

Consensus Statements and Recommended Clinical Procedures Regarding Contemporary Surgical and Radiographic Techniques in Implant Dentistry

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INTRODUCTORY REMARKS

Successful dental implant rehabilitation requires accurate preoperative planning of the surgical intervention based on prosthodontic considerations and validated treatment methods. The introduction and widespread use of cross-sectional imaging in implant dentistry using cone beam computed tomography (CBCT) over the last decade has enabled clinicians to diagnose and evaluate the jaws in three dimensions before and after insertion of dental implants, thus replacing computed tomography (CT) as the standard of care. Furthermore, computer-guided implant surgery uses data from cross-sectional imaging derived from CBCT scans on a routine basis. Considering rapid changes in science

and clinical practice, two systematic reviews in this group, by Bornstein et al and Tahmaseb et al, have centered their focus questions on these topics.

There are two possible surgical interventions for the treatment of the narrow edentulous ridge. The use of narrow-diameter implants has been suggested to avoid augmentation procedures and thus decrease patient morbidity. Nevertheless, this has not been validated in a systematic review of the literature to date. Horizontal augmentation procedures are widely used to increase the bone available for subsequent implant placement. However, knowledge on the efficacy and long-term outcomes of this procedure in the anterior maxilla is still limited. Therefore, the systematic reviews prepared for group 1 by Klein et al and by Kuchler and von Arx evaluated the existing data for these two rather different treatment options.

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All the group members were asked to reveal any conflicts of interest that could potentially influence the outcomes of the consensus deliberations. No such conflicts were identified.

CONE BEAM COMPUTED TOMOGRAPHY (CBCT) IN IMPLANT DENTISTRY

General Comments

The aim of the review by Bornstein et al was to identify, review, analyze, and summarize available evidence on the use of CBCT imaging in pre- and postoperative dental implant therapy with regard to: (1) currently available use guidelines, (2) specific indications and contraindications for use, and (3) the associated relative radiation dose risk.

For all three focused questions, the variability of the selected papers was considerable, making comparisons of outcomes difficult. Regarding guidelines and specific indications or contraindications for CBCT use, it has been stated that the diagnostic procedures must be justified for each patient to demonstrate that the

benefits outweigh the risks (<http://www.eadmf.eu/basic-principles-use-dental-cone-beam-ct>). However, it will be difficult to prove a clear and statistically significant benefit of cross-sectional imaging using CBCT over conventional two-dimensional imaging such as panoramic radiography with respect to implant survival/success and damage of the inferior alveolar nerve or other vital neurovascular structures in the jaws in comparative prospective studies due to the high number of cases (power) needed for such an evaluation. With regard to radiation dose risks, there is a trend for dose optimization by applying specific imaging protocols that include considerations of exposure (mA and kVp), image-quality parameters (eg, number of basis images, resolution), and restriction of the field of view to visualize adequately the region of interest.

Consensus Statements

With respect to CBCT imaging in dental implant therapy and respective use guidelines, specific indications and contraindications for use, and the associated relative radiation dose risk, the following statements can be made:

- Current clinical practice guidelines for CBCT use in implant dentistry provide recommendations that are consensus-based or derived from non-standardized methodological approaches.
- Published indications for CBCT use in implant dentistry vary from preoperative analysis to postoperative evaluation, including complications. However, a clinically significant benefit for CBCT imaging over conventional two-dimensional methods resulting in treatment plan alteration, improved implant success, survival rates, and reduced complications has not been reported to date.
- CBCT imaging exhibits a significantly lower radiation dose risk than conventional CT, but higher than that of two-dimensional radiographic imaging. Different CBCT devices deliver a wide range of radiation doses. Substantial dose reduction can be achieved by using appropriate exposure parameters and reducing the field of view (FOV) to the actual region of interest (ROI).

Treatment Guidelines

- The clinician performing or interpreting CBCT scans for implant dentistry should take into consideration current radiologic guidelines.
- The decision to perform CBCT imaging for treatment planning in implant dentistry should be based on individual patient needs following thorough clinical examination.
- When cross-sectional imaging is indicated, CBCT is preferable over CT.

- CBCT imaging is indicated when information supplemental to the clinical examination and conventional radiographic imaging is considered necessary. CBCT may be an appropriate primary imaging modality in specific circumstances (eg, when multiple treatment needs are anticipated or when jawbone or sinus pathology is suspected).
- The use of a radiographic template in CBCT imaging is advisable to maximize surgical and prosthetic information.
- The FOV of the CBCT examination should be restricted to the ROI whenever possible.
- Patient- and equipment-specific dose reduction measures should be used at all times.
- To improve image data transfer, clinicians should request radiographic devices and third-party dental implant software applications that offer fully compliant DICOM data export.

Recommendations for Future Research

- Future research should evaluate the benefits of CBCT over conventional radiographic imaging according to clinician- and patient-centered outcomes, such as selection and/or change of treatment planning, or reduction of costs and morbidity of procedures.
- Future guidelines for CBCT use in implant dentistry should provide evidence-based statements developed from a systematic review of the literature.
- A standardized set of evaluation and measurement criteria for systematic reviews of the literature for oral and maxillofacial radiological imaging procedures needs to be formulated.
- Further primary research (observational and interventional) is required to provide additional evidence that can be used in the formulation of future guidelines for CBCT use in implant dentistry.
- Manufacturers, medical physicists, and researchers should be encouraged to pool data to facilitate dose reduction measures.

COMPUTER-GUIDED IMPLANT SURGERY

General Comments

Computer-guided (static) surgery is defined as the use of a static surgical template that reproduces virtual implant position directly from computerized tomographic data and does not allow intraoperative modification of implant position. Reports on the use of computer-guided implant surgery have increased over the past years. In addition to avoidance of damage to vital anatomic structures and accomplishing full-arch immediate loading, applications now also include partially edentulous situations. Although more data are now available, it is still difficult to compare reported treatment outcomes

due to a number of factors, such as insufficiently defined preoperative parameters or the variety of therapeutic approaches. In addition, the impact of computer-guided software programs available on the market in treatment planning remains insufficiently defined.

Consensus Statements

- Implants placed utilizing computer-guided surgery with a follow-up period of at least 12 months demonstrate a mean survival rate of 97.3% (n = 1,941), which is comparable to implants placed following conventional procedures.
- There are significantly more data to support the accuracy of computer-guided implant surgery compared to 2008. Meta-analysis of the accuracy revealed a mean error of 0.9 mm at the entry point (n = 1,530), 1.3 mm at the implant apex (n = 1,465), and a mean angular deviation of 3.5 degrees (n = 1,854) with a wide range in all measurements.
- Mucosa-, tooth-, and mini-implant-supported templates demonstrated accuracy of implant placement superior to that of bone-supported guides.
- After template osteotomy preparation, the accuracy of template implant insertion was superior to freehand implant insertion.

Treatment Guidelines

- Guided surgery should be viewed as an adjunct to, not a replacement for, appropriate diagnosis and treatment planning.
- Guided surgery should always be prosthetically driven. This includes either a radiographic template generated from a wax-up, or appropriate software application to create a digital wax-up.
- Information to be gathered from the combination of high-quality CBCT images and digital planning should include locations of vital structures, desired implant positions and dimensions, the need for augmentation therapy, and the planned prostheses.
- Due to the reported mean deviations, an additional 2 mm should be taken into consideration when planning implant position with relation to vital structures and adjacent implants in all directions. In borderline cases, an intraoperative periapical radiograph should be taken as a safety measure.
- Guided surgery may be utilized with a flapless or raised flap approach.
- Only mucosal- and/or tooth- or implant-supported surgical templates should be utilized.
- For improved accuracy, implants should be inserted in a fully guided manner (versus guided implant bed preparation alone) whenever possible.

- Guided surgery may be used with different loading protocols, in partially and fully edentulous indications.
- Indications for guided surgery include: to aid in treatment planning, when encountering complex anatomy, to perform minimally invasive surgery, and to improve patient understanding of therapeutic needs and treatment options.

Recommendations for Future Research

- Standardization of parameters to assess the accuracy of implant placement through the use of a guided surgery approach
- Identification of factors contributing to the inaccuracy of guided surgery implant placement
- Use of new methods such as digital impressions for studies on accuracy of guided implant placement, not using post-operative CBCT imaging
- Randomized controlled trials (RCTs) comparing the efficacy of guided surgery versus conventional treatments, and focusing on patient-centered outcomes

NARROW-DIAMETER IMPLANTS

General Comments

Narrow (reduced)-diameter implants (NDI) were categorized as follows for the systematic review by Klein et al:

- Category 1: one-piece, < 3.0 mm (mini-implants)
- Category 2: two-piece, 3.00 to 3.25 mm
- Category 3: two-piece, 3.30 to 3.50 mm

Potential benefits of NDIs may include less invasive surgery and reduced need for bone augmentation. However, these issues have not yet been scientifically assessed. Possible confounding factors of the studies evaluated might be available bone quantity and quality, splinting of the suprastructure, loading forces of the opposing dentition, and the biomechanical role of the implant-abutment connection.

Consensus Statements

- One-piece titanium mini-implants with a diameter of 1.8 to 2.9 mm demonstrated a mean survival rate of 94.3% (91% to 100%) after a mean follow-up time of 3.9 years (1 to 6 years) for the indications of overdenture treatment in the edentulous mandible (four implants) and for an anterior single tooth (maxillary lateral incisor, mandibular incisor).

- Two-piece titanium implants with a diameter of 3.0 to 3.25 mm demonstrated a mean survival rate of 98.5% (94% to 100%) after a mean follow-up time of 2.8 years (1 to 5 years) in only a single-tooth treatment (maxillary lateral incisor, mandibular incisor).
- Two-piece titanium implants with a diameter of 3.3 to 3.5 mm demonstrated a mean survival rate 96.9% (89% to 100%) after a mean follow-up time of 4.1 years (1 to 11 years) for all indications including posterior regions.
- There is insufficient evidence on the success rates for all NDIs. Clinical parameters and treatment protocols are often not sufficiently described and no controlled comparative studies are available, resulting in a high risk of bias.
- The esthetic effect of a reduced-diameter implant and the resulting emergence profile should be investigated.

HORIZONTAL RIDGE AUGMENTATION IN THE ANTERIOR MAXILLA

General Comments

There is a paucity of information in the literature regarding stability of the bone and esthetic outcomes following horizontal bone augmentation in the anterior maxilla. Confounding variables include the vertical component of the augmentation, defect morphology, periodontal status of the neighboring teeth, number of missing teeth, position of the site, soft tissue characteristics, time between augmentation and implant placement, implant design and diameter, prosthetic connection type and material, and provisional prostheses. Studies available in the literature were not designed for esthetic outcome assessment and included no decision criteria relating to the choice of a simultaneous or staged approach. Combined vertical and horizontal augmentation procedures should also be evaluated in the esthetic area.

Consensus Statements

- Horizontal bone augmentation in the anterior maxilla is a reliable treatment option to enable the proper placement of implants.
- Mean horizontal bone gain in the staged approach (measured at the time of implant placement) ranged from 2.2 to 5 mm. The included studies do not provide information about the long-term stability of horizontal ridge augmentation.
- There is not enough data available to indicate superiority of one method or material over another.
- Survival and success rates of implants placed in horizontally augmented bone were not different from those reported for implants placed in native bone with adequate width.

Treatment Guidelines

- In sites with inadequate ridge width, horizontal bone augmentation is indicated to enable proper implant placement. Ideally, a bone thickness of 2 mm should be achieved on the facial aspect of the implant.
- The primary aim of horizontal ridge augmentation procedures in the anterior maxilla is to optimize implant positioning in order to improve function and esthetic outcome. The position and the shape of the augmented bone influence the soft tissue profile, which should follow the contour of the neighboring teeth.

Treatment Guidelines

- NDIs might be indicated in situations with reduced mesiodistal space or reduced ridge width, provided that the general positioning rules are followed.
- NDIs have several indications. However, the risk of biomechanical problems (eg, fracture) after long-term loading and the limited knowledge of their clinical behavior should be taken into account.
- In this respect, implant diameter should be the widest possible in relation to the emergence profile and ridge configuration.
- NDIs should have a length of 10 mm or more.
- Clinical indications may include:
 1. Single-tooth replacements in the anterior zones: categories 1, 2, and 3 (category 1 and 2 only for incisors). One-piece implants often have specific prosthodontic disadvantages.
 2. Edentulous jaws to be rehabilitated with overdentures: categories 2 and 3, and category 1 for mandibles only (4 implants).
 3. Single posterior, multiple-unit fixed dental prosthesis (FDP), and edentulous jaws to be rehabilitated with FDP: only category 3; individual informed consent should include the possibility of more technical complications. Alternative treatment options should also be discussed.

Recommendations for Future Research

- Future study design should include the comparison of narrow- versus larger-diameter implants with or without an augmentation procedure.
- Future studies should compare new materials and implant designs.
- Success rates and long-term documentation (> 5 years) of potential technical and biological complications have to be reported.

- Clinicians performing horizontal ridge augmentation in the anterior maxilla may choose from a wide range of treatment options, including particulate bone grafts for simultaneous and bone blocks for staged approaches with or without placement of resorbable and nonresorbable membranes.
- Soft tissue augmentation may be required as an adjunctive procedure to improve the esthetic outcome.
- Horizontal ridge augmentation with simultaneous implant placement is indicated when adequate soft tissue conditions are present and correct implant positioning with primary implant stability is achievable.
- If defect morphology is such that successful regeneration is unlikely to be achieved using the simultaneous approach, a staged approach should be used.
- In large defects precluding implant primary stability and proper three-dimensional implant positioning, a staged approach is recommended.
- In general, the choice of augmentation materials should assure the long-term stability of the bone volume created and should be based on solid documentation in the literature.

Recommendations for Future Research

- Data related to long-term stability of horizontal augmentations in the anterior maxilla should be reported, including the width and the height of the facial bone plate.
- Studies should be performed focusing on the type of augmentation procedure, implant design, and grafting material in the anterior maxilla.
- Accepted esthetic outcome indices should be applied to make results measurable and individual studies comparable.
- It is essential that baseline defect morphology is reported.
- In either the simultaneous or the staged approach, augmented bone dimension and ongoing volumetric stability should be reported.
- Regenerated hard tissue characteristics should be examined by histology when evaluating new materials.