM allograft was 78% and 82%, while shrinkage for the FGG was 30.5% and 32.4%, respectively. No significant difference was

found between the FGG and the ADM allograft in regards to plaque and gingival index or in gingival recession after 3 and 6 months. The authors felt that the FGG had a more “patch-like” appearance than did the ADM allograft with poorer esthetics and more post-operative complications due to the donor site. Another difference in procedures is that the FGG autograft is limited in the amount of tissue availability compared to the unlimited allograft material; however, the ADM allograft had greater shrinkage than did the FGG and the ADM site had much less keratinized tissue after 3 and 6 months. As reported, both grafts achieved satisfactory results; however, the FGG achieved a greater increase in keratinized tissue than did the ADM allograft. Because only one case was reported, the influence of the jaw (maxilla versus mandible) on the outcome is unknown and may have affected the final results in this case report.

A descriptive publication regarding a zone of keratinized tissue around teeth and implants reported on five cases, two of which involved soft tissues that were augmented with a FGG in esthetic areas.³⁷ In one case, a 64-year-old woman had an implant placed at the maxillary left second premolar site. After 6 months, a FGG from the palate was used to provide an adequate zone of keratinized tissue. The final restoration revealed an “excellent zone of bound-down keratinized gingiva around the implant.” In a second case involving an implant in the maxillary right lateral incisor site in a 17-year-old woman, the patient was concerned about a concavity on the facial and a bluish, veiny appearance of the soft tissues. In this case an autogenous FGG was used to eliminate the concavity and change the appearance of the tissue. The surgical technique left a small collar of tissue on the facial to help prevent recession and did not involve the interproximal papillae. A 2.0- to

2.5-mm thick FGG tissue graft was placed in the site and the authors reported a "substantial change" in overall color and contour of the facial tissue. However, the tissues did remain slightly bluish in color and edematous in the marginal tissue surrounding the crown.

The last publication involved a case report using a variation in the gingival autograft technique to augment unattached and nonkeratinized mucosa around an implant.³⁶ This technique utilized individual strips of palatal tissue in order to minimize patient discomfort from the traditional autogenous palatal FGG. Five implants supporting an overdenture had been in place for approximately 4 years in the maxillary anterior of a 50-year-old healthy Asian woman. She presented with chronic inflammation and pain in the loose, nonkeratinized soft tissues surrounding the implants. This swollen, pinched tissue was a recurrent problem every 2 to 3 months and required denture relief and a soft liner until the inflammation resolved. This technique includes preparation of the recipient site by suturing the elevated flap to the apical border of the prepared site and the harvesting of thin narrow palatal strips approximately 2 mm wide and 0.50 to 0.75 thick leaving intact palatal tissue between the donor strips to facilitate donor site healing. No sutures or dressing is used at the donor area. At the recipient site, dry foil and surgical dressing is used to stabilize the palatal tissue. At one week, superficial sloughing of tissue was observed as well as epithelialization of the wound. The patient experienced minimal discomfort at both donor and recipient sites and there was increased epithelialization in both areas. The patient reported more comfort in the area of the implants after the procedure. The authors suggest that extended areas can be treated since only strips are used, and that at 3 months there is condensing of the healing strips with coronal migration of the mucogingival junction to a width similar to the total width of the donor strips, regardless of the width of the prepared recipient site or the way in which the strips are laid on the periosteal bed.

Allograft and Coronally Advanced Flap

One case report²⁸ described the use of an ADM graft as an alternative to an autogenous FGG to augment the facial soft tissues around a single implant placed at the time of tooth extraction in the esthetic zone approximately 2 years prior to presentation. In this case report, a coronally advanced flap was combined with the ADM to cover an exposed implant restoration. A 41-year-old systemically healthy, nonsmoking female presented with a chief complaint that the implant prosthesis at the maxillary right lateral incisor was esthetically unacceptable due to marginal tissue recession and that the recession had been increasing over time. The clinical examination revealed thin tissues

with 2 mm of pocket depth, 3 mm of facial recession, and 2 mm of keratinized mucosa and an exposed implant shoulder. The authors used a novel incision design (no vertical incisions) where triangular shaped incisions were made mesially and distally, the depth of which was the dimension desired for flap advancement. The coronal aspect was a butt joint and the rest beveled apically. A partial-thickness flap was created so that the flap could be advanced passively over the ADM allograft. The patient was placed on antibiotics for 7 days. Healing in the first few weeks showed scarring and papilla shrinkage. Six months after treatment, partial coverage of the recession occurred with no bleeding on probing and pocket depths less than or equal to 2 mm. There appeared to be some recession of the tissue between the 2- and 6-month recall visits. The implant shoulder was covered, the scarring had disappeared and the shoulder of the implant was no longer visible. The authors felt that the post-treatment facial tissue was thicker than at pretreatment and the patient was satisfied with the result.

Pediculated Connective Tissue Graft (PCTG)

Two publications reported on cases where a pediculated connective tissue graft (PCTG) was used to improve unesthetic implant restorations. One paper described three cases using this technique to treat what appeared to be three different causes for unesthetic restorations in the maxillary anterior.³³ One case involved a 45-year-old female patient who had repeated prior surgeries yet presented with deficient tissue at the gingival margin and interproximal areas of an implant in the site of the right maxillary central incisor. The treatment plan involved removal of the crown and abutment, placement of an internal cover screw, and healing time for new tissues to grow over the implant. After 3 months, a palatal approach was used to uncover the implant and labial pouch was created with a split-thickness dissection. Pediculated connective tissue from the palate was dissected from the area of the first molar toward the central incisor with the length and width scribed to bone. After elevation from the bone, the pedicle with its base just lingual to the site to be augmented was flipped over a 2-mm healing abutment and tucked into the pouch and sutured. The graft extended at least 3 mm past the implant platform into the pouch. An orthodontic appliance was used over the teeth to keep pressure off of the soft tissues. After 4 months a punch technique was used to uncover the healing screw and a 4-mm healing abutment was placed. Three weeks later, a provisional prosthesis was fabricated and used for 2 months, after which a final impression was taken.

A second case involved a 35-year-old female with two apically and labially malpositioned implants that had been placed 2 years prior to presentation for con-

genitally missing lateral incisors. The implants were visible and the marginal gingiva was 4 mm apical to their ideal location. Similar to the first case, the prostheses were removed, and in this case, implant level impressions taken and then internal cover screws used. Two months later, a 2-mm healing abutment was placed and a PCTG tucked into a labial pouch as described above. Four months were allowed for healing and then a punch technique used with an ovate provisional partial denture for an additional 3 months. Provisional prostheses were then placed for 3 months prior to definitive all-ceramic restorations were made.

In the last case an 18-year-old female presented who had lost the maxillary left lateral incisor and canine due to trauma. Two implants were placed with significant apical gingival margins. A connective tissue graft had been performed that augmented the labial tissues but did not provide coronal placement so the gingival levels remained unesthetic. The patient was wearing a removable provisional prosthesis over the implants. The treatment plan involved covering the implant in the position of the lateral incisor and placing a cantilevered partial denture on the implant in the left canine position. A PCTG was utilized as described in the cases above and the final prosthesis utilized an ovate partial denture over the covered implant. In this case, some gingival-covered porcelain was used to enhance the final restoration. The authors felt that using wide, long, and thick PCTGs that vertical soft tissue augmentation can be predictably achieved; however, the depth and thickness of the palate will influence the amount of tissue that can be utilized. A complication of this technique is excessive tissue on the palatal aspect where the tissue was flipped over (a palatal bump) which might need to be carefully thinned. The authors warned that because the tissue is so vascular, prolonged bleeding could occur even with the punch uncovering procedure. Furthermore, deep probing depths may occur around apically placed implants since vertical soft tissues become thick over the implants in some cases. Lastly, the author cautions that the gingival margin in these cases will recede over time in spite of the augmentation procedure and the use of an angulated abutment.

A variation of a pedicle connective tissue graft from the palate has been described in another publication of a single case report.³⁴ A partial-thickness palatal flap is reflected in this technique, exposing the connective tissue over the palatal bone. This denuded palatal tissue is elevated beginning at the apical extent of the palatal flap coronally over the covered implant and then folded or rolled under the full thickness of the facial aspect of the flap, creating a thicker amount of facial tissue. The author states that this technique is limited in that only about 1 mm of thickness is obtained whereas with a subepithelial connective tissue

graft, one generally obtains around 2 mm of augmented tissue. Thus, this de-epithelialized PCTG involving a roll technique is limited to small defects that require small increases in gingival thickness. The advantages claimed are that the papillae are not involved and all scars are located on the palatal side of the tissue and are not visible. Thick palatal rugae make this technique difficult and a subepithelial CTG is recommended in those cases. One case is presented involving a 40-year-old female who dislocated and lost the left lateral incisor and had an implant placed 2 months after this injury. Four months after implant placement, the patient presented with thin tissue and metal showing through the tissue resulting in an unesthetic appearance. The palatal roll technique was performed to increase the thickness of the facial gingiva and hide the metal show-through. Sutures were used to secure the rolled tissue on the labial as well as to secure and align the gingival margins avoiding excessive vertical tension. A temporary or removable prosthesis must be used to relieve pressure on the tissue during healing. After 1 month, a gingivoplasty was performed to create an anatomical sulcus and after gingival healing occurred, the final restoration was fabricated.

Hyaluronic Gel

Papillary deficiencies around dental implant restorations significantly hamper esthetic results of teeth and implant restorations. One study examined a case series of patients who had deficient papillary tissue around dental implants.³⁹ Eleven patients with 14 sites, including seven women and four men ranging in age from 25 to 75 years (average 55.8 years) were injected with a commercially available hyaluronic acid gel (less than 0.2 mL) 2 to 3 mm apical to the coronal tip of the deficient papillae after a short-acting local anesthetic was administered. Informed consent included that this use of the gel was not approved and was considered experimental or off-label. The patients were seen every 3 weeks and the treatment repeated up to three times. Follow-up ranged from 6 to 25 months after initial injection. Standardized photographs were not used and a computerized program measured changes in pixels and the percent change in negative space between the initial and final examination was calculated. The results revealed that two sites had 100% improvement, seven sites had 94% to 97% improvement, three sites had from 76% to 88% improvement and one site had 57% improvement. In regard to multiple injections, eight sites required two injections and six sites required three injections. According to the authors, there was no relapse in the therapy and all patients considered the treatment to be painless with six patients feeling that their treatment resulted in a clinically significant improvement.

DISCUSSION

A systematic review of the PICO question, “in adult patients with soft tissue deficiencies around maxillary anterior implants, what is the effect on esthetic outcomes when a soft tissue procedure is performed?” yielded 1,532 titles that after two independent reviews by two of the authors ended up in 18 reviewable articles. Our extensive literature search has demonstrated that the available knowledge on this topic is based on a very limited literature support and, thus should be addressed with caution. Only one article was randomized and controlled and the rest were either small case series or a case report demonstrating a technique. Furthermore, few of the case reports provided objective outcomes of their results. In most all reports, techniques used around teeth were applied to implant soft tissue dehiscences and to areas of thin soft tissue or minimal amounts of keratinized tissue. It should be pointed out, however, that because the soft tissue relationships around teeth and implants are different, particularly in regards to the soft connective tissue, the outcomes of periodontal procedures may not be applicable to dental implants. In fact, due to the lack of periodontal ligament and transeptal fibers that insert into root cementum, one might speculate that such periodontal procedures might result in less optimal long-term results around dental implants. The findings in the included systematic review articles are noteworthy regarding the fact that the periodontal procedures performed around the implants gave good initial results from the inflammation involved in wound healing, but virtually all cases resulted in some significant recession as healing resolved and the tissues matured.

Most all cases involved autogenous soft tissue grafts, which is not surprising since this tissue is predominantly used in periodontal mucogingival defects. Due to the fact that soft tissue grafting does not always adequately address the esthetic needs around an implant, the logical conclusion is that attempts should be made to prevent an esthetic soft tissue defect from occurring. This can be helped by performing preimplant placement risk analyses and by making certain that adequate bone is present to support the implant, completely encase the endosseous implant, and support the soft tissues, since there is a limit as to how much soft tissue can exist beyond the bone.

Presurgical Planning and Consultation

An important goal in maintaining a long-term esthetic implant result in the anterior maxillae is creating stable hard and soft tissues. Achieving a long-term esthetic result starts with comprehensive team case planning prior to surgical intervention and a restorative-driven

approach.^{47–56} A patient’s presurgical implant evaluation in the esthetic zone should include an initial visit to establish a diagnosis and prognosis based on a comprehensive examination of the patient’s medical, dental, and compliance history, including their periodontal and restorative needs. Diagnostic casts and necessary radiographs may include cone beam computerized tomography (CBCT) to evaluate important anatomical landmarks,^{57,58} skeletal relationships, and bone availability to aid in careful presurgical planning. Skeletal relationships may require an initial orthognathic evaluation with an oral maxillofacial surgeon and orthodontist or an endodontist who may aid in determining a definitive prognosis of the tooth or teeth in question. In addition, in younger patients, the determination of alveolar bone growth cessation is important prior to anterior maxillary implant placement frequently by evaluation of sequential cephalometric radiographs over a 6- to 12-month time frame. The concern is to avoid placing an implant too early in teenagers or young adults who may not have stopped growing, as the alveolar bone will continue to grow adjacent to the implant, leaving an asymmetrical gingival and incisal relationship with an unesthetic result. Intra- and extraoral photographs with documentation of the patient’s smile at rest and full smile is recommended. These pictures aid in the treatment planning of the case and may influence the surgical approach.^{7,9,10,59}

During the presurgical evaluation and consultation, the clinician should also review with the patient their ERA (see Table 1) and establish their overall esthetic risk. This would take into account the patient’s smile line and esthetic demands, and establish a comprehensive site analysis of hard and soft tissue thickness and width along with the patient’s gingival biotype. If a CBCT is taken, evaluation of the buccal plate presence or lack of along with ridge width will aid the surgeon in preplanning the case and assessing the need for soft and/or hard tissue augmentation^{23,60–63} at the time of or prior to implant placement. The CBCT can also guide the surgeon as to the surgical approach to be performed (type 1: immediate placement with extraction, type 2: 6 to 8 weeks postextraction, type 3: 3 months postextraction, type 4: healed ridge).^{23,59–63} The dentist can then determine the need for, and if appropriate, the fabrication of an anatomically correct surgical guide to aid in correct three-dimensional placement.^{7,8,10,56,64} Diligent presurgical planning and thorough local site evaluation with subsequent patient discussions can frequently help to avoid potential esthetic complications postsurgery. Knowledge of hard and soft tissue dimensions of the existing local site to be treated is helpful in the treatment planning process and in planning for long-term esthetic stability.

Considerations for Treatment Options

There are three important considerations which will influence treatment options of the existing local site:

- The bone: is augmentation needed or not?
- The patient's gingival biotype and its importance in treatment planning decisions.
- The soft tissue: is augmentation needed and what are the surgical options and timing if it is necessary?

Importance of Presurgical Buccal Bone Width.

A key determinant of a long-term esthetic implant restoration is the available bone in three dimensions. Without adequate bone, labial recession with vertical bone loss of the buccal plate, loss of the interproximal papillae, and poor implant positioning will result.^{56,64-66} Although this paper addresses soft tissue augmentation procedures, there is also a need to evaluate the existing local site and its hard tissue and alveolar bone, as its width may reflect the need for a soft tissue or hard procedure concomitant with implant placement. Bone availability at an edentulous site for a future implant can be measured via bone sounding and mapping under local anesthesia, palpation, or most accurately, with the evaluation of a CBCT. When placing implants it would be of interest to know the anatomical dimensions and width of the ridge or socket walls if immediate placement is anticipated prior to the procedure. A presurgical CBCT can provide invaluable information on the need for bone grafting and anticipated implant width, length, and need for creating or reducing the anticipated implant site with orthodontic therapy or extrusion for implant site development.^{55,67,68} Based on limited studies and a general consensus, the scientific community seems to agree that ideally a minimum of 2 mm of buccal bone wall (and preferably more than 2 mm) is necessary once the implant osteotomy has been prepared in a healed site to ensure proper soft tissue support and to avoid the resorption of the buccal bone wall following restoration.^{8,64,65,69-71} Spray and coworkers⁷¹ evaluated two-stage implant placement in healed sites and measured facial thickness at time of implant placement and after 3 to 6 months at second stage uncovering using calipers. There was significantly greater bone loss seen as the facial bone thickness decreased. Sites with > 3 mm of bone loss showed the lowest mean facial bone thickness at 1.3 mm. Whereas sites with no change in facial bone response had a mean thickness of 1.8 ± 1.10 mm at implant placement. Thus, a critical thickness to help in clinical decision-making to reduce facial bone loss was determined at 2 mm. If this minimal requirement is not met, then a hard tissue ridge augmentation procedure (before or at implant place-

ment) should be performed to obtain this minimum dimension of 2 mm after anticipated implant placement.⁷²⁻⁷⁶

The loss of a tooth sets in motion a number of biologic phenomena resulting in the horizontal and vertical loss of the buccal and lingual plate. The alveolar process that harbors a tooth is comprised of spongy bone enclosed in an envelope of compact bone. This compact or cortical bone is continuous with the dense bone found at the lateral aspect to the periodontal ligament (PDL) and is referred to as bundle bone. The periodontal ligament provides the blood supply to bundle bone of a tooth when present and can do so for a lifetime without bone loss even in situations of it being less than 1 mm thick.⁷⁷ As buccal bundle bone is part of the periodontium, and thus a tooth-dependent tissue, it develops in conjunction with the eruption of the tooth.⁷⁸ The removal of the tooth will render this bone useless, and its resorption is a natural consequence resulting in buccal and lingual wall resorption and alveolar ridge reduction. This canine study⁷⁸ showed the importance of the alveolar ridge width in bone architecture maintenance. The buccal bone plate is significantly thinner than the lingual plate, with horizontal resorption most likely also causing vertical height reduction of this thinner buccal bone, with minimal loss of the lingual plate. This marked reduction of the buccal-lingual dimension of the alveolar ridge after tooth removal agrees with other studies.⁷⁹⁻⁸³ In the study by Botticelli and coworkers,⁸¹ when measurements were taken 4 months after the removal of single teeth (maxillary and mandibular canines and premolars) with immediate implant placement, the buccal-lingual dimensions of the marginal bone of the edentulous sites was significantly reduced (approximately 2.8 mm or 40%). In a multicenter prospective, randomized controlled parallel-group study⁸³ of 104 patients and 111 sites to evaluate bone preservation, Sanz and coworkers studied implants with differing geometries placed in fresh extraction sites in the maxilla, and found that the corresponding ridge reduction at 4 months was much less at 1.6 mm or about 25%. The discrepancy between studies may be related to the larger number of patient sites treated as well as the larger number of implant surgeons who were involved in this latter study.⁸³ This agrees with immediate placement of an implant in a dog model, which also did not prevent the buccal lingual ridge contractions that were seen following extraction alone.⁸⁴⁻⁸⁷ Interestingly, in the Araujo et al⁸⁴ and Botticelli et al⁸⁵ studies the implants were positioned in the center of the alveolus with the coronal margin of the rough surface flush to the level of the buccal alveolar wall. This aspect of recommended implant positioning will be addressed later.

The socket bone wall dimensions were studied by CBCT in the anterior maxillae of 93 patients⁶⁹ in a prospective randomized controlled multicenter clinical study in relation to immediate (type 1) implant placement. Huynh-Ba and coworkers⁶⁹ found that 87% of the buccal bone walls were thin (≤ 1 mm) and only 3% of the buccal bone walls were thick (2 mm wide). They also noted that the buccal bony wall was significantly thinner than the palatal bony wall. This agrees with other human clinical studies.⁸⁸⁻⁹⁰ The authors⁶⁹ suggest that in most clinical situations encountered, augmentation procedures are necessary to achieve adequate buccal bony contours around the implant if the minimum buccal bone width of 2 mm is valid to maintain buccal bony wall stability over time. In a follow-up multicenter study at 4-month reentry of these same patients, Tomasi and coworkers⁹¹ used multilevel, multivariate models to further analyze factors that may affect tissue alteration occurring at the buccal and palatal aspects of the bony crest during healing after immediate placement of an implant into an extraction socket. The following variables were evaluated: (1) the distance between the implant surface and the outer bony crest (S-OC), (2) the horizontal residual gap (S-IC), (3) the vertical residual gap (R-D), and (4) the vertical position of the bone crest opposite the implant (R-C). Measurements made at surgical reentry 4 months post-implant placement revealed that (1) the S-OC change was significantly affected by the thickness of the bone crest, (2) the size of the residual gap was dependent on the size of the initial gap and the thickness of the bone crest, and (3) the reduction of the buccal vertical gap was dependent on the age of the subject. In addition, the position of the implant opposite the alveolar crest of the buccal ridge and its buccolingual implant position influenced the amount of buccal crest resorption. The authors stressed that as part of the decision-making process, clinicians need to be aware of the buccal bony wall in the extraction site and the vertical as well as the horizontal positioning of the implant in the socket, as these factors will influence hard (and subsequent esthetic soft) tissue changes during healing.⁹¹ Thus the further to the palatal aspect of the socket that the implant is placed, the less implant exposure was seen at the buccal aspect after 4 months. This also correlated well with the apical placement of the implant. This conclusion was valid irrespective of all other influencing factors included in their model (ie, thickness of remaining bony walls, patient age, smoking habit, and reason for extraction). In addition, at sites with thick bony walls (> 1 mm), there was more bone fill than at sites with a thin alveolar crest (≤ 1 mm). Bone fill had the same relationship, as its amount on the buccal as well as on the palatal aspects was similar and dependent on the original thickness of the alveolar crest.

Smoking and age as patient-related factors also negatively influenced bone fill. The vertical gap fill (RD) was smaller in older than younger subjects and S-IC change was smaller in smokers than nonsmokers. Others have also found that smoking negatively affects the healing of periodontal intrabony defects⁹²⁻⁹⁴ and maxillary socket healing postextraction.⁹⁵

In a recent CBCT study, Januario and coworkers⁸⁹ measured the facial bone wall at 1, 3, and 5 mm from the bone crest in the anterior maxillae in 250 patients and found that in most locations in all tooth sites examined was ≤ 1 mm thick and that close to 50% of sites had a bone wall thickness that was ≤ 0.5 mm. In addition, the distance from the cemento-enamel junction (CEJ) and the facial bone crest varied between 1.6 and 3 mm in this study. To achieve a lasting biological and esthetic outcome an ideal buccal bone width of 2 mm is recommended once the osteotomy site is performed. It can be speculated that immediate implant placement with extraction may require even a greater width to account for the dimensional changes seen following tooth extraction.⁶⁹

In a retrospective review of the esthetic outcomes, Evans and Chen⁹⁶ evaluated 42 nonadjacent single-unit implant restorations using an immediate implant surgical placement protocol with a restorative platform of 4.1 (3i implants) or 4.8 mm (Straumann implants). They found a highly significant change in crown margin height due to marginal tissue recession of 0.9 ± 0.78 mm, which was recorded at all sites with no difference seen between implant systems. Implants with a buccal shoulder position showed three times more recession than implants with a lingual shoulder position (1.8 ± 0.83 mm vs 0.6 ± 0.55 mm).

Schropp and coworkers⁸² examined tissue changes that occurred at the mesial and distal septa between the adjacent tooth and the extraction site following single tooth removal and found only minor alterations at these interproximal locations at 12 months of healing. They did find a reduction in residual alveolar ridge up to 50% in width during the first 3 months of healing. Studies have also shown that multiple adjacent extraction sites induce greater apicocoronal alterations compared with single-tooth extractions. Thus as a consequence of removal of all adult teeth, the alveolar processes will atrophy.⁹⁷⁻⁹⁹ Replacing multiple adjacent teeth in the esthetic zone becomes a greater challenge than single-tooth replacement, as the amount of hard and soft tissue requiring replacement to create gingival symmetry of contralateral natural teeth is difficult if not impossible to obtain, especially in a patient with high esthetic demands and a high lip line. The general loss of buccal bone in these multiple extraction cases can therefore have great clinical implications, and attempts should therefore be made to

limit ridge alterations that would occur. Pietrokovski and Massler⁷⁹ noted that this loss amounted to between 3 and 3.5 mm. The results of a recent study by Januario and coworkers⁸⁹ confirmed results seen clinically, that as much as 50% of the facial wall thickness in the maxillary anterior was ≤ 0.5 mm. It may be concluded based on these two studies that once a tooth is lost, not only may the entire marginal buccal bone wall be lost, but an additional 2 mm of the original socket dimension may also disappear during the process of healing. For a review of ridge preservation techniques see three excellent reviews.^{16,20,74}

In another CBCT study, Miyamoto and Obama⁸⁸ measured the thickness of the labial alveolar bone and its corresponding level of vertical resorption in 18 patients in 31 sites who underwent implant placement in the maxillary anterior region, using either a delayed two-stage placement using nonresorbable expanded polytetrafluoroethylene (e-PTFE) guided bone regeneration (GBR) membrane with a mixture of anorganic bovine bone (DBBM) and freeze-dried bone allograft (FDBA) (group 1), delayed placement using a resorbable GBR membrane with the same graft material (group 2), or immediate placement with autogenous bone grafting (group 3). The buccal plate was measured by CBCT at least 6 months later and the relationship between each measurement and gingival recession was analyzed. Group 1 maintained the most sufficient esthetic mucogingival conditions based on minimal gingival recession (less than 0.5 mm) supported by ample alveolar bone (average of 2.22 ± 0.81 mm in the cervical section) with little vertical bone loss (0.13 ± 0.36 mm). Group 2 had 50% of sites showing measurable gingival recession (0.50 ± 0.53 mm) and corresponding vertical bone loss (0.70 ± 1.02 mm) as well as decreased buccal alveolar bone (average 1.15 ± 0.82 mm in the cervical section). The worst result was in Group 3 where gingival recession was 0.85 ± 0.75 mm, vertical bone loss 3.25 ± 4.68 mm, and buccal alveolar bone 1.19 ± 0.60 mm. There was a negative, but significant, correlation between vertical bone loss and cervical width, as well as middle section width and a similar negative correlation between the cervical and middle width with gingival recession. Vertical bone loss and gingival recession showed a significant positive correlation as expected. The data suggest that gingival recession post-implant placement in the anterior region could be negatively associated with alveolar bone thickness as well as the level of alveolar bone width at the labial aspect. The authors postulated that after implant placement in the anterior region, gingival recession was minimal by a labial bone thickness of more than 1.2 mm at the cervical area of the implant at least 6 months after placement as determined by CBCT. If this 1.2 mm is added to the approximate average bone loss

of 0.7 mm¹⁰⁰ that occurs after raising a flap and disrupting the periosteal vasculature, then the criteria of 2.0 mm appears satisfied ($0.7 \text{ mm} + 1.2 \text{ mm} = 1.9 \text{ mm}$).⁸⁸ This study and others suggest clinical caution as immediate implant placement in the esthetic zone is a technique-sensitive, advanced to complex SAC procedure.^{7,8,10,21,23,53,56,63,64,66,96} This study partially agrees with a prospective study on early (type 2) implant placement at 8 weeks postextraction by Buser and coworkers⁶⁰ who with the aid of a bioabsorbable collagen membrane in combination with autogenous bone grafts and DBBM (which has a low substitution rate), were able to provide successful contour augmentation on the facial aspect of implants and soft tissue stability for up to 3 years. The esthetic outcomes as measured by the pink esthetic score (PES) and the white esthetic score (WES) were favorable for 19 of 20 cases treated in this manner with the platform-switching concept in implant design. One case out of the series measured less than 1 mm of facial recession at 3 years. The stability of the facial soft tissues can be attributed in part to stable facial bone with the use of DBBM granules that will not be resorbed during the natural bone-remodeling process, which helps in maintaining the dimensions of the facial bone wall. Sanz and coworkers' systematic review on early implant placement in postextraction sockets found that this surgical protocol may offer advantages in terms of soft and hard tissue preservation, when compared to a delayed placement protocol.²² The type 2 placement protocol is in contrast to various clinical studies using type 1 placement, which is summarized in a recent systematic review by Chen and Buser.¹⁰¹ Lang and coworkers²¹ recent systematic review on immediately placed implants into fresh extraction sockets noted approximately 20% of patients who underwent immediate implant placement and delayed restorations had suboptimal esthetic outcomes due to facial marginal gingival recession in studies of 3 years or more.²¹ These studies on immediate implant placement have documented an alarming high incidence of mucosal recession in the range of 20% to 40%.^{96,101-105} The recent 4th ITI Consensus Conference in 2008 on dental implant therapy and on immediate implants in particular recommended that immediate implant placement should be considered in selected healthy patients with a low esthetic risk profile and performed by master clinicians with adequate clinical experience and expertise.⁷⁵

To further emphasize the advanced to complex SAC classification of implant placement in the anterior maxillae, Kan and coworkers⁶³ evaluated 100 patient CBCTs retrospectively and classified the relationship of the sagittal root positions of the maxillary anterior teeth (600 samples) to their respective osseous housings. They found that 81.1% were class 1 (the root is

positioned against the labial cortical plate), 6.5% were class 2 (the root is centered in the middle of the alveolar housing without engaging either the labial or palatal cortical plates at the apical third of the root), 0.7% were class 3 (the root is positioned against the palatal plate) and 11.7% were class 4 (at least two thirds of the root is engaging both the labial and palatal cortical plates). The authors believe that this information of the sagittal root position will aid in treatment planning of immediate implant placement with immediate provisionalization (IIPP) with improved interdisciplinary communication. The authors consider class 4 sagittal root position (SRP) as a contraindication for IIPP that requires hard and/or soft tissue augmentation prior to implant placement. This study further supports the importance of a local site CBCT and precise assessment and pre-operative planning as an adjunct to implant treatment planning.¹⁰⁶⁻¹⁰⁹ It allows clinicians to appropriately recognize sites that are favorable for IIPP (class 1 SRP) and sites that are more technique sensitive (class 2 and 3 SRP).

Finally, the horizontal gap buccal to the implant is another important factor to consider in addition to implant placement and its affect on bone remodeling. Ferrus and coworkers¹¹⁰ found that in reentry (stage 2 surgery) at 4 months of 93 placed implants at sites between the maxillary premolars where the horizontal gap buccal to the implant was large (> 1 mm) and where the buccal bone width was wide (> 1 mm) the greatest bone fill was noted. This horizontal gap bone fill was more pronounced in the maxillary premolar than the incisor-canine region. However, the degree of bone fill as measured by horizontal defect resolution was more pronounced in smaller defects. Thus larger buccal gaps will not predictably be completely resolved following immediate implant placement. The authors suggest that grafting material may improve treatment outcomes.¹¹⁰ Their findings agreed in most respects with Botticelli and coworkers⁸¹ who also found that the marginal gap could predictably heal with new bone and defect resolution after immediate implant placement in fresh extraction sites.

Importance of the Patient's Gingival Biotype. Gingival biotype is a term used to describe the thickness of the gingiva in a buccolingual dimension. There is a clinical impression that patients who exhibit a thin tissue biotype also have a thin buccal plate overlying the roots of the maxillary anterior teeth.¹¹¹⁻¹¹⁵ De Rouck and coworkers¹¹⁴ also noted two distinct gingival biotypes. In one-third of their patient population and most prominent in women, was the thin gingival biotype classification with a slender tooth form, narrow zone of keratinized tissue, and high gingival scallop. In two-thirds of the study population and seen predominantly in males was a thick gingival biotype with qua-

dratic tooth form, broad zone of keratinized gingiva, and a flat gingival margin.

Cook and coworkers¹¹⁵ looked at CBCTs, diagnostic impressions and clinical examinations in 60 (26 thin biotype, 34 thick/average biotype) patients in the maxillary canine-to-canine area in cases where no gross tooth malposition were present which can affect the soft and hard tissue thicknesses and position to the alveolar crest. Compared to a thick/average biotype, a thin biotype was associated with a thinner labial plate thickness, a narrower width of keratinized tissue, a greater distance from the CEJ to the initial alveolar crest and probe visibility through the sulcus. This study was the first human evidence to support the clinical impression that a thin biotype is associated with a thin underlying labial plate and a greater distance from the CEJ to the alveolar crest, and a thick or average biotype is associated with a thicker labial plate and a reduced distance from the CEJ to the alveolar crest.¹¹⁵ Probe visibility through the gingival sulcus was a good clinical indicator to differentiate a thin from a thick/average biotype and can be used as a simple diagnostic tool by the clinician. Since the esthetic outcome of implant and other periodontal surgical therapies can be influenced by many factors, knowledge of a patient's gingival biotype can be helpful in clinical surgical decision-making, since the majority of patients likely have teeth in which the distance from the CEJ to the alveolar crest is between 2.5 and 3.5 mm (71.4%), with less frequent measurements of < 2.5 mm (9.2%) or > 3.5 mm (19.4%).¹¹⁵ Kan and coworkers¹¹⁶ defined a thin biotype as one where the outline of the periodontal probe can be seen through the marginal tissue when probing, whereas a thick biotype is one where the probe is camouflaged by the marginal tissue. In their 2- to 8-year follow-up¹¹⁷ of the same patient population (mean 4 years), all 35 maxillary anterior Nobel Biocare implants that were immediately restored were successful with the mean overall facial gingival level change of -1.13 mm significantly greater than that of -0.55 mm at the 1-year exam. This would indicate that facial gingival recession is a dynamic process and may continue beyond 1-year post-implant placement. The effect of tissue biotype on peri-implant tissue response was limited to facial gingival recession and not the interproximal papilla, which partially rebounded over time. Sites with a thick tissue biotype showed significantly less facial gingival level change than sites with a thin tissue biotype at both the 1-year post-implant placement (-0.25 mm vs -0.75 mm, respectively) and final examination at a mean of 4 years postplacement (-0.56 mm vs -1.50 mm, respectively). The authors speculated that the lack of bone grafting of any of the implant-socket gaps or connective tissue under the buccal margin for biotype conversion in the

original protocol may have contributed to the significant overall facial marginal gingiva changes seen in that study. In studies where bone and soft tissue grafting were done to eliminate the implant-tooth socket gap, the observed recession was significantly smaller.

Evans and Chen⁹⁶ also noted that the thin tissue biotype has more of a tendency to recede around dental implants. In their study the thin tissue biotype sites showed greater recession than thick biotype sites (mean 1.0 vs 0.7 mm) although the difference was not statistically significant. They also found that recession was seen at both thin and thick biotype sites and only 14.3% of the sites demonstrated no recession. Thus, presenting with a thick tissue biotype does not make one immune to gingival recession postplacement. Sites with thin tissue biotypes had a greater frequency of gingival recession of 1 mm or greater compared with a thick tissue biotype (45.8% vs 33.3%, respectively) with a mean recession of 1.8 ± 0.82 mm (range, 1 to 3 mm) and 1.3 ± 0.52 mm (range, 1 to 2 mm), respectively. The thin tissue biotype should be looked at as having a higher possible propensity for a greater magnitude of recession in the anterior maxilla than the thick tissue biotype, especially if the implant shoulder is in a more buccal position (as the recommended position is lingual in relation to the center of the alveolus). Similar to thin gingival tissues, thin peri-implant tissues appear more susceptible to recession due to thinner tissues being more friable, less vascularized, and thinner than underlying osseous tissue.^{113,115,117} A thicker tissue biotype is important in implant dentistry as the peri-implant tissue is lacking a periodontal ligament (PDL) blood supply which aids in healing around teeth.¹¹³ Evans and Chen⁹⁶ made important points as to variables that are important besides implant position and tissue biotype. These include surgical and restorative techniques and technical skills and patient variables such as the presence and thickness of the buccal plate, soft tissue volume, and thickness. Smoking, compliance, and plaque control also need to be added as potential variables.¹¹⁸⁻¹²⁰

In contrast, a prospective randomized clinical study by van Kesteren and coworkers¹²¹ measured the soft tissue position following immediate and delayed implant placement and found no significant differences in midbuccal and interproximal soft tissue changes regarding thin vs thick tissue biotypes and implant surgical approaches at 6 months. In this study there was no clear-cut definition for tissue biotype, and additionally, the data may have been affected by the buccal gap bone grafting that was completed in the immediate implant group only.

Statements on Bone Availability and Tissue Biotype

When considering implant placement in the anterior maxillae, there are a number of factors that will influence hard tissue and subsequently soft tissue and esthetic changes. Recommendations to help in controlling these factors include:

1. Use of a CBCT for pre-planning and evaluation of buccal plate thickness along with sagittal root position is helpful in establishing an appropriate treatment plan and in guiding proper 3D placement. An anatomically correct surgical guide is recommended when the interdisciplinary team members deem necessary.
2. Thickening thin bone buccal to the implant in an early placement or healed site with a bioabsorbable collagen membrane in combination with autogenous bone and DBBM granules appears to maintain buccal contours and soft tissue margin location in a mid-term study. Clinical experience would recommend at least 2 mm of bone buccal to the implant upon healing. This dimension helps create soft tissue stability long-term.
3. Correct 3D placement with the vertical (1 mm deeper than the buccal wall) and horizontal position (lingual in relation to the center of the alveolus) of the implant in the socket in an immediate placement case and a minimum of 1.5 to 2 mm from an adjacent tooth or 3 mm between dental implants. Implants placed in extraction sockets should have a larger safety margin with the implant shoulder positioned at least 2 mm from the internal buccal socket wall.¹²²
4. Measuring the width of the horizontal gap (horizontal defect dimension [HDD]) in an immediate placement case with consideration for bone grafting at the time of immediate placement to limit bone remodeling of the buccal plate with subsequent significant facial gingival recession.
5. Noting the patient's tissue (gingival) biotype, which is a reflection of the bony profile in the anterior maxillae, since the thin tissue biotype may be more prone to extremes of marginal tissue recession. Since a thick tissue biotype is desirable, the decision to convert a thin tissue to a thick tissue needs surgical consideration through soft tissue grafting for more predictable surgical and prosthetic outcomes.
6. It should be noted that good plaque control and periodontal health should be established prior to any implant surgical procedure, as this would be a major risk factor for future peri-implant disease.

Good compliance to a future periodontal maintenance program along with smoking reduction with a goal of cessation should be addressed pre-surgically with the patient.

Importance of Keratinized Gingiva and Tissue Thickness Around Teeth and Implants

The keratinized gingiva includes the free and the attached gingiva and extends from the gingival margin to the mucogingival junction.¹²³ Lang and Loe¹²⁴ published the first controlled clinical study that examined the relationship between the width of keratinized gingiva and gingival health. They reported that over 80% of tooth sites with at least 2 mm of keratinized gingiva (with at least 1 mm being attached) showed gingival health whereas the sites with less than these parameters had varying amounts of gingival inflammation. The suggested width of 2 mm of keratinized gingiva, with at least 1 mm of it attached, was recommended for maintenance of gingival health around teeth to prevent a movable gingival margin that could help facilitate the entry of bacteria into the gingival crevice, making them difficult to remove by conventional toothbrushing. Kennedy and coworkers¹²⁵ found in their study that when plaque control was not optimum in patients lacking attached gingiva, the chances of gingival recession was seen in 20% of the sites, whereas under similar poor plaque control, attachment loss was not noted in subjects with wide zones of attached gingiva. When clinically acceptable subgingival crown margins are placed in humans in areas with narrow (≤ 2 mm) or wide zones (> 2 mm) higher Gingival Index scores were recorded in the former.¹²⁶ Stetler and Bissada¹²⁶ recommended gingival augmentation in patients scheduled to receive subgingival restorations where narrow zones of keratinized gingiva exist, and who cannot maintain optimal plaque control levels. A number of studies have alternatively concluded that in the absence of inflammation, gingival health can be maintained and unchanged attachment levels can be maintained in areas lacking keratinized and attached gingiva.¹²⁶⁻¹³¹

The necessity of the presence of keratinized mucosa around dental implants, like teeth, continues to be controversial. Clinical studies by Adell and coworkers¹ and Albrektsson and coworkers² indicated that smooth titanium dental implants placed entirely in alveolar mucosa yielded similar survival rates to those placed within keratinized mucosa. Later studies, however, have documented that the peri-implant and periodontal tissues appear to differ in their resistance to bacterial inflammation.¹²³⁻¹³⁴ Supracrestal collagen fibers around implants are oriented in a parallel "cuff" rather than a perpendicular configuration as in the dentoalveolar complex. These features are

independent of the implant being placed in a one- or two-stage procedure.¹³⁵ The peri-implant "cuff" has a weaker mechanical attachment as compared to the periodontal attachment apparatus around natural teeth. This weaker attachment can increase the susceptibility of dental implants to infection.¹³⁶⁻¹³⁸ The need for a zone of keratinized tissue adjacent to dental implants has been suggested since its absence increases the susceptibility of the peri-implant region to plaque-induced tissue destruction in a study using a monkey model.¹³⁹ Lindhe and Berglundh¹⁴⁰ have also noted that the peri-implant mucosa's ability to regenerate itself is limited by its compromised number of fibroblasts, lack of inductive potential of the periodontal ligament, and less vascular supply. A study by Bouri and coworkers¹⁴¹ in both fully and partially edentulous patients found that the mean Gingival Index score, Plaque Index score, and radiographic bone loss were significantly higher for those implants with a narrow zone (< 2 mm) of keratinized mucosa and were more likely to bleed upon probing. The authors concluded that increased width of keratinized mucosa (≥ 2 mm) around implants is associated with lower mean alveolar bone loss and improved indices of soft tissue health. This study supports the view that narrow zones of keratinized gingiva are less resistant to insult along the implant-mucosa interface. When inflammation is present, its apical proliferation may occur more rapidly than wider zones of keratinized gingiva that have an epithelial seal and are more resistant to the forces of mastication and local trauma that may occur during oral hygiene procedures. As in teeth, more keratinized mucosa means more collagen and less elastic fibers in the lamina propria, which gives the tissue more rigidity and tensile/shearing strength, important factors against mechanical insults.

Warrer and coworkers¹³⁹ documented the protective role of keratinized mucosal tissue around implants in a monkey model. It was found that ligated implants without keratinized mucosa demonstrated significantly more recession and slightly more attachment loss than implants with keratinized mucosa. It can be concluded that if an area is lacking keratinized tissue, there is only a weak tissue seal to cope with the local bacterial challenge. In contrast, Chung and coworkers¹⁴² found no correlation between width of keratinized mucosa and alveolar bone loss, but did find an association with higher plaque accumulation and gingival inflammation. Based on animal and human clinical trials, however, it cannot be concluded that all patients are more prone to plaque accumulation and loss of attachment with resulting recession due to lack of keratinized gingiva.¹⁴³ Esposito and coworkers¹⁴⁴ concluded in their systematic review that there was insufficient evidence to recommend augmenting keratinized tissue

around dental implants to maintain health. However, recent clinical studies indicate additional bone^{141,145} or attachment loss¹⁴⁶ was associated with a lack of keratinized gingiva. It does appear that for some patients a lack of keratinized gingiva may be a risk factor for one or more issues: plaque accumulation, tissue soreness while brushing, increased gingival inflammation, recession, bone loss, and esthetics.^{37,143} The recommendation of Greenstein and Cavallaro was that when there is a lack of keratinized gingiva, clinicians need to make a decision about whether to augment the zone of keratinized gingiva at a site for that particular patient based on the literature, the patient's dental history, the unique characteristics for the site being treated, and clinical experience.¹⁴³ The situations where it would be logical to augment keratinized gingiva would be in the following situations according to these authors:

- Chronically inflamed sites, despite oral hygiene instruction and periodontal therapy (sometimes it is necessary to alter the local gingival topography to make oral hygiene easier for the patient)
- Locations with ongoing loss of clinical attachment, recession and bone loss, regardless of periodontal therapy and good oral hygiene by the patient
- Sites where the patient complains of soreness when brushing, despite the appearance of gingival health
- Dental history suggesting predisposition to periodontitis or recession
- Patients noncompliant with periodic professional maintenance
- To improve esthetics

A combination of keratinized and nonkeratinized peri-implant mucosa gives the prosthetic restoration a more natural look.^{37,147} Jung and coworkers¹⁴⁸ studied the color of the peri-implant mucosa in pig maxillae in vitro and found that mucosa thickness is a crucial factor in terms of discoloration and esthetic appearance caused by different restorative materials. They recommend zirconia abutments in patients with thinner mucosa (≤ 2 mm) because it shows the least color change as compared to titanium. In a tissue thickness of 3.0 mm, no change in color could be distinguished by the human eye on any specimen (titanium, titanium veneered with feldspathic ceramic, zirconia, and zirconia veneered with feldspathic ceramic). The authors recommend measuring the thickness of the peri-implant mucosa to decide which abutment material is indicated in a given clinical situation. Furhauser and coworkers¹⁴⁹ evaluated soft tissue esthetics around single-tooth implant crowns and found that the color of the peri-implant mucosa matched in no more than a third of the cases. This would agree with Jung and co-

workers as to consider the thickness of the tissue prior to determining the final abutment material to be used.

Cochran et al¹⁵⁰ has proposed that a minimum of 3 mm of peri-implant mucosa, referred to as the biologic width, is required for a stable epithelial connective tissue attachment to form and serves as a protective mechanism for the underlying bone.¹⁵¹ The establishment of the biologic width around teeth also involves crestal bone loss as was observed in a surgical tooth lengthening study by Oakley and coworkers.¹⁵²

Regarding esthetics in the anterior maxilla, Zigdon and Machtei¹⁴⁶ observed in their retrospective study that the keratinized mucosa thickness and width around dental implants affects both the clinical and the immunological parameters at these sites. A negative correlation was found between mucosal thickness and marginal recession. Likewise, keratinized mucosa width showed a negative correlation with marginal recession, periodontal attachment level, and prostaglandin E2 (PgE2) levels. A wider mucosal band (> 1 mm) was associated with less marginal recession compared with a narrow (≤ 1 mm) band (0.27 and 0.9 mm, respectively). A thick mucosa (≥ 1 mm) was associated with lesser recession compared with a thin (< 1 mm) mucosa (0.45 and 0.9 mm, respectively). Their findings are of special importance in the esthetic zone, where narrow and thin buccal keratinized mucosa may lead to marginal tissue recession and a localized esthetic problem. Linkevicius and coworkers¹⁵³ also found in a 1-year prospective study in humans that the initial gingival thickness at the alveolar crest might be considered a significant influence on marginal bone stability around implants. If the tissue thickness is 2.5 mm or less, crestal bone loss up to 1.45 mm may occur within the first year of function, despite a supra-crestal position of the implant-abutment interface. The authors further recommended that the measurement of gingival thickness should be mandatory in any evaluation of marginal bone loss. They also recommend considering the thickening of thin mucosa before implant placement, in essence converting a thin tissue biotype into a thicker one. The results of the Linkevicius study are consistent with an animal study by Berglundh and coworkers¹⁵⁴ that reported the potential of thin tissues to cause crestal bone loss during the process of biologic width formation. When tissues were thinned at second stage surgery (to 2 mm in thickness), a minimum dimension of the biologic width was not satisfied and bone resorption occurred to allow a sufficient soft tissue attachment to form. The stability of crestal bone remains controversial. Moreover, the influence of mucosal thickness on crestal bone around implants has been discussed only recently and has received little attention in comparison to other factors.^{153,155,156} In the Berglundh and Lindhe¹⁵⁷ animal study, they reported

that thin tissues could provoke crestal bone loss during reformation of the biologic width, which creates the peri-implant seal.

Interestingly, Anderegg and coworkers¹⁵⁸ found, in the treatment of facial furcation defects using the principles of guided tissue regeneration (GTR) and an ePTFE membrane, a significant difference at 6 months postoperatively in recession between thin tissues (≤ 1 mm: recession 2.1 mm) vs thick tissues (> 1 mm: recession 0.6 mm). Gingival tissue thickness was therefore noted to be an important factor to consider if postoperative recession is to be minimized or avoided in the treatment of GTR cases with ePTFE membranes. The authors further noted that the similarity of this GTR technique to placing a soft tissue graft over an avascular root surface where the failure of thin (≤ 1 mm) free gingival autografts to successfully cover wide recession areas is seen compared with thick autografts (1.5 mm to 2 mm). The thicker the connective tissue, the more intact capillary system is seen than thinner tissues¹⁵⁹ and the greater the chance for flap survival. Baldi and coworkers¹⁶⁰ similarly found flap thickness being significantly associated with the percentage of root coverage in shallow gingival recession defects in humans using the coronally advanced flap technique. They found a flap thickness of > 0.8 mm was associated with 100% root coverage, while < 0.8 -mm-thick flaps never achieved complete root coverage. The tissue biotype appears to be an important factor in many periodontal plastic surgical procedures including implant placement in the anterior maxillary region. Surgically changing a thin to a thick biotype appears to be important in success of these periodontal plastic surgical procedures.

Statements on Need for Keratinized Mucosa and Mucosal Thickness around Implants

Evaluation of the site needs to be analyzed on a case-by-case basis for soft tissue augmentation.

The biologic width appears to be critical in its formation around teeth as well as implants. It will form via crestal bone loss when it does not fulfill its appropriate dimensions of 3 mm.

Consideration for thickening tissues either prior to or at the time of implant placement would be recommended when they are thin, especially in the esthetic zone as thick tissues appear to reduce or prevent marginal tissue recession.

Consideration as to the abutment material to be used in the esthetic zone should be made by the tissue thickness and the patient's esthetic demands on a case-by-case basis. When tissue is thinner in an esthetically demanding patient, the use of zirconia is recommended.

Soft Tissue Augmentation

Surgical Options and Timing. Periodontal plastic surgery has its origins in mucogingival surgery and addresses soft tissue defects that require functional and esthetics results for the patient. Mucogingival surgery as described by Friedman¹⁶¹ addressed only three clinical problems and their treatment: a shallow vestibule, an aberrant frenum, and problems associated with lack of attached gingiva. Periodontal plastic surgery today is much broader in scope in therapies and is considered one aspect of regenerative periodontal surgery.¹⁶² It not only addresses the original mucogingival concerns but also addresses the treatment of the following defects according to Miller and Allen¹⁶² that include:

1. Marginal gingival recession with soft tissue grafting for coverage of denuded root surfaces.
2. Excessive gingival display and treatment of the "gummy smile" which requires crown lengthening through soft and, frequently, hard tissue removal. This procedure is frequently timed prior to or at the same visit of implant placement in patients so as to provide an esthetic symmetrical gingival margin with normal tooth lengths at a normal location in relation to the patient's smile. This form of periodontal plastic surgery is considered excisional or subtractive.
3. Treatment of deficient ridges requiring ridge augmentation to allow for an esthetic final result of either a partial prosthesis or prior to or simultaneously with implant placement.
4. Loss of interdental papillae and soft tissue reconstruction.
5. Surgical exposure of unerupted teeth prior to orthodontic tooth movement.
6. Esthetic defects surrounding dental implants requiring frequently both hard and soft tissue reconstruction.

Soft Tissue Grafting. Epithelized palatal grafts for root coverage were introduced by Miller¹⁶³ and Holbrook and Ochslein¹⁶⁴ to provide not only a functional result of increasing the zones of attached keratinized gingiva but also to gain coverage of exposed root surfaces. However, the color match of the tissues is often less than esthetic, as the palatal tissue tends to be lighter and more opaque than the adjacent gingiva.

Subepithelial connective tissue grafts (SECTG) as described by Langer and Langer¹⁶⁵ result generally in a better color match and do not require removal of the frenum. Both the epithelized grafts and SECTG require adequate donor tissue, which may be an issue in large multiple tooth defects or in patients who are hesitant in having a second surgical site. These concerns have

been addressed with the use of acellular dermal matrix (ADM)^{31,166-169} for the treatment of recession and keratinized mucosal defects along with a porcine collagen matrix (Mucograft)¹⁷⁰⁻¹⁷⁵ and tissue-engineered bilayered cell therapy.^{176,177}

Soft Tissue Augmentation of the Healed Ridge

Studer and coworkers¹⁷⁸ described a localized defect in the alveolar crest as one involving a limited deficit in the volume of bone and soft tissues within the alveolar process. These deficits are frequently found in partially edentulous patients resulting from many causes including traumatic tooth extractions, extractions in the presence of extensive periodontal bone loss or periapical pathology, developmental disorders or removal of tumors.¹⁷⁹ Abrams and coworkers¹⁸⁰ studied the prevalence of anterior ridge deformities in partially edentulous patients and reported the presence of defects in 91% of the cases studied. The anatomical configuration of the ridge defect often determines the selection and sequence of treatment. Seibert^{181,182} categorized ridge defects in three general categories:

1. Class 1: Buccolingual loss of tissue with normal ridge height in an apicocoronal dimension.
2. Class 2: Apicocoronal loss of tissue with normal ridge width in a buccolingual dimension.
3. Class 3: Combined buccolingual and apicocoronal loss of tissue resulting in loss of normal ridge height and ridge width.

Class 1 defects can frequently be treated in a single procedure but class 2 and class 3 defects may require second and third procedures to accomplish the goal of ridge reconstruction with a minimum of two months between procedures. When the prevalence of these defects was evaluated in a partially edentulous population the most prevalent were class 3 defects (55.8%), followed by class 1, (32.8%), and with class 2 defects (2.9%) being the least detected clinically.¹⁸⁰

Various soft tissue procedures have been proposed for ridge augmentation using soft tissues:

The "roll" technique as described by Abrams and coworkers¹⁸⁰ was an original soft tissue augmentation procedure to correct a class 1 or an early class 2 ridge defect. It involves dissecting a de-epithelialized palatal flap and creating a pedicle toward the vestibular aspect. This connective tissue pedicle is then rolled below the vestibular flap in the area of the ridge thus gaining volume of tissue to the buccal aspect of the deficient ridge. The advantage is a good color match of the surrounding tissues involving a single surgical site; however, the disadvantage is the inability to treat larger defects because of the lack of donor tissue availability.

The use of a palatal subepithelial connective tissue graft implanted into a pouch or tunnel prepared in the mucosa that lines the defect was described by Langer and Calagna¹⁸³ and modified by Garber and Rosenberg.¹⁸⁴ This procedure may require multiple surgical procedures to treat large defects of the class 2 and 3 varieties.

Full-thickness free gingival or onlay grafts using the palate as the donor site as described by Seibert^{181,182} and Seibert and Salama.¹⁸⁵ The Seibert "onlay" graft technique was described to treat the clinical challenges of both the class 2 and class 3 ridge defects originally for fixed partial denture sites as it is effective in gaining significant tissue volume in three dimensions. The disadvantages of this technique are the need for two surgical sites, potential partial sloughing of the graft due to lack of blood supply, a poor color match to the surrounding tissues, and the possibility of needing multiple surgical procedures thus adding to patient morbidity. Seibert modified the onlay graft with the interpositional (wedge and inlay) graft¹⁸⁶ where a pouch is created but not closed and a pie-shaped free gingival graft is removed from the palate or tuberosity area and inserted like a wedge into the opening of the pouch. This elevates the labial surface of the pouch to eliminate the ridge concavity. The epithelized surface of the wedge is positioned at the level of the surrounding epithelial surfaces and sutured to the surrounding tissues. The percentage of "take" is improved over the onlay graft procedure as more of the surface area of the grafted tissue receives a flow of plasma and ingrowth of capillaries from the connective tissue surrounding it.¹⁸⁵ Since these prior mentioned procedures were developed for crown and partial denture site development there have been many periodontal plastic surgical procedures developed specifically for implant therapy with the procedure to be used being based on different time points for soft tissue augmentation in the maxillary anterior sextant: soft tissue augmentation prior to implant placement, soft tissue augmentation at the time of implant placement, and soft tissue augmentation postimplant placement.¹⁸⁷

Soft Tissue Augmentation Prior to Implant Placement. In cases of thin tissue biotypes or at the time of extraction and socket preservation, considerations need to be made as to the value or benefit of adding keratinized tissue to augment the future implant site in the maxillary anterior. Based on the biologic width around dental implants, a minimum 3 mm width with a minimum 2 mm thickness of keratinized gingiva is recommended. Surgical procedures to be used prior to implant placement should include using tissues or products that blend well with the surrounding host tissues locally as well as adding the necessary tissue thickness.

The main goals when treating the extraction socket in the esthetic zone is to preserve as much soft and

hard tissue volume as possible existing for future implant placement.¹⁸⁷ Landsberg and Bichacho¹⁸⁸ described a modified ridge preservation technique called “socket seal surgery” where flap elevation is not performed and it combines both bone and soft tissue grafting and is performed prior to implant placement. The authors noted the benefits of closing the extraction site from the oral environment without changing the vestibular depth, enabling optimal preservation of the ridge topography immediately after tooth extraction. The thick epithelized palatal graft containing part of the submucosa can also act as a membrane over a bone graft for socket/ridge preservation.

Jung and coworkers¹⁸⁹ in a prospective study evaluated the short-term healing of this approach in 20 humans in the maxillary and mandibular anterior sextants. They used a biopsy tissue punch technique with a diameter corresponding to the socket orifice with a tissue thickness of 2 to 3 mm in conjunction with DBBM (BioOss Collagen, Geistlich). The authors stressed the importance of meticulous close adaptation of the grafts to the soft tissue wound margins with 6 to 10 single interrupted microsurgical sutures. The primary intention in this study for the placement of the DBBM particles was not to enhance bone formation, but to support the buccal contour of the alveolar ridge and stabilize the blood clot. The authors found that the tissue integrated at 3 weeks at 92.3% of the graft surface and 99.7% at 6 weeks with 0.3% of the surface in four grafts showing incomplete wound closure with no fibrin or graft necrosis present. Using a colorimeter comparison of the graft and the adjacent tissues they found excellent color matching of the grafted and host tissues that could not be detected clinically. The authors concluded that using this approach showed high predictability and reliability for a good esthetic result for future type 2 or type 3 implant placement. Studies have documented that the survival rate of the grafted tissue depends on both the nourishment from the organizing blood clot beneath the graft^{45,190,191} and its close contact to the host’s marginal soft tissues.¹⁸¹ The advantages of using an epithelized FGG over a connective tissue graft is two-fold: the rigidity of the epithelium increases its stability and ease to suture to the surrounding gingival margin preventing tissue collapse and necrosis and secondly, the use of the FGG avoids tissue flap elevation and additional buccal wall resorption which is well documented in animal studies.^{78,192}

Stimmelmayer and coworkers¹⁹³ described a technique for reliable wound closing using a combined epithelized-subepithelial CTG that leaves the mucogingival line in place while supporting the papillae of the neighboring teeth, and has an added advantage of thickening the buccal soft tissue with the resultant local conversion of a thin marginal gingiva biotype to

a thick marginal gingiva biotype. In contrast to Jung and coworkers’ punch technique, the authors’ primary concern with using the FGG to cover extraction sockets is the high failure rate as noted also by Landsberg and Bichacho,¹⁸⁸ because their blood supply relies on the gingival wall of the socket and the subjacent clot. The FGG/socket seal technique also does not thicken the facial soft tissue. Stimmelmayer and coworkers¹⁹³ developed the technique based on the onlay-interpositional graft described by Seibert and Louis¹⁸⁶ for closing extraction sockets. They reported predictable results over the onlay-type grafts due to the improved blood supply by the two inlay components. In their retrospective study of 58 cases, only one patient experienced a soft tissue dehiscence and secondary wound healing.

Other techniques described by Becker and Becker¹⁹⁴ involved coronally advanced flaps for primary closure over extraction sites and ePTFE membranes, which coronally shifts the mucogingival junction and can result in an esthetic deformity in high esthetic areas such as the anterior maxillae. Similarly, the use of rotated palatal connective tissue flaps^{195,196} have the disadvantage of also repositioning the buccal mucogingival line coronally to gain coverage of the rotated flap. The advantage is the two-layer coverage of the augmented site with the palatal pedicle connective graft and its overlying coronally positioned flap. This ensures a good blood supply, as the pedicle flap remains vascularized, as does the coronally positioned buccal flap unlike a FGG. This would aid the undisturbed healing of the grafted socket ensuring complete closure of the GBR site during the healing phase.¹⁹⁵ Another disadvantage of the flap techniques is the extensive flap manipulation needed to gain closure which can result in additional volume shrinkage due to surgical trauma and loss of the fragile buccal plate of bone.^{78,197} Techniques that can minimize or avoid raising a buccal flap may be more suitable from a healing standpoint reducing the risk of soft and hard tissue shrinkage.¹⁸⁷

Statements on Soft Tissue Augmentation Prior to Implant Placement

1. Evaluation of the site needs to be analyzed on a case-by-case basis for soft tissue augmentation.
2. Consideration for soft tissue augmentation would be based on the quantity and quality of the keratinized gingiva present, which may be reflected as a thin or thick gingival biotype. A minimum of 3 mm of keratinized gingiva in the esthetic zone is recommended to allow for the biologic width to reform with a minimal gingival thickness of 2 mm.
3. The main goals when treating the extraction socket in the esthetic zone is to preserve as much as pos-

sible existing soft and hard tissue volume. To effectively limit the loss of the thin friable buccal plate, the avoidance of a buccal gingival flap is recommended for socket preservation procedures. The use of a palatal epithelized free gingival graft as a "socket seal" which is sutured meticulously with microsurgical sutures for tight adaptation of the FGG to the marginal soft tissue walls of the socket has documented success in achieving these goals.

Soft Tissue Augmentation at the Time of Implant Placement

Kan and coworkers¹⁹⁸ stated that the success of the concept of immediate implant placement and provisionalization (IIP) is influenced by a number of factors defined as extrinsic or intrinsic. Extrinsic factors include proper three-dimensional implant positioning and properly contoured provisional restoration.^{7,8,64,117,199} In contrast, intrinsic factors are patient dependent and, therefore can be favorable or unfavorable. They include bone level, soft and hard tissue relationship, buccal bone thickness, and gingival biotype. To achieve an esthetic outcome the conversion of unfavorable traits to favorable traits is vital to achieving an esthetic outcome.²⁰⁰ Kan and coworkers¹¹⁷ in a follow-up paper of their original study with 1-year data reported significant buccal recession in IIP cases, especially those with a thin gingival tissue biotype. However, in their study of 20 patients and 20 sites in the maxillary anterior they did not address the patient's intrinsic factors such as bone thickness (no bone grafting of the buccal gap was done) or biotype conversion with the use of connective tissue grafts. They found that recession was a dynamic process and continued from 1 year onward and by the final examination on average had doubled from -0.5 to -1.00 mm.

In terms of immediate tooth replacement, buccal recession is a common occurrence in these cases^{201,202} especially in the thin gingival biotype when these intrinsic, patient dependent factors are not addressed. In contrast, maintenance of interproximal papillae heights is more predictable in periodontally healthy patients due to predictable tissue rebound over time, which can be anticipated by the interproximal heights of bone on the adjacent tooth surfaces.²⁰³⁻²⁰⁵ Complete papilla fill has been observed when the distance from the contact point to the bone crest was < 5 mm.

Recent clinical studies have reported on the use of connective tissue grafts at implant placement and at immediate tooth replacement for biotype conversion.^{206,207} The study of the subepithelial connective tissue grafting (SCTG) technique in conjunction with bone grafting the implant-socket gap with IIP in the esthetic zone has been recently evaluated in a number of case studies. Redemagni and coworkers²⁰⁸

in a retrospective study evaluated the dimensional alterations after immediate implants and immediate screw-retained restorations in 28 patients using Dentsply 33XIVE implants with a mean follow-up of 20.4 months. A buccal detachment of the gingiva was completed creating an envelope and a palatal connective tissue graft was inserted and the implant-socket gap was grafted with Bio-Oss collagen. They found buccal soft tissue stability with an average of 0.0 mm (range of -0.5 to 1.0 mm).

Chung and coworkers²⁰⁹ evaluated the facial gingival stability following immediate cemented restoration, SCTG (full thickness pouch created to accept the SCTG) with Bio-Oss grafting in the implant-socket gap of 10 patients using Biomet 3i implants with a platform shift between the abutment and the implant. At 12 months, 9 out of 10 implants remained osseointegrated with a mean facial gingival soft tissue change of -0.05 mm, mean marginal bone loss of -0.31, and more than 50% papillae fill in 89% of all sites. The authors concluded that SCTG in conjunction with IIP in the esthetic zone may be beneficial in minimizing facial gingival tissue recession when proper 3-dimensional implant position is achieved and bone graft is placed in the implant-socket gap. Similar results were observed at 1 year in another study of 10 patients by Tsuda and coworkers²¹⁰ using OsseoSpeed (Astra Tech) implants with a platform switch concept, SCTG, bone grafting, and immediate cemented restoration in the esthetic zone. All implants remained osseointegrated, with an overall mean marginal bone level change of 0.10, mean facial gingival level change of -0.05 mm, and more than 50% papilla fill in 80% of all sites.

Cosyn and colleagues²⁷ evaluated immediate screw-retained restorations in 22 patients who presented with thick gingival biotypes (thin biotype patients were excluded). NobelActive implants were used with the platform switch concept and all implant-socket gaps were grafted with Bio-Oss. At 3 months, five cases demonstrated major alveolar process remodeling and were grafted with a SCTG using the pouch technique while two cases showed advanced midfacial gingival recession and were also grafted with a SCTG. Thus a total of seven cases were grafted at 3 months due to esthetic complications. At 6 months, final impressions were taken with final examination completed at 1 year. One implant failed during the study. The authors found similar pink esthetic scores post-treatment (PES 11.86) as they were pre-surgery (PES 12.15). The authors concluded that preservation of pink esthetics is possible following immediate tooth replacement. However, to achieve that, a SCTG is necessary in about one-third of the patients (who presented with a thick gingival biotype).

Kan and coworkers²⁰¹ evaluated the facial gingival tissue stability after IIP and SCTG in the esthetic zone

in 20 consecutive patients (8 thick and 12 thin gingival biotypes) using NobelReplace Tapered Groovy or NobelPerfect Groovy implants and an immediate cemented restoration and grafting of the implant-socket gap with Bio-Oss. The authors noted that at 2.15 years mean follow-up, all implants were functioning and all exhibited a thick gingival biotype. No differences were seen between the initial thick vs thin biotypes in regards to mean marginal bone loss or mean facial soft tissue recession. At the last examination a mean of 0.13 mm facial gingival level was recorded. Over 50% of papilla fill was noted at all sites with $\geq 80\%$ having a 100% papillae fill. The authors concluded that regardless of the initial gingival biotype, the thin gingival biotype can be converted to a thick gingival biotype morphologically and behaviorally with this procedure and, at least in the short term, biotype conversion by increasing quality and quantity of the facial gingival tissue with SCTG might be beneficial for facial gingival stability after an immediate tooth replacement procedure. The authors further stress that careful patient selection and treatment planning, as well as immaculate execution by skillful clinicians, are required to achieve successful results.

Based on the above studies noted, all IIP procedures in the esthetic zone are a complex SAC procedure with the suggested clinical usage of the ERA tool (see Table 1) to aid in treatment planning with the patient.

Statements on Soft Tissue Augmentation at the Time of Implant Placement Using a CTG

Consideration needs to be made on a case-by-case, site-by-site basis using the ERA as a guide as to the need to augment at the time of implant placement with soft and/or hard tissue.

Recent case studies have shown that with IIP there is a benefit in augmenting both the buccal gap and using a CTG to thicken the buccal tissue for biotype conversion to one that is less susceptible to future gingival recession and esthetic deformity. The literature that has been presented in this paper has shown that unpredictable esthetic results are common in the treatment of a dental implant for facial gingival recession.

Immediate implant placement in the esthetic zone is a complex SAC procedure requiring immaculate execution by skillful clinicians as a prerequisite to attempting this procedure.

CONCLUSIONS

The need for soft tissue augmentation procedures around dental implants in the anterior maxillae remains a controversial and unpredictable topic. Although success of implant therapy is similar in the

anterior maxilla and other areas of the mouth, the majority of studies evaluating this therapy in the esthetic zone are lacking literature support, few in number, devoid of long-term follow-up and number of patients, and are subject to inclusion bias and thus should be addressed with caution. Patient-dependent factors are usually not addressed, as a biologic success frequently does not equal an esthetic success to the patient. The use of the ERA tool for all esthetic zone cases can benefit both the clinician and the patient by addressing objective criteria and modifying factors that can affect the final esthetic outcome prior to treatment to avoid any miscommunication and problems of expectation upon completion. All the available knowledge on this topic including the approaches described in this paper is based on very limited literature support and, thus, should be addressed with caution. These concerns should encourage long-term good clinical trials for better assessment of those issues.

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REFERENCES

1. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg* 1981;10:387–416.
2. Albrektsson T, Zarb G, Worthington P, Eriksson A. The long-term efficacy of currently used dental implants: A review and proposed criteria for success. *Int J Oral Maxillofac Implants* 1986;1:11–25.
3. Buser D, Weber HP, Bragger U, Balsiger C. Tissue integration of one-stage ITI implants. 3 year results of a longitudinal study with hollow cylinder and hollow screw implants. *Int J Oral Maxillofac Implants* 1991;6:405–412.
4. Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Different times for loading dental implants. *Cochran Database Syst Rev* 2009a;(1):CD003878.
5. Esposito M, Grusovin MG, Chew YS, Coulthard P, Worthington HV. Interventions for replacing missing teeth: 1-versus 2-stage implant placement. *Cochran Database Syst Rev* 2009b;(3):CD006698.
6. Dawson A, Chen S. *The SAC Classification in Implant Dentistry*. Berlin: Quintessence, 2009.
7. Levine R, Martin W. *Esthetic Risk Assessment in Implant Dentistry*. *Inside Dentistry* 2012;8:66–71.
8. Buser D, Martin W, Belsler UC. Optimizing esthetics for implant restoration in the anterior maxilla: Anatomic and surgical considerations. *Int J Oral Maxillofac Implants* 2004;19(suppl):43–61.
9. Martin W, Morton C, Buser D. Pre-operative analysis and prosthetic treatment planning in esthetic implant dentistry. In: Buser D, Belsler U, Wismeijer D (eds). *ITI Treatment Guide 1: Implant Therapy in the Esthetic Zone: Single Tooth Replacements*. New Malden, Surrey, UK: Publishing Co Ltd; 2007;1:9–24.
10. Levine RA, Nack G. Team treatment planning for the replacement of esthetic zone teeth with dental implants. *Compend Contin Educ Dent* 2011;32:44–50.
11. Roccuzzo M, Bunino M, Needleman I, Sanz M. Periodontal plastic surgery for treatment of localized gingival recessions: A systematic review. *J Clin Periodontol* 2002;29(suppl 3):178–194; discussion 175–176.

12. De Rouck T, Collys K, Cosyn J. Single tooth replacement in the anterior maxillae by means of immediate implantation and provisionalization: A review. *Int J Oral Maxillofac Implants* 2008;23:897–904.
13. Cairo F, Pagliaro U, Nieri M. Treatment of gingival recession w/CAF procedure: A systematic review. *J Clin Periodontol* 2008;35(suppl 8):136–162.
14. Teughels W, Merheb J, Quirynen M. Critical horizontal dimensions of interproximal and buccal bone around implants for optimal aesthetic outcomes: A systematic review. *Clin Oral Implants Res* 2009;20(suppl 4):134–145.
15. Glauser R, Zembic A, Hammerle CH. A systematic review of marginal soft tissue at implants subjected to immediate loading or immediate restoration. *Clin Oral Implants Res* 2006;17(suppl 2):82–92.
16. Vignoletti F, Matesanz P, Rodrigo D, Figuero E, Martin C, Sanz M. Surgical protocols for ridge preservation after tooth extraction. A systematic review. *Clin Oral Implants Res* 2012;23(suppl 5):22–38.
17. den Hartog L, Slater JJ, Vissink A, Meijer HJ, Raghoobar GM. Treatment outcome of immediate, early & 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.
18. Atieh MA, Ibrahim HM, Atieh AH. Platform switching for marginal bone preservation around dental implants: A systematic review and meta-analysis. *J Periodontol* 2010;81:1350–1366.
19. Hwang D, Wang H-L. Flap thickness as a predictor of root coverage: A systematic review *J Periodontol* 2006;77:1625–1634.
20. Tan WL, Wong TLT, Wong MCM, Lang NP. A systematic review of post-extraction alveolar hard and soft tissue dimensional changes in humans. *Clin Oral Implants Res* 2012;23(suppl 5):1–21.
21. Lang NP, Pun L, Lau KY, Li KY, Wong MCM. A systematic review on survival and success rates of implants placed immediately into fresh extraction sockets after at least 1 year. *Clin Oral Implants Res* 2012;23(suppl 5):39–66.
22. Sanz I, Garcia-Gargallo M, Herrera D, Martin C, Fiuero E, Sanz M. Surgical protocols for early implant placement in post-extraction sockets: A systematic review. *Clin Oral Implants Res* 2012;23(suppl 5):67–79.
23. Hämmerle CH, Chen ST, Wilson TG Jr. Consensus statement and recommended clinical procedures regarding the placement of implants in extraction sockets. *Int J Oral Maxillofac Implants* 2004;19(suppl):26–28.
24. Basegmez C, Ersanli S, Demirel K, Bolukbasi N, Yalcin S. The comparison of two techniques to increase the amount of peri-implant attached mucosa: Free gingival grafts versus vestibuloplasty. One-year results from a randomized controlled trial. *Eur J Oral Implantol* 2012;5:139–145.
25. Hsu Y-T, Shieh C-H, Wang H-L. Using soft tissue graft to prevent mid-facial mucosal recession following immediate implant placement. *J Int Acad Periodontol* 2012;14:76–82.
26. Hidaka T, Ueno D. Mucosal dehiscence coverage for dental implant using sprit pouch technique: A two-stage approach. *J Periodontal Implant Sci* 2012;42:105–109.
27. Cosyn J, DeBruyn H, Cleymaet R. Soft tissue preservation and pink aesthetics around single immediate implant restorations: A 1-year prospective study. *Clin Implant Dent Relat Res* 2013;15:847–857.
28. Mareque-Bueno S. A novel surgical procedure for coronally repositioning of the buccal implant mucosa using acellular dermal matrix: A case report. *J Periodontol* 2011;82:151–156.
29. Lai Y-L, Chen H-L, Chang L-Y, Lee S-Y. Resubmergence technique for the management of soft tissue recession around an implant: Case report. *Int J Oral Maxillofac Implants* 2010;25:201–204.
30. Shibli J, d'Avila S. Restoration of the soft-tissue margin in single-tooth implant in the anterior maxilla. *J Oral Implantol* 2006;32:286–290.
31. Yan J-J, Tsai A, Wong M-Y, Hou L-T. Comparison of acellular dermal graft and palatal autograft in the reconstruction of keratinized gingiva around dental implants: A case report. *Int J Periodontics Restorative Dent* 2006;26:287–292.
32. Shibli J, d'Avila S, Marcantonio E Jr. Connective tissue graft to correct peri-implant soft tissue margin: A clinical report. *J Prosthet Dent* 2004;91:119–122.
33. Matthews D. The pediculated connective tissue graft: A technique for improving unaesthetic implant restorations. *Pract Proced Aesthet Dent* 2002;14:719–724.
34. Block M. De-epithelialized connective tissue pedicle graft. *Atlas Oral Maxillofac Surg Clin North Am* 1999;7:109–116.
35. Price R, Price D. Esthetic restoration of a single-tooth dental implant using a subepithelial connective tissue graft: A case report with 3-year follow-up. *Int J Periodontics Restorative Dent* 1999;19:93–101.
36. Han T, Klokkevold P, Takei H. Strip gingival autograft used to correct mucogingival problems around implants. *Int J Periodontics Restorative Dent* 1995;15:405–411.
37. Alpert A. A rationale for attached gingiva at the soft-tissue/implant interface: Esthetic and functional dictates. *Compend Contin Educ Dent* 1994;15:356–366.
38. Silverstein L, Lefkove M. The use of the subepithelial connective tissue graft to enhance both the aesthetics and periodontal contours surrounding dental implants. *J Oral Implantol* 1994;20:135–138.
39. Becker W, Gabitov I, Stepanov M, Kois J, Smidt A, Becker B. Minimally invasive treatment for papillae deficiencies in the esthetic zone: A pilot study. *Clin Implant Dent Relat Res* 2010;12:1–8.
40. Burkhardt R, Joss A, Lang NP. Soft tissue dehiscence coverage around endosseous implants: A prospective cohort study. *Clin Oral Implants Res* 2008;19:451–457.
41. Zucchelli G, Mazzotti C, Mounssif I, Mele M, Stefanini M, Montebugnoli L. A novel surgical-prosthetic approach for soft tissue dehiscence coverage around single implant. *Clin Oral Implants Res* 2013;24:957–962.
42. Huzeler M, Weng D. A single incision technique to harvest subepithelial connective tissue from the palate. *Int J Periodontics Restorative Dent* 1999;19:279–287.
43. Lorenzana ER, Allen EP. The single-incision palatal harvest technique: A strategy for esthetics and patient comfort. *Int J Periodontics Restorative Dent* 2000;20:297–305.
44. Bjorn H. Free transplantation of gingiva propria. *Sveriges Tandlak T* 1963;22:684.
45. Sullivan H, Atkins J. Free autogenous gingival grafts. I. Principles of successful grafting. *Periodontics* 1968;6:121–129.
46. Edlan A, Mejchar B. Plastic surgery of the vestibulum in periodontal therapy. *Int Dent J* 1963;13:539–597.
47. Saadoun AP. The making of beautiful smiles in perio-implantology. In: *Implant Site Development*. First Edition. Sonick M, Hwang D, Saadoun A (eds). Chichester, United Kingdom: Wiley-Blackwell: 2012, 75–100.
48. Belsler 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.
49. Morton D, Martin WC, Ruskin JD. Single-stage Straumann dental implants in the aesthetic zone: Considerations and treatment procedures. *Int J Oral Maxillofac Implants* 2004; 62:57–66.
50. Kois JC. Predictable single tooth peri-implant esthetics: Five diagnostic keys. *Compend Contin Educ Dent* 2001;22:199–206.
51. Garber DA, Belsler UC. Restoration-driven implant placement with restoration-generated site development. *Compend Contin Educ Dent* 1995;16:786–804.
52. Saadoun A, Legall M. Periodontal implications in implant treatment planning for aesthetic results. *Pract Periodontics Aesthet Dent* 1998; 10:655–664.
53. Belsler UC, Buser D, Hess D, Schmid B, Bernard JP, Lang NP. Aesthetic implant restorations in partially edentulous patients—A critical appraisal. *Periodontol* 2000 1998;17:132–150.
54. Chiche FA, Leriche MA. Multidisciplinary implant dentistry for improved esthetics and function. *Pract Periodontics Aesthet Dent* 1998;10:177–186.
55. Levine RA, Katz D. Developing a team approach to complex aesthetics: Treatment considerations. *Pract Proced Aesthet Dent* 2003;15: 301–306.
56. Funato A, Salama MA, Isjikawa T, Garber DA, Salama H. Timing, positioning, & sequential staging in esthetic implant therapy: A four-dimensional perspective. *Int J Periodontics Restorative Dent* 2007;27:313–323.
57. Bornstein MM, Balsiger R, Sendi P, von Arx T. Morphology of the nasopalatine canal and dental implant surgery: A radiographic analysis of 100 consecutive patients using limited cone-beam computed tomography. *Clin Oral Implants Res* 2011;22:295–301.

58. Tozum TF, Guncu GN, Yildirim YD, et al. Evaluation of maxillary incisive canal characteristics related to dental implant treatment with computerized tomography: A clinical multicenter study. *J Periodontol* 2012;83:337–343.
59. Chen S, Buser D. Advantages and disadvantages of treatment options for implant placement in post-extraction sockets. In: Buser D, Wismeijer D, Belser U, (eds). *ITI Treatment Guide: Implant placement in Post-Extraction Sites: Treatment Options*, vol. 3. Berlin: Quintessenz;2008:29–42.
60. Buser D, Wittneben J, Bornstein MM, Grutter L, Chappuis V, Belser UC. 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.
61. 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.
62. Chen ST, Wilson TG Jr, Hammerle CHF. 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.
63. Kan JYK, Roe P, Rungcharassaeng K, Patel RD, Waki T, Lozada JL, Zimmerman G. Classification of sagittal root position in relation to the anterior maxillary osseous housing for immediate implant placement: A cone beam computed tomography study. *Int J Oral Maxillofac Implants* 2011;26:873–876.
64. Grunder U, Gracis S, Capelli M. Influence of the 3D bone-implant relationship on esthetics. *Int J Periodontics Restorative Dent* 2005;25:113–119.
65. Bashutski J, Wang H-L. Common implant esthetic complications. *Implant Dent* 2007;16:340–348.
66. Belser U, Martin W, Jung R, Hammerle CHF, Schmik B, Morton D, Buser D. *ITI Treatment Guide, Volume 1: Implant Therapy in the Esthetic Zone. Single-tooth Replacements*. Berlin:Quintessence;2007.
67. Salama H, Salama M. The role of orthodontic extrusion remodeling in the enhancement of soft and hard tissue profiles prior to implant placement: A systematic approach to the management of extraction site defects. *Int J Periodontics Restorative Dent* 1993;13:312–333.
68. Kim SH, Tramontina VA, Papalexiou V, Luczyszyn SM. Orthodontic extrusion and implant site development using an interocclusal appliance for a severe mucogingival deformity: A clinical report. *J Prosthet Dent* 2011;105:72–77.
69. Huynh-Ba G, Pjetursson BE, Sanz M, et al. Analysis of the socket bone wall dimension in the upper maxillae in relation to immediate implant placement. *Clin Oral Implants Res* 2010;21:37–42.
70. Qahash M, Susin C, Polimeni G, Hall J, Wikesjo UM. Bone dynamics at buccal peri-implant sites. *Clin Oral Implants Res* 2008;19:166–172.
71. Spray JR, Black CG, Morris HF, et al. The influence of bone thickness on facial marginal bone response: Stage 1 placement through stage 2 uncovering. *Ann Periodontol* 2000;5:119–128.
72. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: Clinical results with different bone grafts and bone-substitute materials. *Int J Oral Maxillofac Implants* 2009;24(suppl):218–236.
73. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(suppl):237–259.
74. Darby I, Chen ST, Buser D. Ridge preservation techniques for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(suppl):260–271.
75. Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. *Int J Oral Maxillofac Implants* 2009;24(suppl):272–278.
76. Levine R. Implant site preparation: horizontal ridge augmentation using particulate allograft & the principles of GBR. In: *Implant Site Development*. First Edition, Sonick M, Hwang D, Saadoun A (eds). Chichester, United Kingdom: Wiley-Blackwell; 2012, 179–201.
77. Nobuto T, Yanagihara K, Teranishi Y, Minamibayashi S, Imai H, Yamaoka A. Periosteal microvasculature in the dog alveolar process. *J Periodontol* 1989;60:709–715.
78. Araujo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. *J Clin Periodontol* 2005;32:212–218.
79. Pietrokovski J, Massler M. Alveolar ridge resorption following tooth extraction. *J Prosthet Dent* 1967;17:21–27.
80. Pietrokovski J, Starinsky R, Arensburg B, Kaffe I. Morphologic characteristics of bony edentulous jaws. *J Prosthodont* 2007;16:141–147.
81. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. *J Clin Periodontol* 2004;31:820–828.
82. Schropp L, Kostopoulos L, Wenzel A. Bone healing following immediate versus delayed placement of titanium implants into extraction sockets: A prospective clinical study. *Int J Oral Maxillofac Implants* 2003;18:189–199.
83. Sanz M, Cecchinato D, Ferrus J, Pjetursson EB, Lang NP, Lindhe J. A prospective, randomized-controlled clinical trial to evaluate bone preservation using implants with different geometry placed into extraction sockets in the maxilla. *Clin Oral Implants Res* 2010;21:13–21.
84. Araujo M, Sukekava F, Wennstrom J, Lindhe J. Ridge alterations following implant placement in fresh extraction sockets: An experimental study in the dog. *J Clin Periodontol* 2005;32:645–652.
85. Botticelli D, Persson LG, Lindhe J, Berglundh T. Bone tissue formation adjacent to implants placed in fresh extraction sockets. An experimental study in dogs. *Clin Oral Implants Res* 2006;17:351–358.
86. Caneva M, Salata LA, de Souza SS, Baffone G, Lang NP, Botticelli D. Influence of implant positioning in extraction sockets on osseointegration: Histomorphometric analyses in dogs. *Clin Oral Implants Res* 2010;21:43–49.
87. Barone A, Ricci M, Calvo-Guirado JL, Covani U. Bone remodeling after regenerative procedures placed in fresh extraction sockets: An experimental study in beagle dogs. *Clin Oral Implants Res* 2011;22:1131–1137.
88. 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 Rest Dent* 2011;31:215–225.
89. Januario AL, Duarte WR, Barriviera M, Mesti JC, Araujo MG, Lindhe J. Dimension of the facial bone wall in the anterior maxillae: A cone-beam computed tomography study. *Clin Oral Implants Res* 2011;22:1168–1171.
90. Nevins M, Camelo M, De Paoli S, et al. A study of fate of the buccal wall of extraction sockets of teeth with prominent roots. *Int J Periodontics Rest Dent* 2006;26:19–29.
91. Tomasi C, Sanz M, Cecchinato D, et al. Bone dimensional variations at implants placed in fresh extraction sockets: A multilevel multivariate analysis. *Clin Oral Implants Res* 2010;21:30–36.
92. Cortellini P, Tonetti MS. Long-term tooth survival following regenerative treatment of intrabony defects. *J Periodontol* 2004;75:672–678.
93. Tombelli L, Kim CK, Zimmerman GJ, Wikesjo UM. Retrospective analysis of factors related to clinical outcome of guided tissue regeneration procedures in intrabony defects. *J Clin Periodontol* 2004;31:366–371.
94. Stravropoulos A, Mardas N, Herrero F, Karring T. Smoking affects the outcome of guided tissue regeneration with bioresorbable membranes: A retrospective analysis of intrabony defects. *J Clin Periodontol* 2004;31:945–950.
95. Saldanha JB, Casati MZ, Neto FH, Sallum EA, Nociti JFH. Smoking may affect the alveolar process dimensions and radiographic bone density in maxillary extraction sites: A prospective study in humans. *J Oral Maxillofac Surg* 2006;64:1359–1365.
96. Evans CDJ, Chen ST. Esthetic outcomes of immediate implant placements. *Clin Oral Implants Res* 2008;19:73–80.
97. Lam RV. Contour changes of the alveolar process following extractions. *J Prosthetic Dent* 1960;10:25–32.
98. Tallgren A. The continuing reduction of the residual ridges in complete denture wearers: A mixed-longitudinal study covering 25 years. *J Prosthet Dent* 1972;27:120–132.
99. Johnson K. A study of the dimensional changes occurring in the maxilla following tooth extraction. *Australian Dent Journ* 1969;14:241–244.
100. Wood DL, Hoag PM, Donnenfeld OW, Rosenfeld LD. Alveolar crest reduction following full and partial thickness flaps. *J Periodontol* 1972;43:141–144.

101. Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. *Int J Oral Maxillofac Implants* 2009;24(suppl):186–217.
102. 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.
103. 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.
104. Kan JYK, 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(suppl 1):13–19.
105. Cordaro L, Torsello F, Rocuzzo M. Clinical outcome of submerged vs. non-submerged implants placed in fresh extraction sockets. *Clin Oral Implants Res* 2009;20:1307–1313.
106. Besimo CE, Lambrecht JT, Guindy JS. Accuracy of implant treatment planning utilizing template-guided reformatted computer tomography. *Dentomaxillofac Radiol* 2000;29:46–51.
107. Ganz SD. Presurgical planning with CT-driven fabrication of surgical guides. *J Oral Maxillofac Surg* 2005;63(suppl 2):59–71.
108. Scarfe W, Vaughn WS, Farman AG, Harris BT, Paris MM. Comparison of restoratively projected and surgically acceptable virtual implant position for mandibular overdentures. *Int J Oral Maxillofac Implants* 2012;27:111–118.
109. Fortin T, Champeboux G, Lormee J, Coudert JL. Precise dental implant placement in bone using surgical guides in conjunction with medical imaging techniques. *J Oral Implantol* 2000;26:300–303.
110. Ferrus J, Cecchinato D, Pjetursson EB, Lang NP, Sanz M, Lindhe J. Factors influencing ridge alterations following immediate implant placement into extraction sockets. *Clin Oral Implants Res* 2010; 21:22–29.
111. Seibert JS, Lindhe J. Esthetics in periodontal therapy. In: Lindhe J, Karring T, Lang NP (eds). *Clinical Periodontology and Implant Dentistry*, ed 3. Copenhagen: Munksgaard, 1997:647–681.
112. Muller HP, Heincke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. *J Clin Periodontol* 2000;27:621–626.
113. Lee A, Fu J-H, Wang H-L. Soft tissue biotype affects implant success. *Implant Dent* 2011;20:e38–e47.
114. De Rouck TD, Eghbali R, Collys K, De Bruyn H, Cosyn J. The gingival biotype revisited: Transparency of the periodontal probe through the gingival margin as a method to discriminate thin from thick gingiva. *J Clin Periodontol* 2009;36:428–433.
115. Cook DR, Mealey BL, Verrett RG, et al. Relationship between clinical periodontal biotype and labial plate thickness: An in vivo study. *Int J Periodontics Restorative Dent* 2011;31:345–354.
116. Kan JY, Rungcharassaeng K, Cosyn J. Immediate placement and provisionalization of maxillary anterior single implants: A 1-year prospective study. *Int J Oral Maxillofac Implants* 2003;18:31–39.
117. Kan JYK, 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.
118. Heitz-Mayfield LJA, Huynh-Ba G. History of treated periodontitis and smoking as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(suppl):39–68.
119. Cochran DL, Schou S, Heitz-Mayfield LJA, Bornstein MM, Salvi GE, Martin WC. Consensus statements and recommended clinical procedures regarding risk factors in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(suppl):86–89.
120. Levine RA, Wilson TG Jr. Compliance as a risk major factor in periodontal disease progression. *Compend Contin Educ Dent* 1992;13: 1072–1079.
121. 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.
122. 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.
123. Ainamo J, Loe H. Anatomical characteristics of gingiva. A clinical and microscopic study of the free and attached gingiva. *J Periodontol* 1966;37:5–13.
124. Lang NP, Loe H. The relationship between the width of keratinized gingiva and gingival health. *J Periodontol* 1972;43:623–627.
125. Kennedy JE, Bird WC, Palcanis KG, Dorfman HS. A longitudinal evaluation of varying widths of attached gingiva. *J Clin Periodontol* 1985;12:667–675.
126. Stetler KJ, Bissada NF. Significance of the width of keratinized gingiva on the periodontal status of teeth with submarginal restorations. *J Periodontol* 1987;58:696–700.
127. Miyasato M, Crigger M, Egelberg J. Gingival condition in areas of minimal and appreciable width of keratinized gingiva. *J Clin Periodontol* 1977;4:200–209.
128. Dorfman HS, Kennedy JE, Bird WC. Longitudinal evaluation of free autogenous gingival grafts. A four year report. *J Clin Periodontol* 1980;10:206–221.
129. Hangorsky U, Bissada NF. Clinical assessment of free gingival graft effectiveness on the maintenance of periodontal health. *J Periodontol* 1980;51:274–278.
130. Wennstrom J, Lindhe J, Nyman S. The role of keratinized gingiva in plaque-associated gingivitis in dogs. *J Clin Periodontol* 1982;9: 75–85.
131. Wennstrom J, Lindhe J. Role of attached gingiva for maintenance of periodontal health. Healing following excisional and grafting procedures in dogs. *J Clin Periodontol* 1983;10:206–221.
132. Lindhe J, Berglundh T, Ericsson I, Liljenberg B, Marinello C. Experimental breakdown of peri-implant and periodontal tissues. A study in the beagle dog. *Clin Oral Implants Res* 1992;3:9–16.
133. Ericsson I, Berglundh T, Marinello C, Liljenberg B, Lindhe J. Long-standing plaque and gingivitis at implants and teeth in the dog. *Clin Oral Implants Res* 1992;3:99–103.
134. Berglundh T, Lindhe J, Marinello C, Ericsson I, Liljenberg B. Soft tissue reaction to de novo plaque formation on implants and teeth. An experimental study in the dog. *Clin Oral Implants Res* 1992;3:1–8.
135. Weber HP, Buser D, Donath K, Fiorellini JP, Doppalapud V, Paquette DW, Williams RC. Comparison of healed tissues adjacent to submerged and non-submerged unloaded titanium dental implants. A histometric study in beagle dogs. *Clin Oral Implants Res* 1996;7:11–19.
136. Listgarten MA, Lang NP, Schroeder HE, Schroeder A. Periodontal tissues and their counterparts around endosseous implants. *Clin Oral Implants Res* 1991;2:1–19.
137. Abrahamsson I, Burglundh T, Wennstrom J, Lindhe J. The peri-implant hard and soft tissues at different implant systems. A comparative study in the dog. *Clin Oral Implants Res* 1996;7:212–219.
138. Chavrier C, Couble ML, Hartmann DJ. Qualitative study of collagenous and noncollagenous glycoproteins of the human healthy keratinized mucosa surrounding implants. *Clin Oral Implants Res* 1994;5:117–124.
139. Warrer K, Buser D, Lang NP, Karring T. Plaque-induced peri-implantitis in the presence or absence of keratinized mucosa. An experimental study in monkeys. *Clin Oral Implants Res* 1995;6:131–138.
140. Lindhe J, Berglundh T. The interface between the mucosa and the implant. *Periodontol* 2000 1998;17:47–54.
141. Bouri A Jr, Bissada N, Al-Zahrani MS, Faddoul F, Nouneh I. Width of keratinized gingiva and the health status of the supporting tissues around dental implants. *Int J Oral Maxillofac Implants* 2008;23: 323–326.
142. Chung DM, Oh TJ, Shotwell JL, Misch CE, Wang HL. Significance of keratinized mucosa in maintenance of dental implants with different surfaces. *J Periodontol* 2006;77:1410–1420.
143. Greenstein G, Cavallaro J. The clinical significance of keratinized gingiva around dental implants. *Compend Cont Educ Dent* 2011; 32:24–31.
144. Esposito M, Grusovin MG, Maghaireh H, et al. Interventions for replacing missing teeth: Management of soft tissues for dental implants. *Cochrane Database Syst Rev* 2007;18:CD0006697.
145. Kim BS, Kim YK, Yun PY, et al. Evaluation of peri-implant tissue response according to the presence of keratinized mucosa. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107:e24–e28.

146. Zigdon H, Machtei EE. The dimensions of keratinized mucosa around implants affect clinical and immunological parameters. *Clin Oral Implants Res* 2008;19:387–392.
147. Hurzeler MB, Weng D. A new technique to combine barrier removal at dehiscenced implant sites with a plastic periodontal procedure. *Int J Periodontics Restorative Dent* 1996;16:149–163.
148. Jung RE, Sailer I, Hammerle CHF, Attin T, Schmidlin P. In vitro color changes of soft tissues caused by restorative materials. *Int J Periodontics Restorative Dent* 2007;27:251–257.
149. Furhauer R, Florescu D, Benesch T, Haas R, Mailath G, Watzek G. Evaluation of soft tissue around single-tooth implant crowns: The pink esthetic score. *Clin Oral Implants Res* 2005;16:639–644.
150. Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D. Biologic width around titanium implants. A histometric analysis of the implanto-gingival junction around unloaded and loaded non-submerged implants in the canine mandible. *J Periodontol* 1997;68:186–198.
151. Lindhe J, Berglundh T, Ericsson I, Liljenberg B, Marinello CP. Experimental breakdown of periimplant and periodontal tissues. A study in the beagle dog. *Clin Oral Implants Res* 1992;3:9–16.
152. Oakley E, Rhyu IC, Karatzas S, Gandini-Santiago L, Nevins M, Caton J. Formation of the biologic width following crown lengthening in nonhuman primates. *Int J Periodontics Restorative Dent* 1999;19:529–541.
153. Linkevicius T, Apse P, Grybauskas S, Puisys A. The influence of soft tissue thickness on crestal bone changes around dental implants: A 1-year prospective controlled clinical trial. *Int J Oral Maxillofac Implants* 2009;24:712–719.
154. Berglundh T, Abrahamsson I, Welander M, Lang NP, Lindhe J. Morphogenesis of the peri-implant mucosa: An experimental study in dogs. *Clin Oral Implants Res* 2007;18:1–8.
155. Hermann JS, Buser D, Schenk RK, Schoolfield JD, Cochran DL. Biologic width around one- and two-piece titanium implants: A histometric evaluation of unloaded nonsubmerged & submerged implants in the canine mandible. *Clin Oral Implants Res* 2001;12:559–571.
156. Cardaropoli G, Lekholm U, Wennstrom JL. Tissue alterations at implant-supported single-tooth replacements: A 1-year prospective clinical study. *Clin Oral Implants Res* 2006;17:165–171.
157. Berghlund T, Lindhe J. Dimension of the peri-implant mucosa. Biologic width revisited. *J Clin Periodontol* 1996;23:971–973.
158. Anderegg CR, Metzler DG, Nicoll BK. Gingiva thickness in guided tissue regeneration and associated recession at facial furcation defects. *J Periodontol* 1995;66:397–402.
159. Miller PD. Root coverage with the free gingival graft-factors associated with incomplete coverage. *J Periodontol* 1987;58:674–681.
160. Baldi C, Pini Prato G, Pagliaro U, Nieri M, Saletta D, Muzzi L, Cortellini P. Coronally advanced flap procedure for root coverage. Is flap thickness a relevant predictor to achieve root coverage? A 19-case series. *J Periodontol* 1999;70:1077–1084.
161. Friedman N. Mucogingival surgery. *Texas Dent J* 1957;75:358–362.
162. Miller PD, Allen EP. The development of periodontal plastic surgery. *Periodontology* 2000 1996;11:7–17.
163. Miller PD. Root coverage using a free soft tissue autograft following citric acid application. I. Technique. *Int J Periodontics Restorative Dent* 1982;2:65–70.
164. Holbrook T, Ochsenein C. Complete coverage of the denuded root surface with a one-stage gingival graft. *Int J Periodontics Restorative Dent* 1983;3:8–27.
165. Langer B, Langer L. Subepithelial connective tissue graft technique for root coverage. *J Periodontol* 1985;56:715–720.
166. Thoma DS, Benic GI, Zwahlen M, Hammerle CHF, Jung RE. A systematic review assessing soft tissue augmentation techniques. *Clin Oral Implants Res* 2009;20(suppl 4):146–165.
167. Harris RJ. Gingival augmentation with an acellular dermal matrix: Human histologic evaluation of a case—Placement of the graft on bone. *Int J Periodontics Restorative Dent* 2001;21:69–75.
168. Harris RJ. Clinical evaluation of 3 techniques to augment keratinized tissue without root coverage. *J Periodontol* 2001;72:932–938.
169. Harris RJ. Gingival augmentation with an acellular dermal matrix: Human histologic evaluation of a case—Placement of the graft on periosteum. *Int J Periodontics Restorative Dent* 2004;24:378–385.
170. Cardaropoli D, Tamagnone L, Roffredo A, Gaveglione L. Treatment of gingival recession defects using coronally advanced flap with a porcine collagen matrix compared to coronally advanced flap with connective tissue graft: A randomized controlled clinical trial. *J Periodontol* 2012;83:321–328.
171. Sanz M, Lorenzo R, Aranda JJ, Martin C, Orsini M. Clinical evaluation of a new collagen matrix (Mucograft prototype) to enhance the width of keratinized tissue in patients with fixed prosthetic restorations: A randomized prospective clinical trial. *J Clin Periodontol* 2009;36:868–876.
172. McGuire MK, Scheyer ET. Xenogeneic collagen matrix with coronally advanced flap compared to connective tissue with coronally advanced flap for the treatment of dehiscence-type recession defects. *J Periodontol* 2010;81:1108–1117.
173. Lorenzo R, Garcia V, Orsini M, Conchita M, Sanz M. Clinical efficacy of a xenogeneic collagen matrix in augmenting keratinized mucosa around implants: A randomized controlled prospective clinical trial. *Clin Oral Implants Res* 2012;23:316–324.
174. Nevins M, Nevins M, Kim S-W, Schupbach P, Kim D. The use of mucograft collagen matrix to augment the zone of keratinized tissue around teeth: A pilot study. *Int J Periodontics Restorative Dent* 2011;31:367–373.
175. Roccieta I, Schupbach P, Ghezzi C, Maschera E, Simion M. Soft tissue integration of a porcine collagen membrane: An experimental study in pigs. *Int J Periodontics Restorative Dent* 2012;32:e34–e40.
176. McGuire MK, Scheyer ET, Nunn ME, Lavin PT. A pilot study to evaluate a tissue-engineered bilayered cell therapy as an alternative to tissue from the palate. *J Periodontol* 2008;79:1847–1856.
177. Nevins ML. Tissue-engineered bilayered cell therapy for the treatment of oral mucosal defects: A case series. *Int J Periodontics Restorative Dent* 2010;30:31–39.
178. Studer S, Allen E, Rees T, Kouba A. The thickness of masticatory mucosa in the human hard palate and tuberosity as potential donor sites for ridge augmentation procedures. *J Periodontol* 1997;68:145–151.
179. Gasparini DO. Double-fold connective tissue pedicle graft: A novel approach for ridge augmentation. *Int J Periodontics Rest Dent* 2004;24:280–287.
180. Abrams H, Kopczyk R, Kaplan A. Incidence of anterior ridge deformities in partially edentulous patients. *J Prosthet Dent* 1987;57:191–194.
181. Seibert JS. Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. I. Technique and wound healing. *Compend Contin Educ Dent* 1983;4:437–453.
182. Seibert JS. Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. II. Prosthetic/periodontal interrelationships. *Compend Contin Educ Dent* 1983;4:549–562.
183. Langer B, Calagna L. The subepithelial connective tissue graft. *J Prosthet Dent* 1980;44:363–367.
184. Garber DA, Rosenberg ES. The edentulous ridge in fixed prosthodontics. *Compend Contin Educ Dent* 1981;24:212–224.
185. Seibert JS, Salama H. Alveolar ridge preservation and reconstruction. *Periodontology* 2000, Vol. 11, 1996;69–84.
186. Seibert JS, Louis JV. Soft tissue augmentation utilizing a combination onlay-interpositional graft procedure: A case report. *Int J Periodontics Restorative Dent* 1996;16:310–321.
187. Fickl S, Hurzeler MB. In Implant Site Development. First Edition. Sonick M, Hwang D, Saadoun A (eds). Chichester, United Kingdom: Wiley-Blackwell; 2012, 341–360.
188. Landsberg CJ, Bichacho N. A modified surgical/prosthetic approach for optimal single implant supported crown. Part I—The socket seal surgery. *Pract Periodontics Aesthet Dent* 1994;6:11–17.
189. Jung R, Siegenthaler D, Hammerle C. Postextraction tissue management: A soft tissue punch technique. *Int J Periodontics Restorative Dent* 2004;24:545–553.
190. Nobuto T, Imai H, Yamaoka A. Microvascularization of the free gingival autograft. *J Periodontol* 1988;59:639–646.
191. Sullivan HC, Atkins JH. Free autogenous gingival grafts. III. Principles of successful grafting. *Periodontics* 1968;6:152–160.
192. Fickl S, Schneider D, Zuhr O, Hinze M, Ender A, Jung RE, Hurzeler MB. Dimensional changes of the ridge contour after socket preservation and buccal overbuilding: An animal study. *J Clin Periodontol* 2009;36:442–448.

193. Stimmelmayer M, Allen EP, Reichert TE, Iglhaut G. Use of combination epithelized-subepithelial connective tissue graft for closure and soft tissue augmentation of an extraction site following ridge preservation or implant placement: Description of a technique. *Int J Periodontics Restorative Dent* 2010;30:375–381.
194. Becker W, Becker BE. Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: Surgical techniques and case report. *Int J Periodontics Restorative Dent* 1990;10:376–391.
195. Khoury F, Happe A. The palatal subepithelial connective tissue flap method for soft tissue management to cover maxillary defects: A clinical report. *Int J Oral Maxillofac Implants* 2000;15:415–418.
196. Penarrocha M, Garcia-Mira B, Martinez O. Localized vertical maxillary ridge preservation using bone cores and a rotated palatal flap. *Int J Oral Maxillofac Implants* 2005;20:131–134.
197. Fickl S, Zuhre O, Wachtel H, Stappert CF, Stein JM, Hurzeler MB. Dimensional changes of the alveolar ridge contour after different socket preservation techniques. *J Clin Periodontol* 2008;35:906–913.
198. Kan JYK, Rungcharassaeng K, Lozada JL. Bilaminar subepithelial connective tissue grafts for immediate implant placement and provisionalization in the esthetic zone. *J Calif Dent Assoc* 2005;33:865–871.
199. Kois JC, Kan JYK. Predictable peri-implant gingival aesthetics: Surgical and prosthodontics rationales. *Pract Proced Aesthet Dent* 2000;12:817–824.
200. Kan JYK, 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.
201. Kan JYK, Rungcharassaeng K, Umezu K, Kois JC. Dimensions of peri-implant mucosa: An evaluation of maxillary anterior single implants in humans. *J Periodontol* 2003;74:557–562.
202. De Rouck T, Collys K, Cosyn J. Immediate single-tooth implants in the anterior maxilla: A 1-year case cohort study on hard & soft tissue response. *J Clin Periodontol* 2008;35:649–657.
203. Chocquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow DP, Malevez C. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth implants. A retrospective study in the maxillary anterior region. *J Periodontol* 2001;72:1364–1371.
204. Palmer RM, Palmer PJ, Floyd PD. A 5-year prospective study of Astra single tooth implants. *Clin Oral Implants Res* 2000;11:179–182.
205. Nisapakultorn K, Suphanantachai S, Silksessak O, Rattanamongkolgul S. Factors affecting soft tissue level around anterior maxillary single-tooth implants. *Clin Oral Implants Res* 2010;21(6):662–670.
206. Cornellini R, Brone A, Covani U. Connective tissue grafts in postextraction implants with immediate restoration: A prospective controlled clinical study. *Pract Proced Aesthet Dent* 2008;20:337–343.
207. Bianchi AE, Sanfilippo F. Single-tooth replacement by immediate implant and CT graft: A 1-9-year clinical evaluation. *Clin Oral Implants Res* 2004;15:269–277.
208. Redemagni M, Cremonesi S, Garlini G, Maiorna, C. Soft tissue stability with immediate implants and concave abutments. *Eur J Esthet Dent* 2009;4:328–337.
209. Chung S, Rungcharassaeng K, Kan JY, Roe P, Lozada JL. Immediate single tooth replacement with subepithelial connective tissue graft using platform switching implants: A case series. *J Oral Implantol* 2011;37:559–569.
210. Tsuda H, Rungcharassaeng K, Kan JY, Roe P, Lozada JL, Zimmerman G. 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.