Immediate placement and restoration of implants in the esthetic zone: Trimodal Approach therapeutic options

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Abstract

Recently, a number of clinical and animal studies have been published suggesting the advantages of using immediate post-extraction implants under a flapless protocol, followed by the simultaneous placement of an implant-supported provisional restoration (Trimodal Approach [TA]). Indications and risk of complications of this therapeutic option have also been thoroughly discussed in the literature. Different protocols have been advocated in order to minimize the possible esthetic impact of the post-extraction remodeling of the bundle bone. These include a correct implant position, a flapless approach, the use of an immediate implant-supported provisional restoration, and filling the osseous gap with different biomaterials or thickening the mucosal compartment through soft-tissue grafts. These techniques have been mostly indicated when intact alveolar walls are present at the time of tooth extraction. In this article, the conventional TA is described. Thereafter, variations of this option are discussed, being the modification of the osseous compartment (TAO), and the modification of the mucosal and osseous compartments (TAOM).

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Introduction

Following tooth extraction, a number of events take place in the healing process of the alveolar bone that may considerably affect the architecture of the gingival tissue.[1] The survival rates of immediately post-extraction-placed implants have been shown to be very similar when compared to those of implants placed in healed bone.[2-5]

Recent publications show that immediate implant placement will not affect the physiologic remodeling,[6-11] as this process is associated with the resorption of the bundle bone that follows tooth extraction.

Other studies[12] suggest that a flapless approach will result in a reduced alteration of the soft-tissue contour, as this technique would minimize surgical trauma and, consequently, osteoclastic activity in the area.

Immediate implant placement in the anterior maxilla seems an attractive option, as it is possible to control implant position in single-rooted sockets, and it minimizes the total treatment time from extraction to final restoration. However, numerous articles warn about the risk of unpredictable tissue healing when immediate implants, with or without an immediate provisional restoration, are implemented, showing mean retraction of the soft tissues of 0.5 to 1 mm.[13-17]

A number of factors have been analyzed concerning the final contour of the buccal soft and hard tissue when immediate implants are implemented. Some of these are dimensions of the periodontium and implant position,[1,13,18] flap versus flapless approach,[12,19] distance from the implant neck to the buccal bone wall,[20,21] filling (or not) this space with any bone substitutes,[18,22-24] and placement of an immediate implant-supported provisional restoration.[15,16,25-27] Although no single factor seems to be determinant in the final esthetic outcome, most authors agree that an intact buccal bone wall and ideal implant position are essential when immediate implants are selected as the treatment option.

In selected patients, an immediate implant-supported provisional restoration may be delivered at the time of surgery (Bimodal Approach).[26] The risk increases when a flapless approach is added to the procedure,[27,28] as no visual references of the shape and volume of the buccal bone wall are available. In spite of these considerations, this protocol is often selected as the best treatment option as it reduces trauma and treatment time, and provides immediate esthetics and comfort, making it very well accepted by the patient.[16,17] This procedure could be named the "Trimodal Approach" (TA),[27] for it includes immediate postextraction implant and provisional restoration placement under a flapless protocol (Fig 1).

In their study, Cabello et al[27] analyze the clinical results of the TA on a sample of 14 patients, where single implant-supported restorations in the esthetic zone were delivered. An attempt was also made to correlate the results with the initial gingival biotype of the subjects. The results of this study show a mean recession of 0.45 mm (± 0.25 mm) at 12 months, and an adequate maintenance of mesial and distal papillae.[30] No correlation could be established between the soft-tissue alterations and the gingival biotype.

In the aforementioned article, the authors hypothesize about the role of the provisional restoration, saying that it may produce an “inhibition by contact” for those faster-growing tissues (epithelium and connective tissue), a phenomenon described as Restorative Tissue Inhibitor (RTI). Figs 2 and 3 illustrate this hypothesis.

Most authors agree that these approaches require the integrity of the alveolar walls. This makes a thorough pre-operatory diagnosis and a traumatic extraction procedure critical.

In order to reduce the recession of the peri-implant soft tissues, Araújo et al, in a study on 5 Beagle dogs, showed osseous reduction and mucosal margin recession in immediate implants when the alveolar gap, in its buccal compartment, was filled with a biomaterial.[31]

Other authors have suggested the use of a connective-tissue graft as a simultaneous procedure, by itself or together with the filling of the osseous gap, to improve the esthetic outcomes in very demanding scenarios.[29,32,33]

Different classifications concerning the timing of implant placement and surgical protocols have been previously published.[34-36] These authors propose strategic surgical approaches to different initial clinical situations, particularly related to the presence or absence of soft- and hard-tissue defects. The interesting thing about the classification that we are now proposing is that it solely relates to a Hämmerle’s type I situation (immediate post-extraction implant), with intact alveolar walls, no periodontal or soft-tissue defects, and included in a TA (immediate implant/flapless/immediate provisional implant-supported

Fig 1 Representation of the correct position of the implant in the postextraction socket to allow for a directly screw-retained restoration.

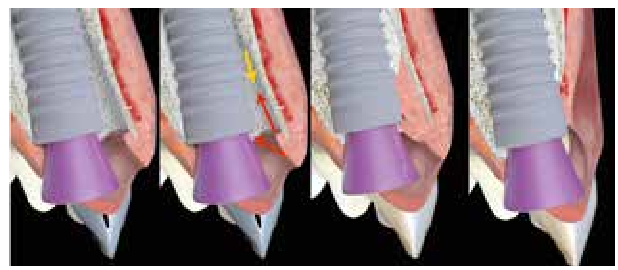

Fig 2 The establishment of a gap between the implant and the osseous wall, and a space between the healing abutment (or a non-anatomical provisional restoration) and the soft tissue, may generate a colonization of this space by cells of those tissues with faster turnover.

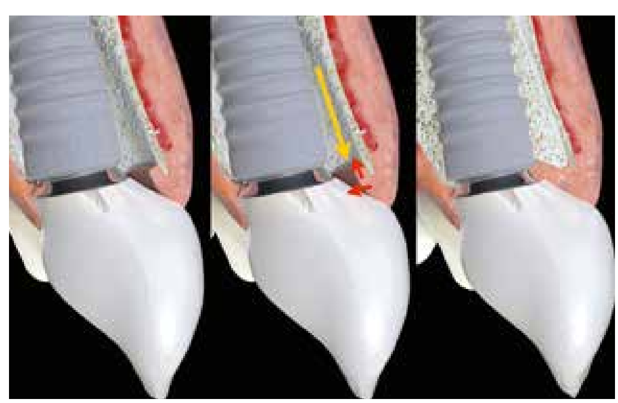

Fig 3 The use of an anatomical contour in the provisional restoration may produce an “inhibition by contact” phenomena that, in turn, will exclude the faster-turnover cells and promote an optimal osseous healing (Restorative Tissue Inhibitor [RTI]).

Fig 4 Trimodal Approach (TA) using a bone level implant and an implant-supported provisional restoration with natural contours, mimicking the extracted natural tooth.

According to the body of information available, three different protocols of the TA may be considered:

- Conventional Trimodal Approach (TA).
- Trimodal Approach with osseous modification (TAO), through filling the buccal alveolar gap with a biomaterial.
- Trimodal Approach with osseous and mucosal modification (TAOM), through a combination of filling the buccal alveolar gap with a biomaterial and adding a buccal connective-tissue graft.

restoration). An open discussion is currently taking place about whether additional procedures should be added to the TA protocol, and a number of studies comparing the clinical results obtained with these different techniques should be expected in the near future. Thus, the classification that follows could help clinicians to chose the appropriate procedure for their patients in the light of the published research.

Conventional Trimodal Approach (TA)

(Fig 4 refers.) A female patient, age 61, presented with a horizontal radicular fracture in the maxillary right canine, resulting in a very bad prognosis for the restoration of the root.[37,38] An implant-supported crown, implementing a TA, was suggested and accepted as the treatment option (Figs 5 and 6).

After exploring the buccal marginal bone position through bone probing, a careful tooth extraction was performed,

Fig 5 Anterior view of the fractured maxillary right canine.

Fig 6 Close-up view of the fracture.

using the Benex extractor (Benex Root Extraction System, Hager & Meisinger) (Figs 7 to 9). Thereafter, and following confirmation of the alveolar wall integrity, the implant site was prepared without a flap elevation, and the implant (TE 4,1x14, SLActive, Straumann) was placed, with an angulation compatible with a screw-retained restoration (Figs 10 and 11). The most coronal level of the polished surface of the implant neck was 2 mm apical to the planned buccal margin of the future restoration,

Fig 7 Detailed aspect of the Benex extractor before the extraction procedure.

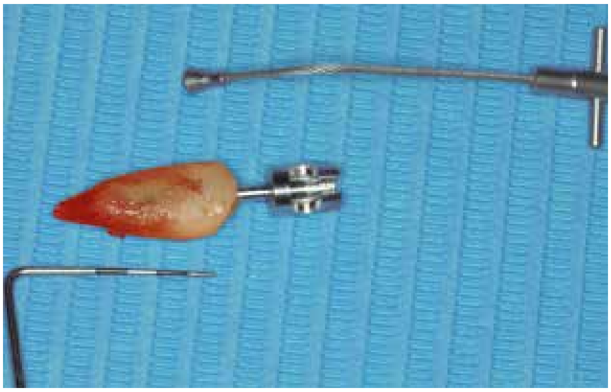

Fig 8 The extracted root and inspection of the anatomy and size to confirm the indication of an immediate implant placement.

Fig 9 Intact alveolar socket and soft-tissue after the extraction.

Fig 10 TE SLActive implant before insertion into the prepared site.

Fig 11 Inserted implant with the transporting device.

Fig 12 Implant-supported provisional restoration delivered after the TA procedure.

Fig 13 Provisional restoration after 3 months of healing.

Fig 14 Impression-making with a customized component to transfer the emergence profile of the provisional restoration to the working cast.

to allow for an adequate emergence profile. Once the implant was inserted and primary stability was confirmed, a provisional implant-supported, screw-retained restoration was produced and delivered through an intra-oral direct procedure. The provisional acrylic resin crown was adjusted to have no occlusal contact, both in maximal intercuspation and in excursive movements, and the emergence profile for this crown was designed so that it simulated the natural tooth contours (anatomic profile) in order to have direct contact with the soft tissue to support it and to produce the Restorative Tissue Inhibitor (RTI) effect (Figs 12 and 13). Postoperative treatment with antibiotics, anti-inflammatories and antiseptic mouth rinse was prescribed, and 10 and 30 days recall visits were performed.

Three months after the surgical and immediate restorative procedures, a final impression was made with a customized impression component to transfer the emergence profile to the working cast (Fig 14).

The final restoration consisted of a metal-ceramic crown, directly screw-retained to a RN synOcta 1,5 abutment (Straumann), using a gold cast-on component (Figs 15 to 19).

The clinical aspect at 12 months and 3 years can be seen in Figs 18 and 19, and 20 and 21, respectively, showing the soft-tissue stability both in the vertical (recession) and horizontal (collapse) dimensions.

Fig 15 Occlusal aspect of the peri-implant soft tissue at the time of final restoration placement.

Fig 16 Buccal aspect of the peri-implant soft tissue once the titanium synOcta abutment has been connected.

Fig 17 Insertion of the screw-retained metal-ceramic restoration.

Fig 18 The final restoration on the day of delivery.

Fig 19 Esthetic aspect of the restoration in smile.

Fig 20 The implant-supported restoration at 3 years.

Fig 21 Aspect of the soft tissue in occlusal view following crown removal at 3 years.

Trimodal Approach with osseous modification (TAO)

(Fig 22 refers.) A female patient, age 38, presented with a tooth fracture in the maxillary right central incisor that again derived into a non-restorable clinical scenario due to the lack of a desirable dentinal ferrule.[37,38] The patient also presented with a defective metal-ceramic crown in the left maxillary incisor, which helped to control the esthetic risk, as both gingival margins could be modified to improve symmetry (Figs 23 and 24).

Fig 22 Trimodal Approach modified with osseous graft in the alveolar gap (TAO).

A traumatic extraction of root 11 was performed under local anesthesia with the Benex extractor (Figs 25 to 27). Careful examination revealed the integrity of the alveolar walls (Fig 28). The implant site was prepared as for the previous patient (TA), except a bone level implant was used (Bone Level 4,1x12 SLActive, Straumann), and the shoulder of the implant was placed slightly subcrestal. A crown-lengthening procedure was performed in the left central incisor with gingivectomy and ultrasonic ostectomy (Figs 29 to 32). After crown lengthening and implant insertion (Fig 33), both provisional restorations – implant and tooth-supported – were made (Figs 36 and 37), and the osseous gap was filled with a xenograft (Bio-Oss, Geistlich). The implant-supported provisional crown was designed as for the previous patient (TA) with an anatomic emergence profile

Fig 23 Initial view of the patient, presenting with 2 crowns in 11 and 21. Tooth 11 has a vertical root, non-restorable. Note that the gingival margin of 11 is slightly more apical than that of 21.

Fig 24 Non-restorable root of right maxillary central incisor.

Fig 25 Root extraction with the Benex extractor.

Fig 26 Clinical aspect of the soft tissues right after the extraction.

Fig 27 The extracted root under inspection of its size and shape to determine the possibility of an immediate implant procedure.

Fig 28 A curette is used to check the integrity of the alveolar walls, a requirement for the TA approach.

Fig 29 Gingivectomy of the adjacent central incisor to produce a gingival margin 0.5 mm apical to the extracted tooth.

Fig 30 Removal of the surgically excised tissue.

Fig 31 Depth and position implant indicator in the prepared site, and intrasulcular ostectomy on the adjacent tooth to provide adequate biologic width.

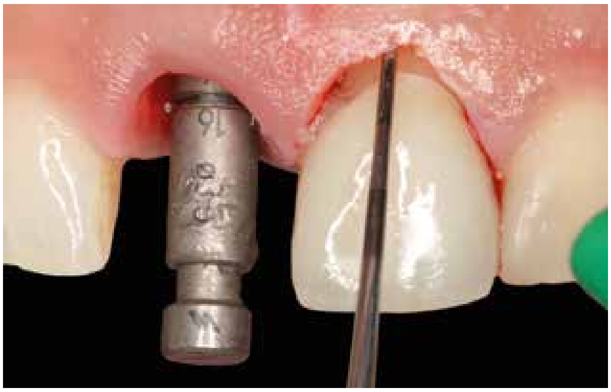

Fig 32 Bone probing to verify the biologic width.

Fig 33 The implant (Bone Level 4,1x14 SLActive, Straumann) during insertion.

Fig 34 The titanium provisional component before the relining of the provisional shell with acrylic resin.

Fig 35 The provisional implant-supported restoration after trimming and polishing, with an anatomic emergence profile reproducing the extracted natural tooth.

Fig 36 A xenograft (Bio-Oss, Geistlich) is used to fill the buccal gap between the implant and the alveolar wall.

Fig 37 Condensation of the biomaterial with a ball instrument.

Fig 38 Clinical view of both provisional restorations, implant and tooth-supported, respectively, right after surgery.

Fig 39 Detailed view of soft-tissue maturation at the time of final impression, 4 months after surgery.

Fig 40 Final ceramic restorations with custom-made zirconia structure (CARES CAD/CAM, Straumann).

Fig 41 Detailed view of the final restorations, showing the natural emergence profile in the implant-supported crown.

Fig 42 Occlusal view of the tooth preparation and implant site. Note the adequate volume in the buccal aspect of the implant, showing no signs of collapse.

Fig 43 Clinical sequence of the restorations try-in.

Fig 44 Final restorations on the day of delivery.

Fig 45 The patient's smile with the new restorations.

Fig 46 The restorations at 2 years recall.

(Fig 38). The tooth-supported provisional crown was made out of acrylic resin (Unifast III, GC), and cemented with provisional cement (Temp-Bond NE, Kerr).

Four months after implant placement, the final impression was made, again with an individualized impression coping (Pattern Resin, GC). Double-cord technique was used to improve the registration of the finish line of the natural tooth (Ultrapak Retraction Cord, Ultradent).

In the dental laboratory, two single, all-ceramic, zirconia-based crowns (CARES, Straumann) were elaborated. The implant-supported crown consisted of a custom-made zirconia abutment directly screw-retained, on which esthetic ceramic was applied. It has been shown that zirconia abutments have improved esthetic[39] and biologic results.[40,41] CAD/CAM technology was also utilized in the crown for the natural tooth (Figs 39 to 45).

The clinical photos show the esthetic outcome at delivery (Figs 44 and 45), and at 2 years recall (Figs 46 and 47).

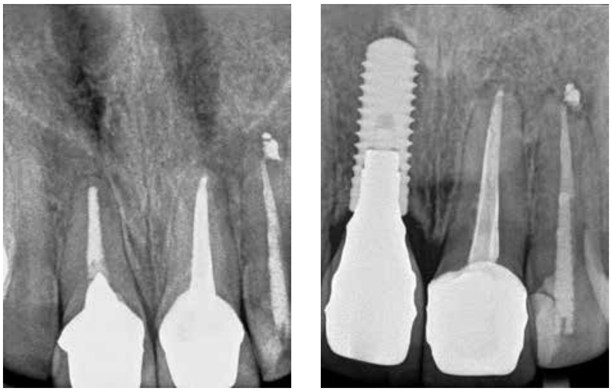

Fig 47 Radiographs pre-operatory, and 2 years after insertion of the restorations. Note the correct maintenance of the peri-implant bone level.

Trimodal Approach with osseous and mucosal modification (TAOM)

(Fig 48 refers.) A female patient consulted for mobility of maxillary right central incisor due to a horizontal subgingival fracture that made restoration unrealistic. Adjacent teeth presented with multiple defective composite restorations that needed replacement. As no procedures were planned to modify the gingival margins in the adjacent teeth, the prevention of soft-tissue changes around the implant site had to be maximized. Thus, a modified TA with osseous and mucosal grafting (TAOM) was recommended (Figs 49 to 51).

After the careful extraction of the fractured tooth (Figs 52 to 54), and examination of the alveolar walls (Fig 55), the implant site was prepared, as previously described. The implant (Bone Level 4,1x14 SLActive, Straumann) was placed, and primary stability confirmed.

Fig 48 Illustration of the TA protocol with osseous and mucosal modification (TAOM).

Fig 49 Clinical view of the maxillary anterior sextant, where the maxillary right central incisor presents with a horizontal root fracture in the coronal third.

Fig 50 View of the patient's smile.

Fig 51 Bone probing of the problem tooth confirming the correct level of the buccal alveolar wall.

Fig 52 Root extraction with the Benex extractor.

Fig 53 Detailed analysis of the extracted root.

Fig 54 Clinical view after the extraction, showing the intact gingival architecture.

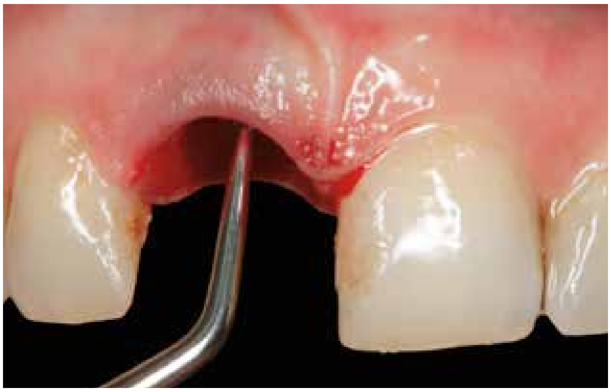

Fig 55 Examination of the alveolar walls to discard dehiscences or perforations.

Fig 56 View after implant insertion (4,1x14 BL SLActive, Straumann) and connection of the provisional titanium abutment before acrylic resin shell relining.

Fig 57 Filling the osseous gap with bovine xenograft (Bio-Oss, Geistlich).

Fig 58 Preparation with a partial-thickness incision using a micro scalpel in the buccal gingival to host a connective-tissue graft.

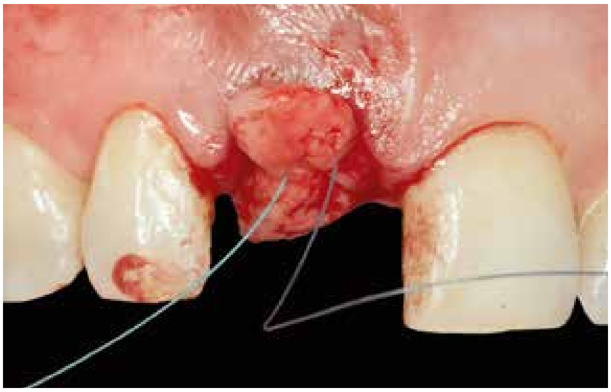

Fig 59 Free connective-tissue graft from the palatal mucosa, before its insertion into the buccal envelope.

Fig 60 Occlusal view, showing placed soft-tissue graft.

Thereafter, the provisional restoration was produced and adjusted, as previously described (Fig 56). The emergence profile in the buccal aspect was slightly concave in this case, as a soft-tissue graft is to be allocated in that area. The osseous gap was filled with bovine xenograft (Bio-Oss, Geistlich) (Fig 57). Finally, an envelope technique was used to secure a free palatal mucosa soft-tissue graft, to minimize soft-tissue shrinkage (Figs 58 to 60). Care was taken to adjust the occlusal contacts of the provisional restoration (Fig 61).

Suture removal for the donor site in the palate was at 10 days, and control appointments were at 1 month (Fig 62) and 3 months, all presenting uneventful healing. Four months after the implant placement, a final impression was made reproducing the emergence profile of the provisional restoration (Fig 63). A direct, zirconia-based, all-ceramic crown was delivered (CARES, Straumann) (Figs 64 to 66).

Discussion

Immediate implants have become a routine procedure as they have a similar survival rate when compared to implants placed in healed bone. Immediate (type 1) protocol is readily accepted by clinicians and patients as it implies one surgical intervention and less trauma, and may provide immediate esthetics and comfort, as well as a shorter total treatment time.[2-5] However, this protocol is considered esthetically risky by many, as post-extraction healing of the alveolar bone may lead to unpredictable changes in the peri-implant tissues, thus altering the gingival architecture and contour. It has been proven that bone remodeling always takes place, even when an immediate implant is placed, as this phenomenon is associated with the resorption of the bundle bone, present only around the natural teeth.[8-10] This process seems to particularly affect the integrity of the often thin buccal wall,[6,7,11] in many patients barely 0.5 mm of total thickness in its coronal section.

A number of clinical protocols have been suggested to control or minimize the effects of this healing process, these being a flapless approach,[12,19] grafting of the alveolar space between the implant and the vestibular wall with different biomaterials,[22-24] or the use of an immediate, implant-supported provisional restoration.[15,16,25-27] However, most of these studies focus on implant survival and hard-tissue changes, paying little attention to the soft-tissue alterations and final esthetic outcome.

Cabello et al,[27] in a recent study using a conventional TA, describes apical changes of the vestibular mucosal margin to be minimal at 12 months (0.45 ± 0.25 mm). No correlation could be established between the gingival biotype or the width of the keratinized mucosa and the aforementioned soft-tissue alterations for this group of patients. In this study, the role of the provisional implant-supported restoration is emphasized, hypothesizing about a possible inhibition by contact of the soft-tissue progression.

A number of research groups have also studied the hard- and soft-tissue changes around immediate implants with somewhat controversial results,

Fig 61 Provisional crown with a slightly concave profile in the buccal aspect to provide room for the soft-tissue graft, and to allow for maturation and increased volume.

Fig 62 Clinical view 6 weeks after surgery.

Fig 63 Impression-making with a customized component to transfer the emergence profile of the provisional restoration to the working cast.

Fig 64 Detailed view of the final restoration, showing the anatomical emergence profile.

Fig 65 Final restoration at the moment of delivery.

Fig 66 Final restorations on the day of delivery.

Fig 67 Final restoration in a lateral view. Note the adequate volume in the buccal aspect of the implant.

mainly due to study design, particularly patient selection and measuring techniques.[42-51]

Although the TA protocol, in view of recent clinical research, is being progressively accepted as a good option when intact alveolar walls are present, a mean recession of 0.5 mm should be expected and taken into consideration. Is for this reason that a number of clinical steps have been suggested and incorporated into the protocol, in order to minimize soft-tissue architecture and volume changes.

To control peri-implant soft-tissue recession, Araújo et al, in a study with 5 Beagle dogs,[31] analyzed the effect of a biomaterial (Bio-Oss Collagen, Geistlich) in the buccal osseous gap when around immediate implants. The results of this study show that changes in both soft tissue and bone levels were higher (1 mm) in control sites when compared with test sites at 6 months.

Another suggested technique is to increase soft-tissue thickness via connective-tissue graft.[29,32,33] Kan et al[29] analyzed the results when a TA protocol was combined with an osseous gap filled with a xenograft (Bio-Oss, Geistlich), together with a connective tissue graft (envelope technique) in the buccal peri-implant mucosa. They treated 20 patients and followed them a mean of 2.5 years (range 1 to 4 years), recording a mean facial gingival level changes of +0.13 mm (± 0.61). They observed slight (though not statistically significant) differences between thin tissue biotype patients (+0.23 mm) and thick tissue biotype patients (+0.06 mm). Cornelini et al,[32] in a similar study, present a gain in the apical position of the buccal mucosal margin of 0.2 mm when combining a TA protocol with the modification of the peri-implant osseous compartment and grafting soft tissue simultaneously. Both research groups recommend this approach in thin biotype patients, as a thicker soft tissue will result.

In spite of this new data, the comparative effectiveness of a TA conventional approach versus a TA protocol with modification of the osseous and soft-tissue compartments has not been clearly shown in well-controlled clinical studies. New research with more conclusive data in this respect is needed.

Conclusions

According to the body of information available, three different modified protocols of the TA may be considered, which may lead to new clinical research, and can be classified as follows:

- Conventional Trimodal Approach (TA).
- Trimodal Approach with osseous modification (TAO), through filling the buccal alveolar gap with a biomaterial.
- Trimodal Approach with osseous and mucosal modification (TAOM), through a combination of filling the buccal alveolar gap with a biomaterial and adding a buccal connective tissue graft.

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References

1. Chen ST, Wilson TG Jr, Hämmerle CH. Immediate or early placement of implants following tooth extraction: review of biologic basis, clinical procedures, and outcomes. Int J Oral Maxillofac Implants 2004;19(suppl):12–25.
2. Bianchi AE, Sanfilippo F. Single-tooth replacement by immediate implant and connective tissue graft: a 1-9-year clinical evaluation. Clin Oral Implants Res 2004;15:269–277.
3. Lang NP, Tonneti MS, Suvan JE, et al. Immediate implant placement with transmucosal healing in areas of aesthetic priority. A multicenter randomized-controlled clinical trial. I. Surgical outcomes. Clin Oral Implants Res 2007;19:188–196.
4. Norton MR. A short-term clinical evaluation of immediately restored maxillary TiOblast single-tooth implants. Int J Oral Maxillofac Implants 2004;19:274–281.
5. Quirynen M, Van Assche N, Botticelli D, Berglundh T. How does the timing of implant placement to extraction affect outcome? Int J Oral Maxillofac Implants 2007;22(suppl):203–223.
6. 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;8:189–199.
7. Cardaropoli D, Debernardi C, Cardaropoli G. Immediate placement of implant into impacted maxillary canine extraction socket. Int J Periodontics Restorative Dent 2007;27:71–77.
8. Araújo MG, Sukekava F, Wennström JL, Lindhe J. Ridge alterations following implant placement in fresh extraction sockets: an experimental study in the dog. J Clin Periodontol 2005;32:645–652.
9. Araújo MG, Sukekava F, Wennström JL, Lindhe J. Tissue modeling following implant placement in fresh extraction sockets. Clin Oral Implants Res 2006;17:615–624.
10. Araújo MG, Wennström JL, Lindhe J. Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. Clin Oral Implants Res 2006;17:606–614.
11. Vignoletti F, de Sanctis M, Berglundh T, Abrahamsson I, Sanz M. Early healing of implants placed into fresh extraction sockets: an experimental study in the beagle dog. III Soft tissue findings. J Clin Periodontol 2009;36:1059–1066.
12. Fickl S, Zuhr O, Wachtel H, Boltz W, Hurzeler M. Tissue alterations after tooth extraction with and without surgical trauma: a volumetric study in the beagle dog. J Clin Periodontol 2008;35:356–363.
13. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
14. Gotfredsen K. A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: a pilot study. Clin Implant Dent Relat Res 2004;6:1–8.
15. Groisman M, Frossard WM, Ferreira HM, de Menezes Filho LM, Touati B. Single tooth implants in the maxillary incisor region with immediate provisionalization: 2 year prospective study. Prac Procedures Aesthetic Dent 2003;15:115–122.

16. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.
17. Kan JY, Rungcharassaeng K, Lozada J, 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.
18. 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.
19. Blanco J, Nuñez V, Aracil L, Muñoz F, Ramos I. Ridge alterations following immediate implant placement in the dog: flap versus flapless surgery. J Clin Periodontol 2008;35:640–648.
20. Paolantonio M, Dolci M, Scaranao A, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 2001;72:1560–1571.
21. Botticelli D, Berglundh T, Lindhe J. The jumping distance revisited: An experimental study in the dog. Clin Oral Implants Res 2003;14:35–42.
22. Juodzbalys G, Wang HL. Soft and hard tissue assessment of immediate implant placement: a case series. Clin Oral Implants Res 2007;18:237–243.
23. Iasella JM, Greenwell H, Miller RL, et al. Ridge preservation with freeze-dried bone allograft and collagen membrane compared to extraction alone for implant site development: a clinical and histological study in humans. J Periodontol 2003;74:990–999.
24. Araújo MG, Linder E, Lindhe J. Effect of a xenograft on early bone formation in extraction sockets: an experimental study in dog. Clin Oral Implants Res 2009;20:1–6.
25. Chaushu G, Chaushu S, Tzohar A, Dayan D. Immediate loading of single tooth implants: immediate versus non-immediate implantation. A clinical report. Int J Oral Maxillofac Implants 2001;16:267–272.
26. Atieh MA, Payne AGT, Duncan WJ, Cullinan MP. Immediate restoration/loading of immediate placed single implants: is it an effective bimodal approach? Clin Oral Implants Res 2009;20:645–659.
27. Cabello G, Rioboo M, Fábrega JG. Immediate placement and restoration of implants in the esthetic zone with a trimodal approach: soft tissue alterations and its relation to gingival biotype. Clin Oral Implants Res (in press).
28. Schwartz-Arad D, Yaniv Y, Levin L, Kaffe I. A radiographic evaluation of cervical bone loss associated with immediate and delayed implants placed for fixed restorations in edentulous jaws. J Periodontol 2004;75:652–657.
29. Kan JY, Rungcharassaeng K, Morimoto T, Lozada, J. Facial gingival tissue stability after connective tissue graft with single immediate tooth replacement in the esthetic zone: consecutive case report. J Oral Maxillofac Surg 2009;67(11, suppl):40–48.
30. Jemt T. Regeneration of gingival papillae after single-implant treatment. Int J Periodontics Restorative Dent 1997;17:327–333.
31. Araújo MG, Linder E, Lindhe J. Bio-Oss collagen in the buccal gap at immediate implants: a 6-month study in the dog. Clin Oral Implants Res 2011;22:1–8.
32. Cornelini R, Barone A, Covani U. Connective tissue grafts in postextraction implants with immediate restoration: A prospective controlled clinical study. Prac Procedures Aesthetic Dent 2008;20:337–343.
33. Chen ST, Darby IB, Reynolds EC, Clement JG. Immediate implant placement postextraction without flap elevation. J Periodontol 2009;80:163–172.
34. Hämmerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19(suppl):26–28.
35. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. Cochrane Database Syst Rev 2007;18:CD003878.
36. Funato A, Salama MA, Ishikawa T, Garber DA, Salama H. Timing, positioning, and sequential staging in esthetic implant therapy: a four-dimensional perspective. Int J Periodontics Restorative Dent 2007;27:313–323.
37. Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. J Prosthet Dent; 1990;63:529–536.
38. Libman WJ, Nicholls JI. Load fatigue of teeth restored with cast posts and cores and complete crowns. Int J Prosthodont; 1995;8:155–161.
39. Sailer I, Philipp A, Zembic A, Pjetursson BE, Hämmerle CH, Zwahlen M. A systematic review of the performance of ceramic and metal implant abutments supporting fixed implant reconstructions. Clin Oral Implants Res; 2009;20(suppl 4):4–31.

40. Abrahamsson I, Berglundh T, Glantz PO, Lindhe J. The mucosal attachment at different abutments. J Clin Periodontol 1998;25:721–727.
41. Welander M, Abrahamsson I, Berglundh T. The mucosal barrier at implant abutments of different materials. Clin Oral Implants Res 2008;19:635–641.
42. Chang M, Wennström JL, Ödman P, Andersson B. Implant supported single-tooth replacements compared to contralateral natural teeth. Crown and soft tissue dimensions. Clin Oral Implants Res 1999;10:185–194.
43. Cornelini R, Cangini F, Covani U, Wilson TG Jr. Immediate restoration of implants placed into fresh extraction sockets for single tooth replacement: a prospective clinical study. Int J Periodontics Restorative Dent 2005;25:439–447.
44. De Rouck T, Collys K, Cosyn J. Immediate single-tooth implants in the anterior maxilla: a 1-year case cohort study on hard and soft tissue response. J Clin Periodontol 2008;35:649–657.
45. De Rouck T, Collys K, Wyn I, Cosyn J. Instant provisionalization of immediate single-tooth implants is essential to optimize esthetic treatment outcome. Clin Oral Implants Res 2009;20:566–570.
46. Kan JY, Morimoto T, Rungcharassaeng K, Roe P, Smith DH. Gingival biotype assessment in the esthetic zone: visual versus direct measurement. Int J Periodontics Restorative Dent 2010;30:237–243.
47. Alpiste-Illueca F. Dimensions of the dentogingival unit in maxillary anterior teeth: A new exploration technique (parallel profile radiograph). Int J Periodontics Restorative Dent 1994;24:386–396.
48. Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong D, Wang HL. Tissue biotype and its relation to the underlying bone morphology. J Periodontol 2010;81:569–574.
49. Palattella P, Torsello F, Cordaro L. Two-year prospective clinical comparison of immediate replacement vs. immediate restoration of single tooth in the esthetic zone. Clin Oral Implant Res 2008;19;1148–1153.
50. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. Int J Periodontics Restorative Dent 2000;20:11–17.
51. 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.