Copyright by

Copyright by Quintessence Not for Publication

Immediate Implant Placement and Provisionalization After Long-Axis Root Fracture and Complete Loss of the Facial Bony Lamella

*Robert Noelken, Dr Med Dent**
*Martin Kunkel, Prof Dr Med, Dr Med Dent***
*Wilfried Wagner, Prof Dr Med, Dr Med Dent****

The aim of this research was to explore the performance of a flapless surgical approach for immediate implant placement, simultaneous alveolar ridge augmentation, and immediate provisionalization in patients with complete loss of the facial bony lamella resulting from long-axis root fracture. Eighteen NobelPerfect implants were placed in 16 patients (follow-up, 13 to 36 months) who had sustained complete loss of the facial bony lamellae. Implants were inserted simultaneous to subperiostal bone augmentation with autogenous bone chips and underwent immediate provisionalization. Outcome variables included implant success, marginal bone levels, and pink esthetic score (PES). All implants achieved excellent primary stability. There were no implant losses. On average, interproximal marginal bone levels stabilized at 1.0 to 1.3 mm above the first thread. Postoperative cone beam computed tomography scans were available for 16 implant sites and confirmed restoration of the facial lamella in the vast majority of patients. Marginal esthetics, as assessed by the PES, was by and large preserved (mean postoperative PES, 12.5). Oral hygiene was highly predictive for the esthetic result. Survival rates, marginal bone levels, and esthetic results suggest a proof-of-principle for the new flapless immediate implant placement technique in patients with complete loss of the facial bony lamella. Oral hygiene status may be considered as a negative prognostic factor for the esthetic outcome. (Int J Periodontics Restorative Dent 2011;31:175–183.)

*Private Practice, Lindau/Lake Constance, Germany; Research Fellow, Department of Oral and Maxillofacial Surgery, University Hospital Mainz, Mainz, Germany.
**Professor and Head, Department of Oral and Maxillofacial Surgery, University Hospital Bochum, Bochum, Germany.
***Professor and Head, Department of Oral and Maxillofacial Surgery, University Hospital Mainz, Mainz, Germany.

Correspondence to: Dr Robert Noelken, Paradiesplatz 7-13, D-88131 Lindau/Lake Constance, Germany; fax: +49 8382 944031; email: praxis@dr-noelken.de.

Bone loss resulting from vertical root fracture[1–3] poses a challenging problem in dental implant dentistry. Since the microbiotic and mechanical sequelae of vertical root fractures typically induce the loss of alveolar bone, and rather often complete resorption of the facial bony lamella,[4] typical requirements for immediate implant placement and especially immediate loading most often will not be fulfilled.[5,6]

For these reasons, implant restoration is often performed as a two- or three-stage procedure.[7–10] Staged approaches, however, imply major drawbacks with regard to the preservation of the residual bone level[11,12] and the marginal gingival contour.[13,14] The respective involuntary changes have been demonstrated clearly to compromise the long-term esthetic results.[15–17] Immediate implant placement and immediate provisionalization substantially add to the preservation of the marginal structure.[18–21] It was the remarkable esthetic outcome achieved in a recently published series on NobelPerfect implants[22] that prompted the authors to transfer

Copyright by Quintessence Not for Publication

the concept of immediate implant placement and provisionalization to the challenging situation of longitudinal root fractures. The rationale emerged from the observation that a layer of autologous bone chips placed in the gap between the implant and the facial soft tissues resulted in the restoration of a stable facial bone layer regardless of the dimension of a preexisting facial bony defect.

Thus, the aim of this study was to systematically explore the performance of a new flapless immediate implant placement technique when applied in patients with complete loss of the facial bony lamella. Specifically, this communication reports implant success rates and focuses on the clinical, radiographic, and esthetic outcomes within a follow-up period of 13 to 36 months.

Method and materials

From April 2004 to December 2006, 16 patients (5 men, 11 women; mean age, 43 years; range, 25 to 64 years) were enrolled in this study. Inclusion criteria were as follows: tooth loss in the esthetic zone following a long-axis root fracture, complete loss of the facial bony lamella, high primary stability expected, and request for an immediate provisional prosthetic restoration. Exclusion criteria included previous radiation therapy, systemic bone diseases, and permanent immunosuppressive medication.

Overall, 18 implants were inserted. In the initial phase of the study, patients received NobelPerfect implants (Nobel Biocare) with a 1.5-mm machined scalloped collar (n = 3). Beginning in November 2005, NobelPerfect Groovy implants (Nobel Biocare) with a TiUnite-surfaced scalloped collar were inserted (n = 15). Thirteen implants replaced maxillary incisors, and 5 implants were inserted in the maxillary first premolar region.

Surgical technique

All surgical interventions were performed using a flapless protocol. The condemned teeth were extracted, with care taken to maintain the lateral and oral alveolar socket walls and the gingival architecture. Hereafter, implant sites were prepared according to the manufacturer's instructions. The implants were placed in contact with the oral lamella of the socket. The scalloped implant neck was placed approximately 2 mm apical to the circumferential soft tissue margin. All implant sites allowed for a 16-mm-long implant to be placed. Implant diameters were 3.5 mm in four implants, 4.3 mm in seven implants, and 5.0 mm in seven implants. To restore the facial bony contour, simultaneous bone grafting was performed by condensing bone chips to the bottom of the facial defect with a plugger. All autogenous bone grafts were harvested at the mandibular ramus. Additional soft tissue grafts were not used.

Copyright by Quintessence Not for Publication

Immediate restoration

In patients undergoing single-tooth replacement, manufactured acrylic teeth were adjusted on top of titanium abutments. For multiple tooth replacements, provisional restorations were fabricated by a lab technician. All provisional restorations were free of occlusal contacts. For further stabilization, all implants were splinted. Patients received clindamycin (starting 2 days preoperatively for 1 week) for perioperative bacterial control.

After a minimum of 3 months, the definitive crowns were fabricated using porcelain-fused-to-metal or Procera zirconia technology (Nobel Biocare) and were cemented using a long-lasting temporary cement (Improv, Alvelogro) or a glass-ionomer cement (Ketac-Cem, 3M ESPE).

Follow-up and definition of outcome variables

Patients were examined at the time of implant placement and at least 13 months later. The primary outcome variables were as follows:

- Implant success according to the criteria established by Buser et al.[23]
- Peri-implant probing depth, registered at six sites around the implants (mesiofacial, facial, distofacial, mesiolingual, lingual, distolingual).
- Status of the interproximal marginal bone level, determined using digital radiographs with a commercial Rinn holder. Specifically, the vertical distance between the mesial and distal bone level and the prominence of the first thread was measured. Attachment levels crestal to the first thread were designated as positive values.
- Status of the facial bone level, determined using cone bean computed tomography (CBCT) data. Specifically, the bone level was determined by the reconstruction according to the long axis of the implants.
- The Sulcular Bleeding Index (SBI) according to Mühlemann and Son,[24] measured prior to surgery and at each follow-up visit.
- The pink esthetic score (PES) according to Fürhauser et al,[25] measured prior to surgery and at each follow-up visit.

Statistical analysis

Survival probabilities were estimated using the Kaplan-Meier method. The endpoint of interest was implant failure according to the criteria established by Buser et al.[23] The analysis exploring the link between marginal bone level and the PES was completed using Spearman rank-based correlations. Subpopulations within the study group (improved vs decreased PES) were compared using nonparametric *U* tests. Paired observations (oral vs facial probing depth, pre- vs postoperative PES) were compared using the Wilcoxon matched pairs test. The reported *P* values were two-sided. All calculations were completed using SPSS for Windows (version 12, IBM).

Copyright by Quintessence
Not for Publication

Fig 1 *Typical treatment protocol for single-tooth replacement.*

Fig 1a *Initial clinical aspect of the right central incisor. The marginal tissues showed slight swelling.*

Fig 1b *After extraction of the affected tooth, a long-axis root fracture was visible.*

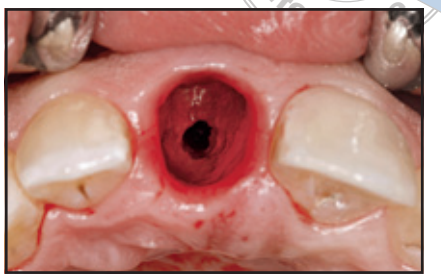


Fig 1c *Intraoperative view after removal of the tooth. The entire facial lamella underwent resorption.*

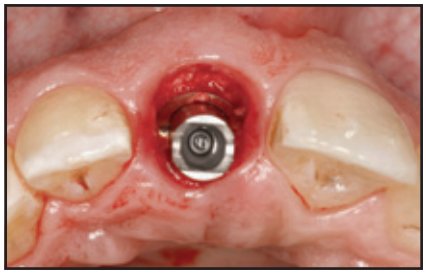
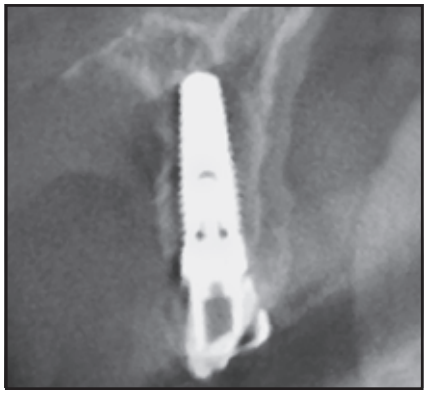
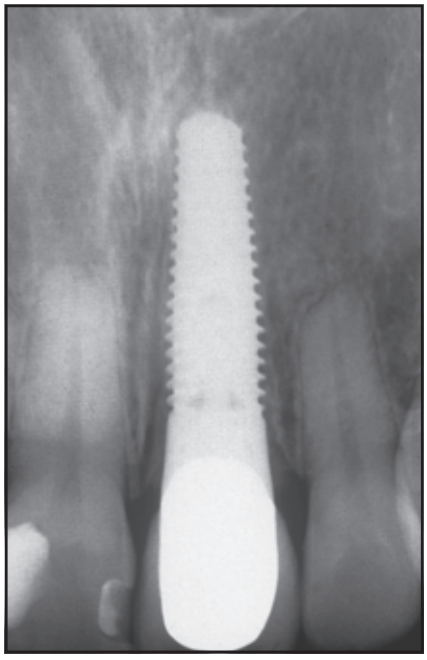


Fig 1d (left) *Intraoperative aspect after reconstruction of the facial lamella with autogenous bone chips from the ramus. Note the slight overextension of the bone graft to achieve a favorable marginal contour after the consolidation phase.*

Fig 1e (right) *CBCT image 5 months after implant placement. Three-dimensional imaging in the sagittal view shows the complete reconstitution of the facial bony lamella.*



Figs 1f and 1g (left) *Clinical and* (right) *radiographic outcomes 19 months after immediate implant placement, immediate provisionalization, and definitive restoration delivery. Complete osseointegration of the implant and favorable marginal bone level at approximately 1.5 mm coronal to the first thread was noticed.*



Copyright by Quintessence
Not for Publication

Fig 2 *Patient with the worst outcome in the case series.*

Fig 2a (right) *Initial clinical aspect showing a long-axis root fracture with complete loss of the facial lamella, a fistula, and a recession-type defect.*

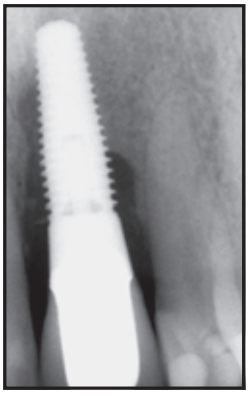


Fig 2b (left) *Radiographic outcome 15 months after immediate implant placement showing excessive bone loss following overextrusion of cement.*

Fig 2c (right) *Clinical aspect at final examination. There was a lack of inflammation despite severe bone resorption. The marginal soft tissue level improved, but the overall PES score was unchanged.*

Results

All patients fully attended the follow-up. Although the facial bony lamella was completely absent, all implants yielded sufficient primary stability for immediate placement of the provisional restoration. Figure 1 illustrates the typical treatment protocol for a single-tooth replacement. Figure 2 presents the preoperative aspects and final outcome of the patient with the worst clinical outcome in terms of marginal bone level. This implant was classified as a failure because of excessive bone loss.

Implant success

Within the follow-up period (13 to 36 months; median, 22 months), no implant had to be removed. No major loss of marginal bone was observed except for in one patient (Fig 2). On retrospective analysis, this excessive bone loss occurred because of an initially unrecognized cement overextrusion to the sulcus at the time of delivering the definitive crown. Four months later, this patient presented with purulent sulcular outflow. Although the cement was removed and secondary augmentation was performed, the defect did not recover. The implant did not show an unfavorable esthetic outcome or renewed suppuration through the final examination (Fig 2c). Nevertheless, this implant was considered a failure. Thus, the success rate, according to the criteria of Buser et al,[23] was 94% (mean survival, 34 months; 95% confidence interval, 31 to 38 months) (Fig 3).

Copyright by Quintessence Not for Publication

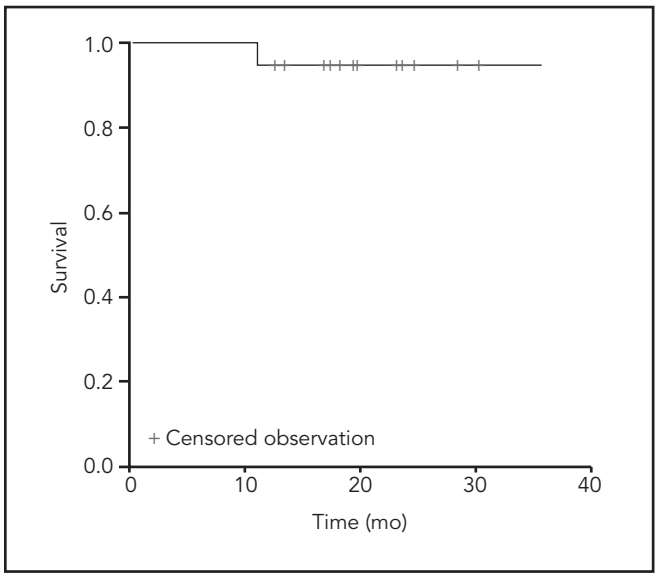


Fig 3 *Kaplan-Meier estimate for implant survival.*

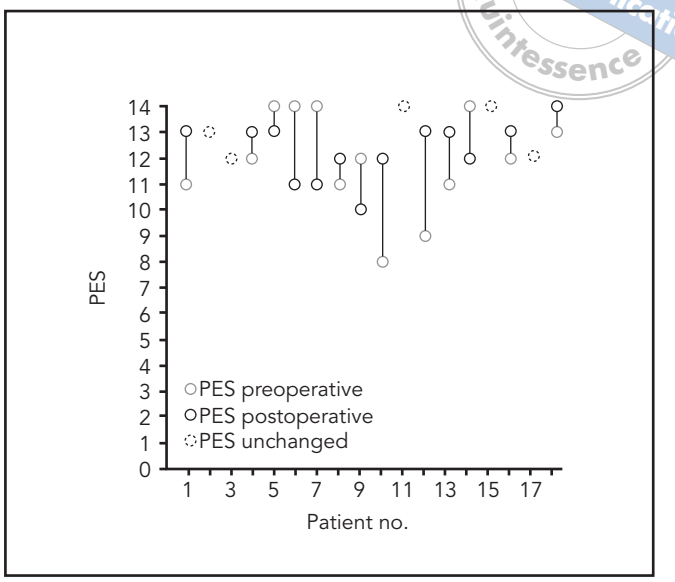


Fig 4 *Pre- and postoperative PES ratings. In approximately 70% of implants, the esthetic status was improved or preserved compared with the initial situation.*

Probing depth

Mean peri-implant probing depth ranged from 3.7 mm (facial) to 4.6 mm (disto-oral). Probing depths indicated no inferior bone level on the facial aspect (mean, 3.7 mm) when compared to the oral aspect (mean, 3.9 mm). By contrast, the distolingual probing depth was slightly higher than the distobuccal (4.6 vs 4.2 mm), reflected in a moderate trend toward a difference ($P = .073$, Wicoxon matched pairs analysis). Thus, the data suggest no relevant differences between marginal tissue levels at the preserved oral and reconstructed facial aspects of the implants. In the "complication case" (Fig 2), probing depths of up to 9 mm were observed.

Marginal bone level

Referring to the contour of the first thread, the average interproximal marginal bone level was 1.3 mm (range, –2.6 to 2.7 mm) at the mesial aspect and 1.0 mm (range, –3.9 to 3.1 mm) at the distal aspect. The respective values in the "complication case" were –2.6 and –3.9 mm. Excluding the complication case, the average interproximal marginal bone level was 1.6 mm (range, 0.0 to 2.7 mm) at the mesial aspect and 1.3 mm (range, 0.0 to 3.1 mm) at the distal aspect.

When the interproximal marginal bone level was considered as a function of time, there was no correlation between the marginal bone status and the length of the follow-up period ($r = –0.368$, $P = .133$; Spearman rank correlation coefficient).

Follow-up CBCTs were available for 16 patients. The reconstruction of up to 10 slices within the long axis of the implants confirmed gross reconstitution of the facial bony lamella in all patients (Fig 1e). However, in 4 patients, single slices suggested small longitudinal zones of incomplete bone coverage in the midline at the facial prominence measuring 0.5 to 1.0 mm in width.

PES

Improvement of the PES was noticed in 8 implant sites. In 5 sites, the esthetic status was unchanged, while 5 sites sustained a slight to moderate decrease (Fig 4). Thus, overall, the PES remained unchanged by the intervention ($P = .646$, Wilcoxon matched pairs test). At the final

Copyright by Quintessence Not for Publication

Table 1 Mean pre- and postoperative PES values

Variable	Preoperative	Postoperative
Mesial papilla	1.7	1.6
Distal papilla	1.6	1.7
Level of soft tissue margin	1.7	1.7
Soft tissue contour	1.8	2.0
Alveolar process contour	1.9	1.6
Soft tissue color	1.8	1.9
Soft tissue texture	1.7	2.0
Total	12.2	12.5

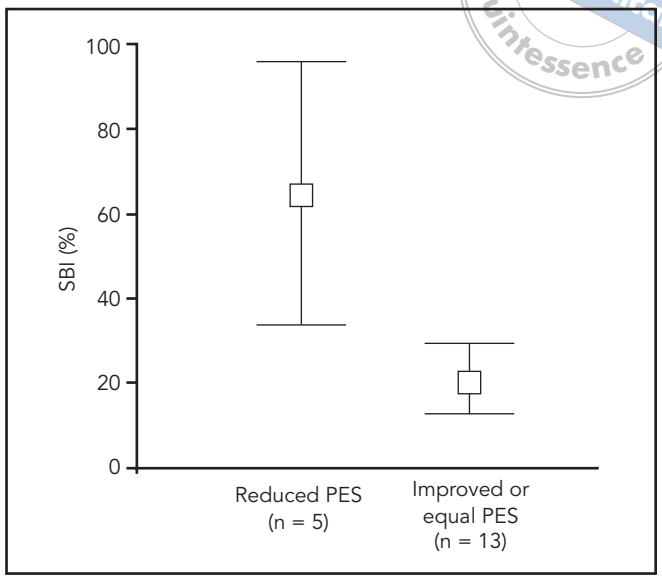


Fig 5 *SBI according to esthetic outcome. When comparing the implants with reduced postoperative PES scores to those with improved or equal scores, the preoperative SBI emerged as a simple predictive parameter.*

examination, the mean PES amounted to 12.5 (range, 10.0 to 14.0), while the preoperative PES averaged 12.2 (range, 8.0 to 14.0). The detailed values of the PES are given in Table 1. Thus, the integrity of the gingival architecture could be largely maintained with this flapless approach. The most critical single PES item in this cohort was the alveolar process contour. In 12 implant sites, the natural appearance of this zone was preserved, but another 6 sites showed a slight to moderate loss of the bony contour.

When looking at potential determinants of the PES, neither demographic or anamnestic data nor the interproximal marginal bone level were predictive for the postoperative esthetic outcome. However, the SBI was strongly associated with the esthetic outcome, with an increased SBI score suggesting an improved likelihood of a decrease in the esthetic score and vice versa ($P = .002$, *U* test) (Fig 5).

Discussion

This analysis addressed the clinical performance of a new flapless immediate implant placement and augmentation technique in patients with complete loss of the facial bony lamella because of vertical root fractures. Clinical reports on this issue are rare. Evian et al[26] reported the therapeutic management for immediate implant placement in sites with periapical deficiencies where the marginal bone was preserved. They raised a flap in the apical region without compromising the integrity of the coronal bone and gingiva. However, this technique is not suitable for complete facial bony defects.

To get one step further, a flapless approach was combined with a subperiostal ridge augmentation via bone chips for reconstruction of the entire facial alveolar wall. This treatment concept provides continuous bony support of the marginal gingiva and promises prevention of the collapse of the marginal contour.

Since primary stability is the cornerstone of immediate provisionalization, 16-mm-long implants were used and splinted to the neighboring teeth or other implants to assure maximum anchorage and to distribute stress to the surrounding bone.[27]

It remains open whether the specific implant design and surface or the surgical concept is the key to the support of the marginal contour

Copyright by Quintessence Not for Publication

and the reconstitution of the bony lamella. However, although all patients had extended defects of the facial alveolar bone lamella, the clinical outcome parameters were in line with the results reported for immediate loading of standard platform[5,6,18–21] or scalloped implants[28–32] in favorable bone conditions. Thus, success rates, marginal bone levels, and esthetic results suggest a proof-of-principle for this flapless immediate implant placement and augmentation technique.

It is remarkable that the results are in striking contrast to several previous reports[33–35] suggesting that soft tissue compromise and gingival recession could hardly be avoided, regardless of immediate[35] or delayed[33] provisionalization. However, there are fundamental differences between these studies and the current case series. In this study, the gingival architecture was preserved, implants were placed at the oral aspect of the alveolar contour allowing for bony reconstruction within the envelope, and allografts were avoided. Taken together, these details might explain the rather stable esthetic outcome, since they all contribute to minimal inflammatory reactions, which otherwise might promote renewed bone resorption and consecutive soft tissue collapse.

Due to the restriction of the case series to longitudinal root fractures, only a limited number of patients were included in this cohort. However, even with the small patient sample, oral hygiene emerged as a relevant predictive factor for esthetic outcome.

In spite of the promising results, implant-supported tooth replacement in the esthetic zone remains a critical issue, especially when the alveolar bone is lost because of inflammatory resorption. Although, on average, a favorable interproximal bone level was maintained and comparable PES ratings were obtained at pre- and postoperative evaluations, the data presented in Fig 4 indicate that a relevant proportion of the patients experienced some esthetic compromise. It remains to be explored whether these drawbacks may be avoided by a strict patient selection based on oral hygiene parameters such as the SBI or by further refinements of the surgical approach. However, by applying the protocol specified above, preservation or improvement of the esthetic status was achieved in two thirds of the patients.

Conclusion

Survival rates, marginal bone levels, and esthetic results suggest a proof-of-principle for a flapless immediate implant placement technique in patients with complete loss of the facial bony lamella. Oral hygiene status may be considered as a negative prognostic factor for the esthetic outcome.

Acknowledgment

This work was supported in part by a grant from Nobel Biocare to Dr Robert Noelken and Prof Wilfried Wagner.

References

1. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod 1989;15:512–516.
2. Zhi-Yue L, Yu-Xing Z. Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. J Prosthet Dent 2003;89:368–373.
3. Milot P, Stein RS. Root fracture in endodontically treated teeth related to post selection and crown design. J Prosthet Dent 1992;68:428–435.
4. Ricucci D, Bergenholtz G. Bacterial status in root-filled teeth exposed to the oral environment by loss of restoration and fracture or caries—A histobacteriological study of treated cases. Int Endod J 2003;36:787–802.
5. Wöhrle PS. Single-tooth replacement in the aesthetic zone with immediate provisionalization: Fourteen consecutive case reports. Pract Periodontics Aesthet Dent 1998;10:1107–1114.
6. Kan JYK, Rungcharassaeng K. Immediate placement and provisionalization of maxillary anterior single implants: A surgical and prosthodontic rationale. Pract Periodontics Aesthetic Dent 2000;12:817–824.
7. Keith JD Jr, Salama MA. Ridge preservation and augmentation using regenerative materials to enhance implant predictability and esthetics. Compend Contin Educ Dent 2007;28:614–621.
8. Cardaropoli G, Araújo M, Hayacibara R, Sukekava F, Lindhe J. Healing of extraction sockets and surgically produced—augmented and non-augmented—defects in the alveolar ridge. An experimental study in the dog. J Clin Periodontol 2005;32:435–440.
9. Salama H, Salama MA, Garber DA, Adar P. Developing optimal peri-implant papillae within the esthetic zone: Guided soft tissue augmentation. J Esthet Dent 1995;7:125–129.
10. Evian CI, al-Maseeh J, Symeonides E. Soft tissue augmentation for implant dentistry. Compend Contin Educ Dent 2003;24:195–198, 200–202, 204–206.
11. Carlsson GE, Bergman B, Headgård B. Changes in contour of the maxillary alveolar process under immediate dentures. A longitudinal clinical and x-ray cephalometric study covering 5 years. Acta Odontol Scand 1967;25:45–75.

Copyright by Quintessence Not for Publication

12. Becker W, Ochsenbein C, Tibbetts L, Becker BE. Alveolar bone anatomic profiles as measured from dry skulls. Clinical ramifications. J Clin Periodontol 1997;24: 727–731.
13. Spear FM. Maintenance of the interdental papilla following anterior tooth removal. Pract Periodontics Aesthet Dent 1999; 11:21–28.
14. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol 1992;63:995–996.
15. Salama H, Salama MA, Garber D, Adar P. The interproximal height of bone: A guidepost to predictable aesthetic strategies and soft tissue contours in anterior tooth replacement. Pract Periodontics Aesthet Dent 1998;10:1131–1141.
16. Ko CC, Douglas WH, DeLong R, et al. Effects of implant healing time on crestal bone loss of a controlled-load dental implant. J Dent Res 2003;82:585–591.
17. Kan JYK, Rungcharassaeng K. Site development for anterior implant esthetics: The dentulous site. Compend Contin Educ Dent 2001;22:221–226, 228, 230–231.
18. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. Int J Periodontics Restorative Dent 1989;9:332–343.
19. Gelb DA. Immediate implant surgery: Three-year retrospective evaluation of 50 consecutive cases. Int J Oral Maxillofac Implants 1993;8:388–399.
20. Hui E, Chow J, Li D, Liu J, Wat P, Law H. Immediate provisional for single-tooth implant replacement with Brånemark system: Preliminary report. Clin Implant Dent Relat Res 2001;3:79–86.
21. Kan JYK, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.
22. Noelken R, Morbach T, Kunkel M, Wagner W. Immediate function with NobelPerfect implants in the anterior dental arch. Int J Periodontics Restorative Dent 2007;27:276–285.
23. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. Clin Oral Implants Res 1997;8:161–172.
24. Mühlemann HR, Son S. Gingival sulcus bleeding—A leading symptom in initial gingivitis. Helv Odontol Acta 1971;15: 107–113.
25. Fürhauser 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.
26. Evian CI, Al-Momani A, Rosenberg ES, Sanavi F. Therapeutic management for immediate implant placement in sites with periapical deficiences where coronal bone is present: Technique and case report. Int J Oral Maxillofac Implants 2006; 21:476–480.
27. Bergkvist G, Simonsson K, Rydberg K, Johansson F, Dérand T. A finite element analysis of stress distribution in bone tissue surrounding uncoupled or splinted dental implants. Clin Implant Dent Relat Res 2008;10:40–46.
28. Rocci A, Gottlow J. Esthetic outcome of immediately loaded scalloped implants placed in extraction sites using flapless surgery. A 6 months report of 4 cases. Appl Osseo Res 2004;4:55–62.
29. Wöhrle PS. Nobel Perfect esthetic scalloped implant: Rationale for a new design. Clin Implant Dent Relat Res 2003; 5(suppl 1):64–73.
30. Nowzari H, Chee W, Yi K, Pak M, Ho Chung W, Rich S. Scalloped dental implants: A retrospective analysis of radiographic and clinical outcomes of 17 NobelPerfect implants in 6 patients. Clin Implant Dent Relat Res 2006;8:1–10.
31. McAllister BS. Scalloped implant designs enhance interproximal bone levels. Int J Periodontics Restorative Dent 2007;27: 9–15.
32. Kan JYK, Rungcharassaeng K, Liddelow G, Henry P, Goodacre CJ. Periimplant tissue response following immediate provisional restoration of scalloped implants in the esthetic zone: A one-year pilot prospective multicenter study. J Prosthet Dent 2007;97(suppl):S109–S118 [erratum 2008;99:167].
33. Evans CJD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
34. 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.
35. 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 [erratum 2008;66:2195–2196].