European Association of Dental Implantologists
Bundesverband der implantologisch tätigen Zahnärzte in Europa e.V.

Guideline 2024

Update digital workflow in implant dentistry

19th European Consensus Conference (EuCC) 2024 in Cologne

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1 Methods

1.1 Objective

The purpose of this guideline is to offer recommendations for clinicians engaging in implant dentistry, enabling them to correctly assess potential indications (and any limitations) for a digital workflow.

1.2 Introduction

This consensus guideline covers the various digital procedures for diagnosis, surgical preparation, digital implant planning and prosthetic rehabilitation typically used in accordance with the indications recommended by the European Consensus Conference on implantology (EuCC, Cologne, Germany, February 10th, 2024).

All consensus recommendations in this paper should be considered as guidelines only. The patient's specific situation is always an important consideration and may justify a deviation from the recommendations of this consensus paper.

1.3 Background

Digital procedures to improve or simplify the implant prosthetic workflow are presented for various treatment steps. To ensure an acceptable treatment outcome, the selection of the appropriate digital procedure for each indication is necessary.

1.4 Literature search

The Cochrane Library, EMBASE, DIMDI and Medline literature databases were used to conduct a systematic search of recent published data on digital workflows and directly related topics. Selective search criteria were used, including terms such as *digital, implant, cad/cam, superstructure, surgical guide*. The publications identified by the search were screened by reading their abstracts; those irrelevant to the subject were identified and excluded. Articles found to be potentially relevant were obtained in full-text form. Multiple review papers with meta-analyses and randomized controlled trials (RCTs) as well as other prospective or retrospective systematic clinical studies proved to be available on the subject.

1.5 Procedure for developing the Consensus Conference guidelines

A preliminary version on which the EuCC based its deliberations was prepared and authored by Dr Jörg Neugebauer of the Interdisciplinary Dep. for Oral Surgery and Implantology and Department of Oral and Maxillofacial Plastic Surgery at the University of Cologne, Germany. The preliminary report was then reviewed and discussed by the sitting committee members in five steps as follows:

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

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2 Problem

Complex implant/prosthetic treatment can be performed in various stages with the support of digital technology. Today the aim in selected cases has been to improve the treatment efficiency and outcome by using a fully digital workflow**[26, 27]**. Various concepts are in use, but the innovation cycles and outcomes should be considered for complication-free use in daily practice.

3 Digital diagnosis

3.1 Introduction

Routine implantological diagnosis is still based on panoramic imaging, which has limitations in terms of measurement accuracy and the possibility to determine the available bone supply, especially in the posterior maxilla**[20, 62]**. Due to the invasiveness of ionizing radiation 3D diagnosis should be decided by individual basis**[36]**.

3.2 Cone-beam CT

The adjunctive use of 3D-data based on cone-beam technology provides more information to help avoid problems and perform a more detailed diagnosis**[15]**. Various indication for immediate implant placement, control of grafting procedures and anatomical evaluation are proven**[53]**. Scanning parameters such as voxel size vary depending on the device used and result in discrepancies at the subclinical level, which might influence the subsequent process chain**[68]**. Modern devices with low dose protocol allow implant planning with a reduced dose without increasing the accuracy of guided implant placement **[54]**

4 Digital impression and imaging

The use of digital information other than x-ray as a contribution to the overall prosthetic diagnosis based on function and aesthetics.

4.1 Definition

Digital impressions are taken as chairside scans to generate the data to fabricate surgical guides, master-casts and implant superstructures.

4.2 Current observations

Digital impressions and CAD/CAM procedures are time-saving and provide stable and predictable outcomes**[77]**. No difference on clinical outcome for conventional and digital impression, even in full arch cases**[19, 41]** The accuracy of complete-arch scanning by IOSs differs based on clinical scenarios, like scanning strategy **[40, 74]**.

Digital scanning was found to be more time-efficient and convenient than conventional impression making for implant-supported restorations.**[43]** No significant differences were found in radiographic marginal bone loss between treatments performed with digital scans and conventional impressions.**[60]**

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4.3 Prevention of complications

- Precise scanning of full arches require specific scan strategies.
- The transfer of the occlusal situation and the articulation is not established on a routine basis.
- Significant accuracy differences were found between the IOSs, which require an individual selection for the various treatment protocolls.**[74]**

5 CAD/CAM supported grafting techniques

5.1 Introduction

To reduce donor site morbidity, various kind of allogeneic or xenogeneic block grafts were presented in the past**[32]**. There has been controversy regarding the evidence for their outcomes**[6, 8]**. Alternatively, a titanium mesh is used to stabilize the graft, but this requires an intensive intraoperative adaptation to the defect. Custom dental implants made by copy-milling were first presented more than two decades ago, but have not become established as routine clinical procedures**[34, 59]**.

5.2 Custom-made bone block and implants

To improve outcomes and simplify workflows, the use of CAD/CAM technology and cone-beam volumetric data for custom-made bone blocks, shaping of titanium-meshes and implants are recommended**[11, 12, 38, 65]**
To improve the outcome various techniques of 3D-printed scaffolds with the option of the use of stem-cells or BMP are under scientific evaluation**[9]**

5.2 Current observations

Reports on the clinical outcomes are still controversial **[18, 33]**
Exposure rate on CAD/CAM titanium mesh is lower than conventional formation, but still a high exposure rate of 31% was observed**[23, 80]**

5.3 Prevention of complications

Specific soft-tissue management necessary for 3d-printed titanium meshes

6 Digital driven implant placement

6.1 Introduction

Various systems for guided surgery are available, using surgical guides and real-time navigation[14, 48]. The accuracy for surgical guides shows no significant difference real-time navigation[2, 44].
Moreover, computer-guided surgery can effectuate an accurate implant placement and less postsurgery discomfort.[77]
By using surgical guides, more reproducible and more accurate results can be achieved in comparison to free-hand placement**[29, 49, 50, 69]**.

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6.2 Current observations

Discrepancies between planned and actual implant positions can be up to about 1 mm crestally and around 2 mm in the apical region, with an angular deviation of about 5 degrees**[14, 67]**. These results have been confirmed by RCTs**[73]**. Surgical guides strictly supported by soft tissue in the edentulous jaw are not inferior**[72]**.
Bone-supported surgical guides exhibit lower accuracy**[14]**.
No difference for GS or FH in respect of MBL changes**[75, 78]**
Flap and flapless approaches provided similar implant survival rates, but the flap technique provided a slightly better MBL than the flapless approach**[71]**.
Further evidence regarding more clinically relevant outcomes of efficacy (implant survival and success, prosthetically and biologically correct positioning), long-term prognosis, and costs, is currently scarce.[63]
Flapless procedures less buccal bone resorption in immediate implant cases[42, 55]
Augmented reality better than conventional navigation and free hand**[75, 78]**

6.3 Prevention of complications

- Greater deviations for longer implants and shorter sleeves**[66]**.
- Conventional guides or guides based on optical scans are more accurate than guides designed based on CBCT data**[61]**.
- For completely edentulous jaws, fixation with mini-implants or anchor screws increases accuracy**[14]**.
- Keyless systems seem to have a higher precision in comparison to key systems**[22]**
- Case selection for type of guided surgery requires previous experience in conventional procedures in order to be able to switch if required.
- Minimally invasive therapies such as flapless surgery require specific training to achieve an optimal outcome**[46, 72]**.
- Greater deviations may occur in individual operator and patient situations depending on the fixation and the type of edentulism**[10, 22, 57]**.

7 Digital lab procedures

Various printing techniques are available for manufacturing surgical implant guides, implant analog models, metallic primary frameworks, secondary ceramic or polymer superstructures**[56]**.

7.1.2 Current observations

For clinical acceptable accuracy of implant analog cast various technical parameters must be considered. **[25]** Depending on the printer technology accuracy may change under light exposure**[79]**.

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7.2. CAD/CAM abutments

7.2.1 Definition

Custom CAD/CAM abutments can be produced by chairside procedures with prefabricated inserts or by milling centres on the original or on a copy of the implant interface**[30]**. No information is available regarding the precision and quality of the two procedures**[37]**.

7.2.2 Current observations

Custom CAD/CAM abutments offer many options for ideal design in terms of biomechanical and material parameters. The use of custom CAD/CAM abutments does not guarantee that subgingival cement residue is avoided, although a reduction in cement residue has been shown after crown cementation**[76]**.

The use of custom CAD/CAM abutments showed advantages in soft-tissue stability in a multicentre prospective clinical trial after a two-year follow-up**[39]**. Controversial data indicate no improvement in clinical performance or patient satisfaction compared to the use of stock zirconia abutments**[58, 64]**.

Special emphasis should be placed on the precision of the implant/abutment interface. Initial research in vitro has demonstrated no difference in terms of implant adaptation of stock vs. one-piece CAD/CAM abutments**[7]**.

7.2.3 Prevention of complications

- Care must still be taken to always carefully remove cement residue after intraoral cementation.
- The use of resin-based luting agents in combination with air-abrasion of titanium inserts and zirconia copings provided stable retention of two-piece CAD/CAM abutments**[21]**.
- Screw-retained crown abutments might be favourable from a biological point of view, with a risk of mechanical complications.

7.3. CAD/CAM superstructures

7.3.1 Definition

Various CAD/CAM fabrication procedures such as milling or selective laser melting are available**[30, 35]**; they require the validation of workflows. Studies on the precision of screw-retained CAD/CAM superstructures showed improved accuracy in comparison to conventional or copy-milled superstructures, with no relevant differences between the materials used**[1, 16, 17, 31]**.

The marginal fit of implant-supported frameworks manufactured by AM or SM methods is in the clinically acceptable range.**[47, 70]**

7.3.2 Current observations

The available data indicate promising results for CAD/CAM-fabricated implant-supported restorations; nonetheless, current evidence is limited due to the quality of available studies and the paucity of data on long-term clinical outcomes of five years or more**[24, 52]**.

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7.3.2 Prevention of complications

- When using CAD/CAM technology it is recommended to follow a validated workflow.
- If one step in the workflow is changed, it is recommended to revalidate the complete workflow.

8 AI in implant dentistry

8.1 Introduction

A growing number of studies emplayed deep learning in implant dentistry mainly in digital imaging with radiographs**[5]**. AI models using panoramic and periapical radiographs can accurately identify and categorize dental implant systems or detect marginal bone level changes.**[4, 13]**

8.2 Current observations

First algorithm may determine critical structures like the IAN canal and the available bone for an artificial implant planning**[5]**. The benefit in comparison to conventional approaches is not proven.**[45]**

9 Conclusion

Digital technologies are improving in implant dentistry with well clinical outcome and improvement of PROMs. Specific parameters for the individual workflow must beconsidered by the health care provider.

Cologne, 6 February 2024

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