CLINICAL ORAL IMPLANTS RESEARCH

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Computer-guided implant therapy and soft- and hard-tissue aspects. The Third EAO Consensus Conference 2012

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Conflicts of interest:
The authors have declared no potential conflicts.

Key words: accuracy, advantages, guided implant placement, implants, keratinized tissue, ridge preservation

Abstract

Introduction: The objectives of this working group were to update the existing knowledge base in computer-guided implant treatment (accuracy and clinical advantages), to search for scientific evidence on the need for keratinized tissue around implants, and to review recent literature in the search for new insights into ridge preservation after tooth extraction.

Material and methods: The literature was systematically searched and critically reviewed. Four manuscripts were prepared, three systematic and one narrative review, that allowed the group to develop evidence-based conclusions, as well as clinical implications and recommendations for future research.

Results: The results and conclusions of the reviews were presented in the following papers:

- Van Assche et al. (2012) Accuracy of computer-aided implant placement.
- Hultin et al. (2012) Clinical advantages of computer-guided implant placement: a systematic review.
- Wennström & Derks (2012) Is there a need for keratinized mucosa around implants to maintain health and tissue stability?
- Wang & Lang (2012) Ridge preservation after tooth extraction.

The group's consensus statements, clinical implications and implications for future research are presented in this article.

The remit of this working group (3) were:

1. To evaluate the accuracy of guided implant placement, as well as to analyse the clinical advantages of this kind of minimally invasive/computer-guided procedure. To cover this topic, two systematic reviews were carried out, and a meta-analysis on the accuracy of guided surgery was performed. The information is presented in the following papers:
   - Van Assche et al. (2012) Accuracy of computer-guided implant placement.
   - Hultin et al. (2012)Clinical advantages of computer-guided implant placement.
2. To analyse the scientific evidence supporting the need for keratinized mucosa around dental implants. For that purpose the following systematic review was carried out:
   - Wennström & Derks (2012)Is there a need for keratinized/attached gingiva at implants?
3. Finally the group also searched the recent literature for new insights into the developing area of alveolar ridge preservation after tooth extraction. The resulting literature search was condensed into the following narrative review:
   - Wang & Lang (2012). New insights into ridge preservation after tooth extraction.

Accuracy of computer-guided implant placement

Aim

To assess the accuracy of static computer-guided implant placement.

General conclusions from the paper

- There are no in vivo RCTs in the dental literature that report the accuracy of computer-guided implant placement compared with a "brain guided approach."

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Date:
Accepted 09 June 2012

To cite this article:
Sicilia A, Botticelli D. Computer-guided implant therapy and soft- and hard-tissue aspects. The Third EAO Consensus Conference 2012.
Clin. Oral Implants Res. **23**(Suppl. 6), 2012, 157–161
doi: 10.1111/j.1600-0501.2012.02553.x

- Irrespective of the study design the mean deviation of implants inserted using guided surgery techniques was: 1.09 mm at entry, a mean deviation of 1.28 mm at the apex and 3.9° in angulation. However, there was significant variation in the results.
- Factors reported influencing the accuracy of the computer-guided approach in a negative way are bone-supported guides, the use of multiple templates and the lack of guide fixation.
- The various studies addressing computer-guided implant placement looked at many different variables making inter study comparison difficult if not impossible.
- The results of the various studies have also been reported in different ways thus limiting comparison of the inter study results.
- In the literature there is little information on vertical deviation when using computer-guided implant systems.
- Little is reported on the required bone volume and its effect on precision when using guided implant surgery techniques.

Group's consensus

- Guided surgery does not guarantee a precise implant placement.
- When using this technique one should consider in a horizontal direction a mean system error of 1.2 mm, and in a vertical direction an error of 0.5 mm. However, the clinician should be aware that deviations of up to 6 mm have been reported.
- The use of multiple templates during implant placement can introduce more inaccuracy compared with using one template during the whole intervention.
- Bone-supported templates can give less accurate results than tooth and mucosa-supported templates.

Clinical implications

- The 3-D planning of guided surgery gives the practitioner more insight into the anatomical and prosthetic limitations of the treatment. A blind trust of the precision of the transfer of this information via the drill guide to the execution of implant treatment must be approached with caution. Therefore, this technique is recommended to be used in favourable situations.

Implications for research

- There is little data on the precision of guided surgery in cases of severe horizontal bone resorption. Research in this area should provide insights into the application of computer-guided implant placement in these cases.
- A standardization of research parameters will lead to a better comparison of research outcome data.
- RCTs comparing "brain guided" implant surgery to the computer-guided approach are needed to provide the clinician with evidence-based information when choosing a surgical technique and to realize the possible advantages of guided surgery.
- RCTs comparing different guided techniques for different indications are needed to provide the clinician with an evidence-based approach when choosing this type of surgical technique.

Clinical advantages of computer-guided implant placement

Aim

To systematically scrutinize the current scientific literature regarding the clinical advantages of computer guidance of implant placement.

Focused question

Are there clinical advantages when using computer-guided implant placement compared with conventional treatment protocols?

The following aspects were evaluated:

- Patient-centred outcomes.
- Implant and prosthesis survival rates.
- Technical and biological complications.
- Duration of treatment.
- Cost-effectiveness.
- Avoidance of bone augmentation, by optimal implant positioning.
- Reduction of surgical trauma (e.g. in specified groups of patients/clinical conditions).

Major conclusions from the paper

- This systematic review reveals no obvious differences between conventional and guided implant treatments regarding implant-survival rate. However, limited scientific evidence is available.
- Several unexpected procedure-linked adverse events were reported in most studies, indicating that the clinical demands on the surgeon were no less during guided implant placement than during conventional placement.
- Flapless guided surgery may lead to less pain and less discomfort than conventional implant surgery.

Group's consensus

- According to the available evidence (three controlled short-time comparative studies) no differences in short-term survival could be found between implants placed with guided or conventional surgery. Due to the limited data, no conclusion can be made concerning short-term survival either of the provisional or the definitive prostheses.
- Several complications have been observed; some of them are specific to the guided technique (such as fracture of the template, complications related to the limited access and visibility due to the flapless approach or misfit of the prostheses). Hence, the skills and training that the clinician dealing with guided implant surgery needs, should not be less than those required for conventional implant placement.
- Data from three prospective controlled studies (1 RCT) suggest that guided implant surgery, with a flapless approach, significantly reduces postoperative patient discomfort and pain.

Clinical implications

- Guided implant protocols may help the clinician to perform successful implant therapy avoiding flap elevation, causing less pain and discomfort to the patient.
- Clinicians have to be aware that computer-driven flapless surgery often overlooks the ideal location of important soft-tissue anatomy, such as the thickness, width and position of keratinized tissue.
- Guided implant surgery is technically demanding and not free from specific procedure-related complications. Hence, the belief that "less training is needed" is far from accurate.
- Surgical skills and experience of the clinician using this surgical technique go above and beyond those necessary for providing regular implant surgery.

Implications for research

- The use of these techniques implies an increase in planning time and additional costs relating to the investment in equipment and production of the templates. This should be considered when evaluating their potential applications, and research assessing the cost/benefit ratio is needed.
- There is a limit to the information we can obtain about the soft tissues of the patient with CAT/CBCT examinations. New technologies combining data from CAT/CBCT with information on the soft

tissues and crown morphology, obtained by means of optical digital high-resolution scanners, should be encouraged.
- Several studies evaluate the accuracy of the final implant position with respect to the planned position. However, no studies evaluate the adequacy of the planning (which is based fundamentally on information relating to the hard tissues) with the ideal aesthetic and functional planning that the clinician intended to achieve. Thus, RCTs evaluating the achievement of the previously defined aesthetic and functional objectives should be carried out.
- The shortcomings of guided implant surgery should be compared with "brain guided" surgery to better understand the magnitude of the deviations reported.
- It is recommended that scientific papers in this respect report on the percentage of procedures in which the guided surgery protocol could no longer be followed.

Is there a need for keratinized mucosa around implants to maintain health and tissue stability?

Aim

The objective of the present review was to analyse the literature with regard to the need for keratinized mucosa around implants to maintain health and tissue stability.

Major conclusions from the paper

Within the limitations of the current review, the following conclusions may be drawn:
- Collectively, the findings of this review show that evidence with regard to the need for the presence, or a certain amount, of keratinized mucosa around implants to maintain health and tissue stability is limited.
- Longitudinal studies in well-maintained populations showed no significant association between "inadequate" keratinized tissue and higher plaque scores. However, in some studies in less well-maintained populations a significant association was reported.
- Longitudinal and cross-sectional studies in well-maintained populations showed no significant association between "inadequate" keratinized tissue and gingival inflammation. However, in some studies in less well-maintained populations a significant association was reported.
- Recession was reported in the early phase (6–12 months) and may be more pronounced at sites without keratinized mucosa (three out of three studies). However, a long-term effect of "inadequate" keratinized mucosa on soft-tissue recession was shown in only one study (4 years; immediate implants; flapless), while two studies with a traditional surgical approach, showed no differences.
- Due to scarcity of available information and methodological limitations, it was not possible to evaluate whether the amount or presence of keratinized peri-implant mucosa could be associated with changes in interproximal bone levels (one study; 4 years) or implant loss (one study; 1–10 years).

Group's consensus

- There is a lack of high-quality studies evaluating the need for keratinized mucosa around implants to maintain health and tissue stability.
- Despite methodological problems and heterogeneity of studies, 40 to 50% of the included studies demonstrated statistically significant associations between lack of "adequate" keratinized tissue and higher plaque and bleeding scores. The studies that did not demonstrate an association usually included well-maintained populations.
- Significant soft-tissue recession around implants may occur in the early phase after prosthetic therapy (6–12 months) and may be more pronounced at sites with "inadequate" keratinized mucosa. The association is less evident in long-term follow-up studies (1–5 years).
- No conclusions could be drawn with regard to the influence of the quality of bordering mucosa on interproximal bone level changes and on the risk for implant loss.

Clinical implications

- There is a lack of evidence in regard to risks/benefits of absence/presence of keratinized mucosa at dental implants. However, data suggest that in clinical situations where proper plaque control is not achieved (e.g. limited compliance, reduced dexterity, lack of accessibility) the presence of keratinized mucosa around implants may be of benefit.
- Despite the absence of strong associations between absence/presence of keratinized mucosa and peri-implant health, it is recommended that efforts to preserve existing keratinized mucosa are maximized during the treatment procedures.
- There is a lack of evidence supporting the concept that grafting procedures aimed at increasing the amount of keratinized mucosa improve outcomes of implant therapy.
- Although no study evaluated patient-centred outcomes with regard to oral hygiene performance, one has to consider that some patients might experience pain or discomfort during brushing at sites with a bordering lining mucosa, which in turn may hamper adequate cleaning. In such cases one might consider a grafting procedure to establish a wider zone of keratinized mucosa.

Implications for research

Future research should monitor the amount of keratinized mucosa over time as well as the thickness of peri-implant soft tissues.

There is a need for:
- Clinical studies of preferably longitudinal design to evaluate in more detail potential associations between the amount of keratinized mucosa around implants and plaque accumulation, soft-tissue health, soft-tissue recession, marginal bone level changes and implant loss.
- Studies evaluating whether the amount of keratinized mucosa around implants has an effect on patient-centred outcomes (e.g. discomfort during daily oral hygiene measures, overall perception, aesthetic perception).
- Randomized clinical trials evaluating the effect of soft-tissue grafting techniques aimed at increasing the width/thickness of keratinized mucosa.

Ridge preservation after tooth extraction: a narrative review

Aim

To evaluate recent studies and to explore new insights on the topic of ridge preservation.

Major conclusions from the paper

- With implants placed immediately into extraction sockets (IPIES) alone, the expected vertical buccal bone resorption in dogs was 2.6 mm–4.1 mm after 3 months of healing (Araújo et al. 2005; Blanco et al. 2011). The expected

horizontal bone resorption in human subjects was 56% buccally and 30% lingually (Botticelli et al. 2004).
- The use of bone fillers around IPIES may contribute to the preservation of the buccal hard tissue (Araújo et al. 2011).
- IPIES do not prevent the resorption of the alveolar bone (Araújo et al. 2005, 2006).
- Immediate loading of the implants does not preserve the alveolar bone ridge (Blanco et al. 2011).
- Simultaneous guided bone regeneration procedures could partially resolve alveolar bone resorption by 23–47% vertically and 73% horizontally on the buccal aspect in dogs after 3–4 months of healing (Caneva et al. 2010, 2011, 2012; Park et al. 2011). However, this depended on the type of membrane as well as the techniques applied.
- In immediate transmucosal implants placed in humans, after 6 months of healing, buccal alveolar bone resorption was less after Bio-Oss grafting with (20%) and without membrane (16%) compared to the control sites (48%) with the use of immediate implants (Chen et al. 2007).
- Increasing the diameter of the implant to minimize the gap between the implant and the alveolar bony wall does not preserve alveolar bone ridges. On the contrary, this approach was associated with accentuated bone resorption (Caneva et al. 2010).
- One dog study showed that unfilled sockets underwent three times the amount of horizontal resorption as sockets filled with xenograft (Bio-Oss®) (Araújo & Lindhe 2009).
- Various bone substitutes have been tested in clinical trials for their effects on ridge preservation.
- Based on radiographic measurements, magnesium-enriched hydroxyapatite showed superior effects on preserving ridge height than did calcium sulphate (87% vs. 34%) (Crespi et al. 2009).
- Sockets treated with anorganic bovine bone matrix (ABM) + synthetic cell-binding peptide P-15 had significantly less ridge width resorption (26%) than unfilled sockets. However, the ridge height resorption did not differ between test and control sites (Fernandes et al. 2011).
- An anorganic bovine-derived hydroxyapatite matrix delivered in a putty form combined with a synthetic cell-binding peptide P-15 showed only minor effects in preserving the alveolar ridge height, but no effect in preserving ridge width (Neiva et al. 2008).
- The medical-grade calcium sulphate hemihydrates (MGCSH) proved to be effective on preserving both ridge width (37.5%) and ridge height (58.3%) (Aimetti et al. 2009).
- Ridge preservation using human demineralized bone matrix was effective irrespective of the particle sizes used (Hoang & Mealey 2011).
- Although DFDBA may be claimed to be more osteoinductive, its effect on ridge preservation is similar to that of FDBA (Wood & Mealey 2011).
- Although collagen plugs were claimed to have an advantage in avoiding surgery, no definite recommendations can be made based on their poor outcome on preserving the alveolar ridge (Kim et al. 2011).
- Applying the guided bone regeneration principle by using bone substitutes together with a collagen membrane has shown clear effects on preserving alveolar ridge height as well as ridge width (Cornelini et al. 2004; Chen et al. 2007; Barone et al. 2008; Horowitz et al. 2009).
- One clinical trial showed that applying β-tricalcium phosphate (β-TCP) and type I collagen with or without placing membranes was effective in preserving the alveolar bony ridge (Brkovic et al. 2011).
- A dog study revealed that using free gingival grafts in combination with bone substitutes did not provide additional ridge preservation compared with bone substitutes alone (Fickl et al. 2008).
- A clinical trial showed that achieving primary flap closure did not have additional beneficial effects on preserving the ridge width. On the other hand, patients experienced more discomfort with primarily closed flaps. Moreover, the mucogingival junction was significantly more coronally displaced in the primary closed flap sites (Engler-Hamm et al. 2011).

Group's consensus

- Implants placed immediately into extraction sockets (IPIES) do not preserve the alveolar ridge regardless of the dimensions of the implants.
- IPIES with simultaneous Guided Bone Regeneration (GBR) procedures or grafting of the residual space may reduce the resorption of the alveolar ridge but the outcome depends on the type of membrane or material, technical procedure and treatment protocol.
- After extraction, various calcium phosphate-based grafting materials help in preserving the alveolar ridge.
- GBR procedures following tooth extraction showed clear effects on ridge preservation but preservation may often be incomplete.
- The scientific data scrutinizing the necessity of applying soft-tissue grafts for primary flap closure in ridge preservation after tooth extraction and without simultaneous implant placement is scarce. Based on one animal and one clinical study there is no additional beneficial effect to be expected with this protocol.

Clinical implications

- After tooth extraction, ridge resorption cannot be fully prevented regardless of the use of biomaterials and irrespective of immediate implant placement, implant type or surgical procedure. This may result in an unsatisfactory aesthetic outcome.
- When implants are placed in a previously preserved ridge, additional GBR or soft-tissue grafting techniques may be required to enhance the clinical outcome in terms of bone volume and/or soft-tissue aesthetics.

Implications for research

- Further research on ridge preservation, with and without immediate implant placement, should focus on material development and surgical approaches to further enhance the outcome.
- There is a need for studies evaluating the efficacy of the combination of therapies designed to prevent ridge resorption and maintain aesthetics.
- This research should include the assessment of three-dimensional soft- and hard-tissue changes. Further improvements in the use of techniques such as Cone beam CT, ultrasonic or scanning methods, are essential for validation of outcome measures related to alveolar ridge preservation and aesthetics.

Conflict of interest and source of funding statement

The authors have declared no conflicts of interest. Workgroup 3 participants declared that they had no conflicts of interests.

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