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Consensus Statements and Recommended Clinical Procedures Regarding Surgical Techniques

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INTRODUCTORY REMARKS

Techniques and biomaterials associated with the surgical placement of dental implants continue to develop and have facilitated the expansion of clinical indications for implant therapy. However, the variety of procedures and biomaterials available can create a confusing picture for the implant surgeon who has the responsibility for recommending the most appropriate surgical approach with the lowest risk of complications and morbidity to the patient. The aim of group 4 was to review the surgical techniques and biomaterials used in current practice, and to evaluate the evidence supporting the use of these procedures.

Fourteen months prior to the conference, four groups of researchers prepared comprehensive review papers on four different topics: *(1)* clinical and esthetic outcomes of implants placed in postextraction sites, *(2)* bone augmentation procedures in localized defects in the alveolar ridge with different bone grafts and bone substitute materials, *(3)* bone augmentation procedures in extended defects in the alveolar ridge, and *(4)* ridge preservation techniques for implant therapy. The reviewers were asked to review the literature in a systematic manner, to consider all levels of evidence except for expert opinion, and to prepare narrative review papers. At the conference, these review papers were thoroughly critiqued by an international group of specialists in periodontics, oral and maxillofacial surgery, and prosthodontics, each with particular clinical expertise and research experience. First, the group was asked to consider whether the review papers were valid methodologically and whether the conclusions drawn were a fair reflection of the evidence available. Second, additional contributions by group members were called for and the manuscripts were amended if deemed appropriate. Third, preliminary consensus statements and clinical recommendations were drafted and presented to the plenum. Comments and recommendations were received from the plenum, and a final set of consensus statements and clinical recommendations were prepared.

Disclosure

All the group members were asked to reveal any conflicts of interest potentially influencing the outcomes of the consensus work. No such conflicts were identified.

IMPLANTS IN POSTEXTRACTION SITES

The following consensus statements and clinical recommendations are derived from the review paper by Chen and Buser, as well as that of Darby et al (on ridge preservation techniques).

Definition of Terms

At the 3rd ITI Consensus Conference in 2003, it was recognized that descriptive terms for the time points for implant placement after tooth extraction encountered in the dental literature were imprecise, and therefore open to interpretation. A classification system for timing of implant placement after tooth extraction was therefore proposed, based on desired clinical outcomes during healing rather than on descriptive terms or rigid time frames following extraction.[1] In this classification system, *type 1* refers to the placement of an implant into a tooth socket concurrently with the extraction; *type 2* refers to the placement of an implant after substantial soft tissue

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Table 1 Advantages and Disadvantages of the Various Time Points for Implant Placement After Tooth Extraction

Classification	Advantages	Disadvantages
Type 1	• Extraction and implant placement are combined in the same surgical procedure • Reduced overall treatment time compared to types 2, 3, and 4 • Peri-implant defects often present as two- or three-walled defects, which are favorable for simultaneous bone augmentation procedures	• Morphology of the site may increase the difficulty of placing an implant in an ideal position • Morphology of the site may compromise initial implant stability • Lack of soft tissue volume makes attainment of tension-free primary closure more difficult • Increased risk of marginal mucosal recession • Inability to predict bone modeling may compromise outcomes
Type 2	• Reduced treatment time • Additional soft tissue volume allows for easier attainment of tension-free closure • Additional soft tissue volume may enhance soft tissue esthetic outcomes • Flattening of facial bone contours facilitates grafting of the facial surface of the bone • Peri-implant defects often present as two- or three-walled defects, which are favorable for simultaneous bone augmentation procedures • Allows for resolution of pathology associated with the extracted tooth	• Two surgical procedures are required • Morphology of the site may compromise initial implant stability
Type 3	• Partial bone healing usually allows implant stability to be more readily attained • Additional soft tissue volume allows for easier attainment of tension-free closure • Additional soft tissue volume may enhance soft tissue-esthetic outcomes • Peri-implant defects often present as two- or three-walled defects, which are favorable for simultaneous bone augmentation procedures • Flattening of facial bone contours facilitates grafting of the facial surface of the bone • Allows for resolution of pathology associated with the extracted tooth	• Two surgical procedures are required • Extended treatment time as compared to type 1 and type 2 placement • Socket walls exhibit varying amounts of resorption • Increased horizontal bone resorption may limit the volume of bone for implant placement
Type 4	• Bone healing usually allows implant stability to be readily attained • Additional soft tissue volume allows for easier attainment of tension-free closure • Additional soft tissue volume may enhance soft tissue esthetic outcomes • Allows for resolution of pathology associated with the extracted tooth	• Two surgical procedures are required • Extended treatment time compared to type 1, type 2, and type 3 placement • Socket walls exhibit greatest amounts of resorption • Greatest chance of increased bone resorption limiting the volume of bone for implant placement

healing has taken place, but before any clinically significant bone fill occurs within the socket; *type 3* is placement of an implant following significant clinical and/or radiographic bone fill of the socket; and *type 4* is placement of the implant into a fully healed site.

In spite of this new classification system, descriptive terms have remained in use since 2003. Therefore, to avoid ambiguity and misinterpretation of the various time points for implant placement after tooth extraction, the descriptive terminology in the *ITI Treatment Guide, Volume 3*, as described above (see also Table 1 in the review by Chen and Buser) was adopted for this Consensus Conference.[2]

The following additional terms were defined:

- *Postextraction implant placement:* Used to collectively describe type 1, type 2, and type 3 implant placements.
- *Early implant placement:* Used to collectively describe type 2 and type 3 implant placements.
- *Peri-implant defect:* The space between the exposed implant surface and the inner surface of the walls of a fresh or healing extraction socket.
- *Ridge preservation:* A procedure to minimize vertical and horizontal ridge alterations in postextraction sites.

Healing and Regenerative Outcomes

Modeling of the ridge after extraction continues to occur following implant placement. Bone augmentation procedures are effective in promoting bone regeneration with immediate and early implant placement. Bone augmentation procedures may compensate for modeling changes and may improve ridge contours. Bone augmentation procedures are more successful with immediate and early implant placement than with late placement.

Survival Outcomes

The survival rates of postextraction implants are high and comparable to those of implants placed in healed sites.

Esthetic Outcomes

Immediate implant placement is associated with risk of mucosal recession. Risk indicators include thin tissue biotype, thin facial bone, dehiscence of the facial bone, and malposition of the implant.

Based on esthetic indices, 80% of immediate implant sites demonstrate satisfactory outcomes.

Ridge Preservation

Ridge preservation procedures following tooth extraction result in a greater orofacial dimension of bone than when no ridge preservation procedures are performed.

Advantages and Disadvantages of Implant Placement Times

There are advantages and disadvantages for each of the time points for implant placement following tooth extraction that should be carefully considered. These are described below and summarized in Table 1.

With immediate implant placement (type 1), combining tooth extraction and implant placement reduces the number of surgical procedures that the patient needs to undergo. The peri-implant defect usually presents as a two- or three-walled defect, which is amenable to simultaneous bone augmentation techniques. In addition, there is an opportunity to attach a provisional restoration to the implant soon after placement so that the patient avoids the need for an interim removable prosthesis. However, these advantages are counteracted by the increased technical difficulty of preparing the osteotomy to allow the implant to be placed with initial stability and in a good prosthetic position. There is also an increased risk of mucosal recession, which may compromise soft tissue esthetic outcomes. Additional hard and soft tissue augmentation procedures are usually required to overcome this risk, further increasing the technical demands of the procedure. Although grafting of the peri-implant defect with particulate bone or bone substitutes is readily achieved, grafting of the external surface of the facial bone is more demanding due to the convexity of the bone wall. If primary soft tissue closure is required, the lack of soft tissue increases the difficulty of attaining tension-free closure. Flap advancement may alter the mucogingival line. Clinicians should be mindful of the fact that bone modeling following tooth extraction is unpredictable. This may potentially lead to suboptimal bone regenerative outcomes and unpredictable dimensional changes.

With early implant placement (type 2), healing of the soft tissues increases the volume of mucosa at the site. This facilitates manipulation of the surgical flaps and allows flap advancement for partial submergence of the implant or primary closure to be more readily achieved. In areas of high esthetic importance, the increased volume of soft tissue may enhance soft tissue esthetic outcomes. In the 4- to 8-week period following tooth extraction, slight flattening of the facial bone wall is commonly observed. This facilitates grafting of the facial surface of the bone with bone substitutes possessing low rates of substitution. These grafts may serve to limit long-term dimensional changes of the ridge. As there is minimal bone regeneration within the socket at this time point, peri-implant defects are usually still present. However, the defects usually present with two or three intact walls, which are amenable to simultaneous bone augmentation techniques. The lack of bone regeneration within the socket may increase the difficulty of attaining initial stability of the implant. This approach allows pathology associated with the extracted tooth to resolve prior to implant placement.

For early implant placement (type 3), partial bone healing in the socket usually allows implant stability to be more readily attained compared to type 1 and type 2 placement. The soft tissues are usually fully healed, allowing tension-free closure of the site. The increased volume of soft tissue may enhance soft tissue esthetic outcomes. However, it should be noted that modeling of the bone is more advanced than with type 2 implant placement. The socket walls exhibit varying degrees of resorption that may limit the volume available for implant placement. Peri-implant defects may still be present, but they are usually reduced in orofacial dimension. Two- and three-walled defects are amenable to simultaneous bone augmentation procedures. Flattening of the facial bone facilitates grafting of the facial surface with bone substitutes, a procedure usually necessary for augmentation of ridge contour. With Type 3 placement, the increased time from tooth extraction allows healing of extended pathological defects to take place.

In late implant placement (type 4), the socket walls exhibit the greatest amount of resorption. Although the soft tissues are fully healed and manipulation of the surgical flaps is facilitated, ongoing modeling and horizontal resorption increases the risk of there being insufficient bone volume to place the implant. Additionally, there is a greater risk that peri-implant defects will present as no- or one-wall defects, compared to immediate and early implant placement.

Clinical Recommendations

- The clinician has the option of placing implants immediately, early, or late following tooth extraction. The advantages and disadvantages of each approach need to be carefully considered in order to reduce the risk of complications. Therefore, to ensure optimum outcomes, a proper risk assessment of the patient and site should be undertaken. This includes an esthetic risk assessment[3] in areas of esthetic importance.
- Whenever implants are placed in postextraction sites, the need for regenerative therapy must always be assessed. Bone augmentation is recommended to compensate for bone modeling, and to optimize functional and esthetic outcomes. In all

four placement protocols the ability to attain primary stability in the appropriate restorative position is a requirement. Presence of an acute infection is an absolute contraindication.

- Immediate implant placement (type 1) may be considered in patients and sites with a low esthetic risk profile.[3] This includes single-tooth sites with thick tissue biotypes and with thick and intact facial bone walls.
- Early implant placement with soft tissue healing (type 2) may be considered in the majority of sites due to an increased volume of soft tissue available. Early implant placement with partial bone healing (type 3) may be considered if primary stability of the implant in the correct restorative position cannot be achieved with type 2 placement.
- In sites where extensive bone modeling is anticipated, late implant placement (type 4) is the least desirable option. When Type 4 implant placement is indicated, ridge preservation procedures using low-substitution–rate graft materials and membranes are recommended. Such indications include the growing patient, where primary stability cannot be achieved with type 1, 2, or 3 placements due to anatomical restrictions, or when a delay in implant treatment is anticipated.

BONE AUGMENTATION PROCEDURES IN LOCALIZED ALVEOLAR RIDGE DEFECTS

The following consensus statements and clinical recommendations are derived from the review paper by Jensen and Terheyden. Aspects of this paper dealing with sinus floor grafting have been incorporated into the next section of these consensus statements.

Definition of Terms

The following definitions were adopted from the *Glossary of Oral and Maxillofacial Implants*[4]:

- *Autograft* (synonymous with *autogenous graft*): Tissue transferred from one location to another within the same individual.
- *Allograft:* A graft between genetically dissimilar members of the same species.
- *Xenograft:* A graft taken from a donor of another species.
- *Alloplast:* Inorganic, synthetic, or inert foreign material implanted into tissue.
- *Dehiscence:* A buccal or lingual bone defect in the crestal area extending apically at an implant.
- *Fenestration:* A buccal or lingual window defect of either bone or soft tissue, occurring over a root, implant, or alveolar ridge.

General Statements

There are a variety of augmentation materials available with different biologic and mechanical properties, ranging from particulate alloplastic materials to intraorally harvested block grafts.

There are a variety of defect situations with increasing complexity, ranging from fenestrations to dehiscences to lateral deficiencies to vertical deficiencies including combinations of these.

Survival rates of implants placed in regenerated bone after treatment of localized defects in the alveolar ridge are comparable to survival rates of implants placed in native bone. It was not possible to demonstrate the superiority of one augmentation technique over another based on implant survival rates.

Dehiscence and Fenestration-type Defects

Augmentation of dehiscence and fenestration-type defects is effective in reducing the amount of exposed implant surface. Complete resolution of dehiscence and fenestration-type defects cannot be predictably accomplished, regardless of which grafting protocol is employed.

Increased defect fill was observed when the augmentation procedure included the use of a barrier membrane.

Survival rates of implants placed simultaneously with augmentation of dehiscence or fenestration-type defects are high.

Horizontal Ridge Augmentation

Techniques are available to effectively and predictably increase the width of the alveolar ridge. Augmentation utilizing autogenous bone blocks with or without membranes results in higher gains in ridge width and lower complication rates than use of particulate materials with or without a membrane. Survival rates of implants placed in horizontally augmented alveolar ridges are high.

Vertical Ridge Augmentation

Techniques are available to increase the height of the alveolar ridge. However, the predictability is substantially lower and the complication rate substantially higher than with horizontal ridge augmentation procedures.

Augmentation utilizing autogenous bone blocks with or without membranes results in higher gains in ridge height than use of particulate materials with or without a membrane.

Survival rates of implants placed in vertically augmented alveolar ridges are high.

Maxillary Sinus Floor Elevation Using the Transalveolar Approach

Maxillary sinus floor elevation using the transalveolar approach is predictable for augmenting bone in the posterior maxilla. A variety of grafting materials can be safely and predictably used, alone or in combination. These materials include autografts, allografts, xenografts, and alloplastic materials. At present, it is not clear whether the introduction of a grafting material improves the prognosis.

Clinical Recommendations

- Dehiscence and fenestration-type defects may be successfully managed using a particulate autograft, allograft, or xenograft covered with a membrane.
- Horizontal ridge augmentations often require the use of an autogenous block graft, which may be combined with a membrane and/or a particulate autograft, allograft, or xenograft.
- Vertical ridge augmentations most often require the use of an autogenous block graft, which may be combined with a membrane and/or a particulate autograft, allograft, or xenograft. Despite the use of an autogenous block graft, elevated rates of complications and a need for additional grafting have to be anticipated. Even localized vertical bone deficiencies may require advanced surgical procedures like distraction osteogenesis, interpositional grafts, or onlay grafts from extraoral donor sites.
- The clinician should be aware that the obtainable defect fill decreases and complication rates and need for additional grafting procedures increase with more demanding defect types. The augmentation material should be selected according to the biologic and mechanical characteristics needed in the specific clinical situation.
- The use of a membrane is indicated whenever a particulate material is applied.

BONE AUGMENTATION PROCEDURES IN EXTENDED ALVEOLAR RIDGE DEFECTS

The following consensus statements and clinical recommendations are derived from the review paper by Chiapasco et al. These statements also incorporate aspects of the review paper by Jensen and Terheyden that deal with sinus floor grafting.

Definition of Terms

The following definitions were adopted from the *Glossary of Oral and Maxillofacial Implants*[4]:

- *Onlay graft:* A graft used in block form and fixed upon the cortical surface of the recipient bed with a screw. The origin may be an autograft, allograft, alloplast, or xenograft.
- *Maxillary sinus floor elevation:* An augmentation procedure for the placement of implants in the posterior maxilla where pnuematization of the maxillary sinus and/or vertical loss of alveolar bone has occurred.
- *Split-ridge technique:* An augmentation procedure to increase the width of a narrow residual ridge by surgically splitting it or expanding it with a series of osteotomes of increasing diameter.
- *Distraction osteogenesis:* A surgical process for reconstruction of skeletal deformities that involves gradual controlled displacement of surgically created fractures to simultaneously expand soft tissue and bone volume.

General Statements

Several surgical procedures are available and effective for the augmentation of deficient edentulous ridges, allowing implants to be placed. However, most of the studies are retrospective in nature, with small sample sizes and short follow-up periods. Therefore, direct comparisons between studies should not be made and definitive conclusions cannot be drawn.

Onlay Bone Grafting of Severely Resorbed Edentulous Ridges

Autogenous onlay bone grafting procedures are effective and predictable for the correction of severely resorbed edentulous ridges to allow implant placement. Uneventful healing/consolidation of grafts taken from intra- and/or extraoral donor sites occurs in the majority of cases.

Acceptable survival rates of implants placed in maxillae and mandibles reconstructed with autogenous onlay bone grafts are reported. The survival rates are slightly lower than those of implants placed in native bone.

Maxillary Sinus Floor Elevation Using the Lateral Approach

Maxillary sinus floor elevation procedures are predictable for augmentation of bone in the posterior maxilla. A variety of grafting materials can be safely and predictably used, alone or in combination. These materials include autografts, allografts, xenografts, and alloplastic materials. The use of autografts does not influence survival rates of rough-surfaced implants but may reduce healing times.

The quantity and quality of bone in the residual maxilla influence survival rates of implants independently from the type of grafting procedure.

Survival rates of rough-surfaced implants placed in augmented maxillary sinuses are similar to those of implants inserted in native bone.

Split-Ridge/Ridge-Expansion Techniques with Simultaneous Implant Placement

Split-ridge and expansion techniques are effective for the correction of moderately resorbed edentulous ridges in selected cases. Survival rates of implants placed at sites augmented using split-ridge/ridge-expansion techniques are similar to those of implants inserted in native bone.

Split-Ridge Technique with Interpositional Bone Grafts

There is a lack of evidence concerning the split-ridge technique with interpositional bone graft and delayed implant placement.

Vertical Distraction Osteogenesis

Alveolar distraction osteogenesis can be used to augment vertically deficient alveolar ridges in selected cases. It has a high rate of complications, which include change of the distracting vector, incomplete distraction, fracture of the distracting device, and partial relapse of the initial bone gain.

Survival rates of implants placed at sites augmented using distraction osteogenesis are similar to those of implants inserted in native bone.

Le Fort I Osteotomy with Interpositional Autogenous Bone Grafts

Le Fort I osteotomy with interpositional autogenous bone grafting can be used successfully to treat extreme atrophy of the maxilla associated with severe intermaxillary discrepancy. This procedure is technically demanding and is associated with considerable postoperative morbidity.

Survival rates of implants placed after Le Fort I osteotomy with interpositional autogenous bone graft are lower than those reported for implants placed in native bone.

Clinical Recommendations

- Bone augmentation procedures should always follow a prosthetically driven plan to allow ideal three-dimensional implant positioning. The concept of "prosthetically driven bone augmentation" should be taken into consideration whenever possible.

Autogenous Onlay Bone Grafting of Severely Resorbed Edentulous Ridges:

- Onlay bone grafting is a technique-sensitive procedure and is recommended only for well-trained clinicians.
- Both intraoral donor sites (including the mental symphysis, the mandibular body and ramus, and the maxillary tuberosity) and extraoral donor sites (including the iliac crest and the calvarium) can be used for collecting autogenous bone.
- The choice between intraoral and extraoral sites is mainly related to the quantity of bone necessary to reconstruct the deficient alveolar ridge. Preference should be given to donor sites where the cortical component is more prevalent, in order to reduce the risk of early or late resorption of the graft.
- Bone harvesting from the mental symphysis is associated with relevant morbidity, and the quantity of available bone is frequently limited. Neural damage to the incisal nerve occurs frequently. Therefore, the mental symphysis should not be the first choice for harvesting.
- Bone harvesting from the maxillary tuberosity is followed by low morbidity but is not well documented. The quality and quantity of available bone is often poor. Indications are limited to reconstruction of small defects.
- Bone harvesting from the mandibular ramus offers good quality and quantity of available bone, due to the possibility of harvesting from both sides.
- Bone harvesting from the iliac crest offers high quantities of bone. However, the cancellous bone component is dominant and may lead to a higher risk of unpredictable bone resorption. When bone is harvested from the anterior iliac crest there may be associated gait disturbances.
- Bone harvesting from the calvarium offers greater quantities of highly corticalized bone and is associated with low morbidity.
- Accurate modeling and stabilization of the graft with screws, and tension-free primary closure of the overlying flaps, are fundamental for the success of the procedure. Overcorrection of the defect is recommended to compensate for the potential risk of bone resorption. Coverage of the bone grafts with a low-resorption–rate xenograft/alloplastic material, with or without a membrane, may be indicated to reduce bone resorption.
- The economic and biologic costs of bone transplantation must be carefully weighed. In selected clinical situations short and/or reduced-diameter implants may be considered instead.
- The severely atrophic edentulous maxilla frequently needs onlay bone grafts due to poor quality of the residual bone and the presence of pneumatized cavities, including the maxillary sinus and the nose.
- Both implant placement in conjunction with bone grafting and delayed implant placement have been proposed. Delayed implant placement is recommended.

Split-Ridge/Ridge-Expansion Techniques:

- Split-ridge/ridge-expansion techniques are indicated in selected situations where atrophy of the edentulous ridge has developed horizontally and cancellous bone is present between the oral and facial cortical plates, and adequate residual height exists.
- Excessive facial inclination of the alveolar ridge may contraindicate this procedure, as it may worsen the initial situation from a prosthetic point of view.
- The presence of undercuts may increase the risk of bone fracture.
- This technique is mainly indicated in the maxilla. Ridge expansion in the mandible is frequently difficult due to the rigidity of the bone.

Vertical Distraction Osteogenesis:

- Vertical distraction osteogenesis is a technique-sensitive procedure and is recommended only for well-trained clinicians.
- Indications of this technique should be limited to vertically deficient ridges with adequate residual width. As the segment to be distracted has to be at least 3 mm in height, severely deficient mandibles are not good candidates due to the risk of neural damage and/or mandibular fracture.
- The presence of maxillary sinus and/or nasal cavities may be contraindications.
- The rigidity of the palatal mucosa may negatively influence the distraction vector.

Le Fort I Osteotomy with Interpositional Autogenous Bone Grafts:

- Le Fort I osteotomy with interpositional autogenous bone grafts is indicated in cases of extremely severe resorption, and where there is an unfavorable horizontal and vertical intermaxillary relationship.
- This procedure is technique-sensitive and is recommended only for well-trained clinicians.

Sinus Floor Elevation Using the Lateral Approach:

- In sites with limited initial bone height not allowing insertion of the desired implant length, sinus floor elevation via the lateral approach can be used to increase the bone height.
- As atrophy of the maxilla occurs three-dimensionally, the edentulous posterior maxilla should not only be evaluated in terms of initial bone height below the maxillary sinus but also in relation to any vertical and horizontal ridge deficiencies. If relevant vertical/horizontal intermaxillary discrepancy is present, an onlay bone augmentation may be considered to create both sufficient bone volume and proper intermaxillary relationships, to optimize implant placement and related prosthetic restoration.
- Data related to the initial clinical situation should be reported, and defects classified according to well-defined criteria.
- If the initial bone height allows primary implant stability, simultaneous implant placement (one-staged) can be recommended. In situations where primary stability cannot be achieved, the elevation of the sinus floor should be performed in a separate surgical procedure followed by delayed implant insertion (two-staged).
- Rough-surfaced implants should be utilized. Coverage of the access window with a membrane may be considered.

Sinus Floor Elevation Using the Transalveolar Approach:

- Sinus floor elevation using the transalveolar approach can be recommended in sites with sufficient alveolar crest width, initial bone height of 5 mm or more, and relatively flat sinus floor anatomy.
- The main disadvantage of this technique is possible perforation of the sinus membrane, which is difficult to manage. Therefore, the transalveolar technique should only be performed by clinicians with experience in performing sinus floor elevation via the lateral approach.
- A prerequisite for using this technique is that primary implant stability is achieved.

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