Guidelines

Short and Angulated Implants (Development Stage: S2\(^1\))

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Participants: Dr Phil Bennett, Christian Berger, Dr Alexander Bär, Dr Dirk U. Duddeck, Dr Spyros Karatzas, Professor Fouad Khoury, Professor Vitomir Konstantinovic, PD Dr Hans-Joachim Nickenig, Dr Mustafa Ramazanoglu, Professor Joachim E. Zöller

Protocol: Dr Thomas Ratajczak

1. Methods

Objective
The purpose of this guide is to offer recommendations for clinicians engaging in implant dentistry, enabling them to correctly assess potential indications (and any limitations thereof) for short or angulated implants.

Background
Prevalence of the clinical problem, therapeutic uncertainty, avoidance of complications.

Literature search
The Cochrane Library, EMBASE, DIMDI and Medline literature databases were used to conduct the search. Selected search criteria were used, including terms such as short implants, angulated implants, stress analysis, biomechanics, and implant failure. The studies returned by the search were screened by reading the abstracts. Studies found to be irrelevant to the subject were identified and excluded on this basis. All articles that were found to be (potentially) relevant were obtained in full-text form. No randomized controlled trials or other systematic clinical studies were available on the subject.

Procedure for developing the guide/consensus conference
A preliminary version on which the EuCC based its deliberation was prepared and authored by PD Dr H.J. Nickenig and Professor J.E. Zöller of the Interdisciplinary Policlinic for Oral Surgery and Implantology and Department of Oral and Maxillofacial Plastic Surgery at the University of Cologne/Germany. The consensus conference was organized in five steps:

- Reviewing the preliminary draft
- Collecting alternative proposals
- Voting on recommendations and levels of recommendation
- Discussing non-consensual issues
- Final voting

\(^1\) Development stage S2 = a formal process of consensus finding or a formal review of evidence has taken place.
2. Use of short implants

2.1 Introduction
Short implants are increasingly being discussed as a treatment alternative in situations characterized by limited vertical bone height, considering the extensive requirements of surgical and reconstructive implant treatment. Based on biomechanical considerations (e.g. the crown-implant ratio), less than favourable loading conditions must be expected to act on the implant and implant bed with short implants than with standard implants. Advanced implant features (design and surface) and the use of specific treatment options are believed to minimize the risk of treatment.

No randomized controlled trials were available at the time of the consensus conference. The studies that were available for review were mainly retrospective studies (evidence levels IIb/III), so the level of recommendation of these Guidelines falls into class B (indicating “should”-type recommendations).

This guide refers only to short implants for prosthetic loading.

2.1 Definition of short, medium and long implants
Implants are usually referred to as short if their length measures less than 8mm. Medium implants are 9–13 mm in length, and long implants are usually understood to be over 13 mm in length (Olate et al., 2010, review). By comparison, the cut off for distinguishing between narrow and wide implants is approximately 4 mm.

2.2 Indications for short implants
Short implants are primarily used in the maxillary and mandibular posterior segments if the vertical bone volume is reduced with still a sufficient width of bone and limited by anatomical structures (maxillary sinus, mandibular canal). They are placed as an alternative to conducting procedures of bone augmentation (Romeo et al., 2010; Renouard and Nisand, 2006).

2.3 Survival rates and experience
The findings of this retrospective study are based on observation periods ranging from 2 up to a maximum of 5 years on average (Anitua et al., 2008; Anitua et al., 2010; Arlin, 2006; Corrente et al., 2009; Li et al., 2010; Malo et al., 2006; Misch et al., 2006; Morand and Irinakis, 2007). Most of the more recent studies involve favourable survival rates ranging from 95% to 99%. Somewhat less favourable values (94 to 96% after 2 years) have been reported for the posterior maxilla (Renouard and Nisand, 2005). It has been indicated that implants with reduced length and diameter should be expected to carry an increased rate of implant loss, reaching up to 10% after 3–5 years (Das Neves et al., 2006).

Generally the level of evidence is rather low yet. For instance in a comparative study, 15 patients showing 5–6 mm of subantral bone volume and 15 patients showing 5–6 mm of bone volume above the mandibular canal were evaluated. Short implants were used in the study group, while the control group involved standard implants in conjunction with bone augmentation. Minor clinical differences were observed with regard to complications in the healing phase and in the early phase of prosthetic service. The patients felt that both procedures were acceptable (Felice et al., 2009).

No randomized controlled trials or other systematic clinical studies were available on the subject.
2.4 Avoiding complications
Some authors have offered recommendations on how to avoid complications that are mainly biomechanical in nature. These recommendations include:

- Machined short implants should not be used (Renouard et al., 2006; Das Neves et al., 2006; Olate et al., 2010).
- Short implants should only be used if bone quality is favourable (Renouard and Nisand, 2006; Romeo et al., 2010).
- Primary splinting of short implants (Misch et al., 2006).
- Cantilever pontics should be avoided (Misch et al., 2006).
- Guiding surfaces for lateral movements should be avoided (Misch, 2005; Romeo et al., 2010).
- Short implants should not be used in patients with parafunctional habits (Romeo et al., 2010).
- The implant surgeon and restorative dentist should have adequate clinical experience (Misch et al., 2006; Romeo et al., 2010).

2.5 Recommendations for the inclusion of short implants
For the time being, the benefit-to-risk ratio of short implants (less than 8 mm in length) cannot be clearly assessed in terms of suitability for practical use (evidence level III is offered by the currently available studies). No randomized controlled trials or other systematic clinical studies were available on this subject. The process of selecting appropriate patients for such treatment should therefore include a critical appraisal of treatment alternatives (bone augmentation plus medium or long implants). Crestal bone loss potentially influences the survival rate of short implants more than on long implants.

Any inclusion of short implants should be consistent with a well-proven surgical and implant-restorative treatment concepts (also see 2.4 „Avoiding complications“). Long-term postoperative care is essential with special emphasis on prevention of crestal bone loss. The length of implants has an influence on the crown-implant-ratio and has to be considered in implant restorative treatment concepts.

The implant surgeon and restorative dentist must have adequate training and clinical experience.

3. Use of angulated implants

3.1 Introduction
Angulated implants, too, are increasingly being discussed as an alternative treatment option in situations of limited vertical bone height, considering the extensive requirements of surgical and reconstructive implant treatment. The objective of placing implants in a tilted fashion is to utilize as much bone as possible, bypassing endangered adjacent structures (e.g. the mental foramen in the mandible or the maxillary sinus in the maxilla), and to increase the surface area for restorative support (through diverging implant axes). Restorations can be inserted on these implants via angulated abutments.

At the time of the consensus conference, few randomized controlled trials and other systemic clinical studies were available on the subject (evidence levels IIb/III); the search was therefore extended to include the results of basic research and in-vitro studies.
3.2 Bone-related experience

Cehreli et al., 2002 demonstrated in their in-vitro study that angulated implants were associated with higher forces acting on the implant-bone interface during axial loading of maxillary or mandibular superstructures that were supported by four implants. Finite-element analysis has led to the conclusion that the degree of loading to which the bone is subjected by angulated implants will depend on bone quality, with load levels becoming progressively smaller as the amount of cortical bone anchorage increases. Particularly high loads acting on the implant-bone interface must be expected in single-tooth restorations, and these loads will become more severe with increasing length of the load arm involved (off-axis loading) (O’Mahony et al., 2009, finite-element study). All-on-four concepts evaluated by photoelastic analysis revealed that only small differences in the forces acting on the implant-bone interface should be expected with implants exhibiting inclinations of 15°–30° and with primary splinting. Force levels should be expected to increase disproportionately with more heavily inclined (> 40°) implants (Begg et al., 2009). Peak loads will occur in the apical implant segment, followed by the crestal segment, while force levels will be lowest in the central implant segment. Reports on the immediate loading of angulated implants have existed for 5–10 years in the context of all-on-four concepts used in the maxilla/mandible (Ferreira et al., 2010; Maló et al., 2003). Favourable survival outcomes are available for all-on-four concepts in conjunction with primary splinting via all-in-one bridges; however, no results have yet been reported based on follow-up intervals exceeding 2–5 years (Maló et al., 2007).

3.3 Restoration-related experience

Numerous studies have been published on problems related to the accuracy of transfer-ring impressions (Conrad et al., 2007, in vitro). Special impression techniques, such as the use of custom transfer abutments, have been reported. Pampel et al. (2006) and Assuncao et al. (2004) concluded from their in-vitro studies that the accuracy of impressions becomes increasingly less favourable in the presence of greater angulations between implants. Other problems related to implant prosthetic concepts concern the loss of retention of the superstructures involved (ball attachments are particularly affected), which will depend on the degree of abutment divergence. Significant loss of retention should be expected even at a divergence of 20°–30°, while smaller differences of up to 10° will have negligible effects (Gulizio et al., 2005, in vitro). One-piece solid abutments are to be recommended if angulated designs are used (Lin et al., 2008).

Walton et al., 2001, reported in an in-vitro-study that angular divergences between implants do not play a major role if confined to a single three-dimensional plane (e.g. the frontal plane or the sagittal plane), while significantly more prosthetic complications can be expected, if angular deviations are also present in a different plane (e.g. lateral, ventral, dorsal).

3.4 Recommendations

- The use of angulated implants should remain confined to situations of favourable bone quality (preferably greater than D3).
- Angulated implants should only be placed after suitable 3D-planning, leading to 3D-treatment guidance.
- Greater inclinations of the implants lead to increased force levels at the implant-bone and implant-abutment-interfaces. Therefore extreme angulations should be avoided.
- Inter-implant angulations should be confined to a single three-dimensional plane to simplify prosthetic restoration.
• Single-tooth restorations and cantilever bridges on angulated implants should be avoided, and the aim should be to splint the implants.
• The implant surgeon and restorative dentist must have adequate training and clinical experience.

4. References

4.1 Short implants


Anitua E, Orive G. Short implants in maxillae and mandibles: a retrospective study with 1 to 8 years of follow-up. J Periodontol 2010;81(6):819-26


Misch CE. Short dental implants: a literature review and rationale for use. Dent Today 2005;24(8):64-6, 68


4.2 Angulated implants


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Christian Berger
President