Project Deliverable

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Abstract:

In implantology, determination of bone dimensions, bone morphology, bone structure and quality dictates implant selection. The main goal of the present study was to investigate how implants are planned based on two-dimensional (2D) radiographs (panoramic radiographs or peri-apical) and on CBCT images. For this purpose, we used questions about the confidence of the observers as well as measurements of the implant and its surrounding structures.

Fifty four partially edentulous patients were recruited for this purpose. Imaging consisted of two- and three-dimensional (2D and 3D) imaging. Six observers made an implant planning on the 2D image datasets and at least one month later on the 3D image dataset.

There was a clear difference for 2D and 3D planning in choosing implant length, and for confidence score. Moreover, surgical events, such as dehiscence or sinus perforation, were better predicted with 3D than with 2D images.

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1. The Context

1.1 SEDENTEXCT Aims and objectives

The aim of this project is the acquisition of the key information necessary for sound and scientifically based clinical use of dental Cone Beam Computed Tomography (CBCT). In order that safety and efficacy are assured and enhanced in the 'real world', the parallel aim is to use the information to develop evidence-based guidelines dealing with justification, optimisation and referral criteria and to provide a means of dissemination and training for users of CBCT. The objectives and methodology of the collaborative project are:

1. To develop evidence-based guidelines on use of CBCT in dentistry, including referral criteria, quality assurance guidelines and optimisation strategies. Guideline development will use systematic review and established methodology, involving stakeholder input.

2. To determine the level of patient dose in dental CBCT, paying special attention to paediatric dosimetry, and personnel dose.

3. To perform diagnostic accuracy studies for CBCT for key clinical applications in dentistry by use of in vitro and clinical studies.

4. To develop a quality assurance programme, including a tool/tools for quality assurance work (including a marketable quality assurance phantom) and to define exposure protocols for specific clinical applications.

5. To measure cost-effectiveness of important clinical uses of CBCT compared with traditional methods.

6. To conduct valorisation, including dissemination and training, activities via an 'open access' website.

At all points, stakeholder involvement will be intrinsic to study design.

1.2 Work package 4 (WP4) objectives

- To determine *in vitro* the segmentation, linear and/or diagnostic accuracy of various CBCT scanners versus MSCT (WP4.1)
- To assess the diagnostic accuracy of CBCT in an animal model (WP4.2)
- To determine the diagnostic accuracy of various CBCT scanners for specified clinical applications (WP4.3)

1.3 Deliverable D4.3

In implantology, determination of bone dimensions, bone morphology, bone structure and quality dictates implant selection. Deliverable D4.3 (linear and diagnostic accuracy for bone quantification using different CBCT scanners) describes the results of the clinical study on implant planning. It synthesises the observer results in assessing bone properties and planning implant surgery based on 2D radiographs and 3D CBCT images. Moreover, it investigates whether a difference in bone quantity and/or quality categorises the difference in assessment and planning.

2. The Methodology

Fifty four patients (27 males, 27 females, mean age 51 years (standard deviation 15) were recruited at the Oral Imaging Center of Katholieke Universiteit Leuven and at the Department of Oral Radiology of “Iuliu Hatieganu University”, Cluj-Napoca. All patients were referred for imaging of the maxillofacial region in preparation for implant placement and signed informed consent forms. Only partially edentulous patients were included in the study. Imaging consisted of 2D (peri-apical radiographs and panoramic radiographs) and 3D imaging (CBCT scans). In Leuven, peri-apical radiographs were made with toestel Minray equipment (Soredex, Tuusula, Finland). In Cluj, panoramic radiographs were made with Instrumentarium OP100 equipment (Tuusula, Finland). The CBCT devices were Scanora 3D (Soredex, Tuusula, Finland) in Leuven and NewTom 3G (QR, Verona, Italy) in Cluj. Clinical settings, as recommended by the manufacturers, were used.

Six observers, all members of clinical university staff, participated in the study (five maxillofacial surgeons and one dentomaxillofacial radiologist). With an interval of at least one month, the clinicians were asked to undertake implant planning based on the 2D and 3D image datasets respectively. A training session was organised for calibration and the images were presented in randomised order. The software used for this planning in 2D and 3D was Digora (Soredex, Tuusula, Finland) and OnDemand 3D (Cybermed, Seoul, Korea) respectively.

The assessment form is attached as Appendix 1. Summarising this form, the observers needed to provide bone and implant properties and give an opinion on their confidence to perform surgery with the information available on the radiographs. Observer agreement was analysed using Spearman’s rank correlation. For each observer, the difference in planning decisions between 2D and 3D imaging was compared. Implants served as measurement units. To analyse the implant location on 2D and 3D planning, the McNemar test was used. For implant length and diameter, the distance between the planned implant and the nearest tooth/implant and the confidence levels, Wilcoxon’s test was used. For an answer to the question: can 2D and/or 3D predict complications during surgery, we used the Chi square test to compare proportions of agreement.

3. Results

Out of the 54 patients, three decided not to go through with implant surgery. The total number of patients was therefore reduced to 51. A total of 220 implant locations were evaluated.

3.1 Observer agreement

3.1.1 Implant location

In an Excel table, a column of all possible implant locations was created, followed by the choice of the observers to plan (“1”) or not to plan (“0”) an implant, based on 2D or 3D images. For each imaging technique, the observers’ answers were summed.

Table 1 shows the frequency table of those sums where “best agreement” is given by sums 0 and 6; second best for 1 and 5; third best for 2 and 4 and worst agreement by 3.

Table 1: Observer agreement on implant location

Observers' agreement on implant location		
	Based on 2D	Based on 3D
Best agreement	61%	64%
Second best agreement	20%	16%
Third best agreement	14%	16%
Worst agreement	4%	4%

We can see comparable proportions for the inter-observer agreement on implant location based on 2D and 3D images.

3.1.2 Implant length, implant diameter and distance from implant to neighbouring element

Full tables for observer agreement of the following parameters are shown in Appendix 2: implant length, implant diameter and distance from implant to neighbouring element. From those tables, we can see a great variety in inter-observer agreement, with rather low inter-observer agreement and the lowest performance on implant diameter.

3.2 2D versus 3D

3.2.1 Implant location

In an Excel table, one column was constructed with all answers on possible implant locations from all observers, based on 2D images. The second column contained the answers from all observers, based on 3D images. We found an agreement 92% of the cases and disagreement in 8% of the cases.

For more elaborate analysis, we performed the McNemar test. The results of this test for comparing the implant location based on 2D and 3D imaging are shown below for each observer separately (Table 2). This test evaluates whether there is a different proportion of implants planned on 2D images, compared to 3D images.

Table 2: Results of McNemar test - comparison of implants planned on 2D and 2D images

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Difference in proportion	2.15%	8.99%	2.66%	0.53%	3.23%	2.23%
Confidence interval	1.94 to 5.14	3.15 to 12.87	0.58 to 3.58	4.27 to 5.16	2.63 to 8.32	0.44 to 2.23
p-value	0.39	0.003	0.13	1	0.33	0.13

Overall, there does not seem to be a difference between the choice of implant location based on 2D and on 3D images.

3.2.2 Implant length

In an Excel table, one column was constructed with all answers on implant length from all observers, based on 2D images. The second column contained the answers from all observers, based on 3D images. We found the same length in 31% of the cases. 41% of planned implants were longer on 2D and the remaining 27% was shorter on 2D planning.

Table 3 shows the results for the Wilcoxon test for paired samples. A positive difference in this context means that a longer implant was chosen based on the CBCT planning. A negative difference results from a shorter implant based on CBCT planning than the implant chosen based on a 2D planning.

Table 3: Results of Wilcoxon test for paired samples: observer results on implant lengths

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Median 2D_3D	12_12	12_12	11_10	11_10	11_12	11_10
Positive difference	16	15	37	40	103	23
Negative difference	24	30	106	102	39	65
p-value	0.23	0.03	<0.0001	<0.0001	<0.0001	<0.0001

Except for observer 1, all observers choose different implant lengths based on 2D and 3D images. Mostly, a shorter implant is chosen based on 3D images.

3.2.3 Implant diameter

In an Excel table, one column was constructed with all answers on implant diameter from all observers, based on 2D images. The second column contained the answers from all observers, based on 3D images. We found the same diameter in 52% of the cases. 22% of planned implants were narrower on CBCT and the remaining 26% were wider on CBCT planning.

Table 4 shows the results for the Wilcoxon test for paired samples. A positive difference in this context means that a wider implant was chosen based on the CBCT planning. A negative difference results from a narrower implant based on CBCT planning than the implant chosen based on a 2D planning.

Table 4: Results of Wilcoxon test for paired samples: observer results on implant diameter

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Median 2D_3D	4.1_4.1	4.1_4.1	3.8_3.8	3.8_3.8	4_4.1	3.8_3.5
Positive difference	12	57	48	38	101	44
Negative difference	18	7	71	104	38	51
p-value	0.47	<0.0001	0.53	0.0001	0.003	0.05

Differences between implant diameters are present but very small. Based on these results, we cannot draw a general conclusion on the difference in implant diameter chosen based on 2D and 3D images.

3.2.4 Distance implant – neighbouring element

Table 5 shows the results for the Wilcoxon test for paired samples. A positive difference in this context means that the distance between the implant and its neighbouring element was higher on the CBCT planning than on 2D planning. The opposite is true for a negative difference.

Table 5: Results of Wilcoxon test for paired samples: observer results on distance between the implant and its neighbouring element

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Median 2D_3D	6.8_7.23	6.4_6.29	6.3_7.2	6.4_6.42	5.9_5.6	5.19_5.80
Positive difference	74	61	87	78	57	70
Negative difference	61	78	58	67	83	57
p-value	0.12	0.07	0.0007	0.76	0.02	0.29

Differences are very small and not clinically relevant.

3.2.5 Surgeon's convincement and confidence

The convincement question probed the general feeling of the surgeon on whether there was enough information available on the images to perform surgery. The confidence question referred more specific to the surgeons' own confidence in performing surgery with the images available.

Tables 6 and 7 show the results for the Wilcoxon test for paired samples. A positive difference in this context means that the rating for CBCT was higher than for 2D. The opposite is true for a negative difference.

For more convenient interpretation of the tables, the questions and answers are repeated below.

Table 6: *How convinced are you that these images will give you enough information to perform surgery without complications?* 1=Very convinced; 2=Convinced; 3=No opinion; 4=Doubtful, unsure; 5=Very doubtful, unsure

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Median 2D_3D	4_2	4_1	4_1	4_1	3_1	2_2
Positive difference	0	0	0	0	0	45
Negative difference	104	142	135	145	139	42
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.17

Table 7: *How confident are you that you can perform the implant surgery only with these images.* 1=Very confident; 2=Confident; 3=No opinion; 4=Doubtful, unsure; 5=Very doubtful, unsure

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6
Median 2D_3D	3_2	4_2	2_2	3_2	3_2	3_2
Positive difference	0	0	6	15	32	35
Negative difference	100	130	84	79	86	53
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.39

An overview of all responses on the first and the second question is shown in the graph below (Figure 1). It shows the frequency of responses in the five categories for all observers.

Figure 1: Frequency of observer responses

Observers' convincement **Observers' confidence**

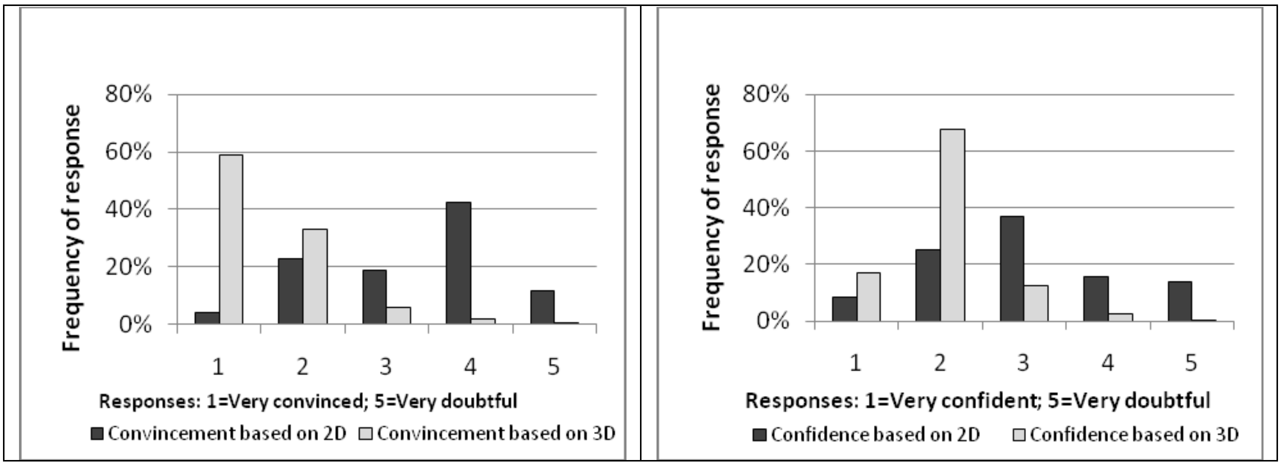

Table 8 shows the results of the analysis of whether there was a different opinion, depending on the region of implant placement.

Table 8: Comparison of convincement and confidence for different implant locations

	Observers' convincement		Observers' confidence	
	2D	**3D**	**2D**	**3D**
Upper frontal	3.3	1.5	2.9	1.9
Upper central	3.8	1.8	3.4	2.2
Upper lateral	3.9	1.7	3.5	2.2
Lower frontal	3.3	1.6	3.3	1.8
Lower central	3.1	1.5	2.9	1.8
Lower lateral	3.0	1.5	3.0	1.7

The table shows the best results for the lower lateral area and the most insecure results for the upper lateral and upper central area of the mouth.

3.2.6 Surgical events

We calculated the agreement between the observers' opinion on uneventful surgery and the actual surgical report. Surgical events could be: dehiscence, fenestration, sinus perforation, mandibular canal perforation, malpositioning. For 2D images this agreement was 34% and for 3D images, 54%. The Chi square test for the comparison of these proportions gave a p-value of 0.002.

4. Conclusions

4.1 Implant location

The first step of implant planning is choosing the exact location of the future implant in the maxilla or mandible. Designating the right location on the dental crest is generally determined by the dimensions of the bone supposed to receive the implant. However this is not the only important factor. Of equal importance are the need for prosthetic rehabilitation and biomechanically balanced support depending on the type of treatment. Next to bone dimension, bone quality is also important (Ribeiro-Rotta et al 2010).

In the present study, only partially edentulous patients were included, which made the optimal location of the implant in many cases abundantly clear.

Our results showed that 92% of the implants had the same location on 2D and CBCT planning and only 8% of the implants had a different location in 2D and CBCT planning. Only one of the observers showed a statistically significant difference for the location of implants between their planning on 2D and CBCT; the difference was not statistically significant for all the other observers.

In more complex cases, with large edentulous areas, the implant planning might target a fixed solution with a large number of crowns supported by the implants or, alternatively, a full prothesis placed on the implants. These options largely depend on the dimensions of healthy bone available as a basis for the implant, but also on a series of factors of a more subjective kind, such as the experience of the implantologist and the attitude of the patient with regard to one or the other therapeutic option. In the present study, there were two situations with patients presenting large maxillary and mandibular edentulous areas, worsened by pronounced lateral resorption of the dental crest. In one of the cases, studied on 2D images, all examiners opted for the same implants, relying on a sinus lift to bring the crest to the desirable height. After having studied the CBCT images, three examiners changed their therapy plan, suggesting an overdenture solution for the entire maxillary area, reconsidering the number of the implants and their location. In another case two of the examiners chose the overdenture, based on the 2D planning, whereas based on the CBCT images, one more specialist gave up on the idea of a fixed solution, and decided for the overdenture option. Based on these examples, we assume that, for large edentulous areas, the choice of implant location or more in general, the therapeutical approach, might well be influenced by the availability of 3D images. In the decision process, however, the experience of the surgeon should not be underestimated as an important variable.

This might be explored in follow-up research involving edentulous patients and surgeons/trainee surgeons with and without with specified years of experience.

4.2 Implant length

Our overall results revealed that only in 31% of implants, the implant lengths chosen by observers were the same on 2D planning as with CBCT planning. In 42% of the cases, the observers chose to place shorter implants based on CBCT images compared to 2D images. The remaining 27% stands for implants longer on CBCT planning than on 2D planning. The Wilcoxon test demonstrated a significant difference between the length of implants chosen on 2D images compared with the length planned on CBCT images in five out of six examiners. This might point to the importance of precise data on alveolar bone dimensions, to avoid damaging the mandibular canal of the maxillary sinus floor.

In these results, we see a reflection of what can be found in the literature: bone height, alveolar crest dimension and the identification of anatomically important structures can accurately be assessed on CBCT images (Fatemitabar et al. (2010), Leung et al. (2010), Lofthag-Hansen et al. (2008)).

The height of the alveolar crest can be estimated on a panoramic radiograph or on a periapical radiography as well. Estimating the proper implant length on these radiographs, based on the alveolar crest size, might be erroneous because of a pronounced angle of the alveolar crest or because of bone defects that are often invisible on the 2D images used. Another planning pitfall can be the mandibular canal, which is not always clear on 2D images, e.g. due to its lingual position (Mehra et al (2009). Nevertheless, Vazquez et al (2008) consider that panoramic radiography can be considered a safe pre-operative evaluation tool for routine implant placement in the posterior mandibular area under the condition that a safety margin of at least 2 mm is kept above the mandibular canal. The authors performed a study on the incidence of lesions involving the inferior alveolar nerve after placing implants relying only on panoramic radiography and a graduated implant scale provided by the implant manufacturer. Only in two cases out of 2584 there was permanent damage to the alveolar nerve (0.08%). Yet it should be mentioned that this problem was not objectivised by neurophysiologic testing. Higher percentages, up to 17% of remaining altered sensation, were found by Abarca et al (2006) and Liang et al (2008).

Multiple factors influence the choice of implant length: the available height of alveolar bone and the angulation of the crest. Reduced alveolar bone height does not necessarily impose a short implant because bone grafting can offer the extra height needed for an implant of optimal length. For some surgeons, the most important factor in implant planning is the length of the implant, which should guarantee stability, even if it means that a bone graft is required to obtain this. Other surgeons however, consider short implants satisfactory, e.g. in the (pre)molar area and are at ease to avoid in that way post-surgical risks introduced by the grafting procedure (Romeo et al (2010), Esposito et al (2010)). Evidently, the choice of the length of an implant is influenced by anatomical characteristics, but also by the surgeon’s personal opinion and experience and by the patient’s clinical condition. It is therefore difficult to get straightforward results on the difference between the implant length, based on 2D versus 3D planning. This finding coincides with the poor agreement in planning vs. surgery, found for both 2D and 3D preoperative planning, for the implant size (Jacobs et al 1999 a and b).

4.3 Implant diameter

Our overall results showed a concordance of diameter in 52% of implants (2D vs CBCT). In 22% of the cases, the observers chose to place narrower implants based on CBCT images compared to 2D images. The remaining 26% stands for implants wider on CBCT planning than on 2D planning. The Wilcoxon test showed variable results for all observers: for two, there was no difference in diameter on 2D and CBCT. For two observers, the diameters were bigger on 2D planning and for a further two, the diameters were smaller on 2D planning.

The implant diameter should be planned taking in consideration the alveolar crest width, height, angle and the consistency of the available bone. For an accurate planning of the implant diameter it is deemed necessary to use a radiological examination that provides a cross-sectional image. When using only 2D radiological methods, the surgeon needs additional information about the alveolar crest width, given by clinical examination. The implant diameter can also be influenced by bone density, for less mineralized bone requires wider diameters. CBCT examinations provide important information about bone density, whereas such information is less clear on 2D radiographs, and not assessable by clinical examinations.

4.4 Length, diameter and success rate

Cannizzaro et al. (2009) established that the primary stability of short implants is comparable to that of longer implants only if the diameters were larger for short (8mm) implants. They found no difference for secondary stability.

Other authors however, believe that the amount of lost short implants is notably higher than the amount of lost long implants. Olate et al (2010) found no relation between early loss of implants and the osseous quality or implant diameter but did find a difference between implant loss of short versus long implants. Cooper et al (2010) confirmed the latter by showing a higher risk of primary implant instability for short implants. Overall, it seems that larger implant diameter gives better primary stability and is associated with a higher surgical success rate (Krennmair et al. (2010)). Yet often it is necessary to use narrow implants, especially for replacing teeth in the incisive region or when the toothless area is narrow.

The success rate of the implants depends also on the degree of stress distribution within the alveolar bone. Anitua et al. (2010) demonstrated that implant diameter has a more significant influence than implant length on stress distribution in alveolar bone, and that the use of wider implants could reduce the stress in the bone surrounding the implant. For this reason, the use of short though wide implants could be a reasonable alternative in the case of limited residual ridge height.

4.5 Implant distance to neighbouring element

The distance from the implant to the adjacent teeth or implants should not be less than 2 mm. Even for narrow edentulous spaces, this distance needs to be respected and sometimes it is not possible to place multiple implants in narrow spaces.

The Wilcoxon test for all observers for this parameter showed very small differences between 2D and CBCT planning ($\leq$ 1mm), which were only significant for one out of six observers.

4.6 Convincement: "Are you convinced that these images provide enough information to perform surgery without complications?"

It is indisputable that the observers were more convinced that CBCT images gave enough information compared with the 2D images. Only one observer scored more or less equal on both image types, all others indicating a higher convincement score for CBCT images.

The convincement score was assessed by dental region in order to identify in what edentulous region the imaging techniques were more or less likely to convince the surgeons. As shown in the results section, the convincement scores showed very low variation. The worst score appeared for 2D images in the upper lateral region. Implant placement in this region could provoke maxillary sinus floor perforation when there is (unrecognized) alveolar crest resorption.

4.7 Confidence score: "Are you confident that you can perform the implant surgery?"

As with convincement scores, the observers were all more confident about their therapeutic planning based on CBCT compared with 2D images.

The lowest confidence scores again appeared in the upper lateral region, both for 2D and CBCT images. This might be explained by the higher risk and worse depiction of the maxillary area.

4.8 General conclusion

The difference in planning implants based on 2D and CBCT images appeared most clearly as a difference in the length of the implant and in the confidence of observers to perform surgery with the information available. It is important to use the available bone space in an optimal way, and the choices about the implants to be placed can be made with more conviction when the ‘critical boundaries’ can be assessed in all planes.

For the surgical procedure itself, efficiency and safety (avoiding complications) should be monitored and might be different based on different planning. It seems obvious that the more information collected *a priori*, the more efficient the surgery can be. Indeed, this is what we found from a preliminary analysis, where any surgical event could be better predicted using 3D images. However, more in depth research is required to draw firm conclusions that can be generalised.

The comparison of implant planning based on 2D and 3D images is complicated, as a randomised controlled trial is hard to establish, considering that there are few matching cases. Even to look for symmetrical needs in a split mouth design would be hard and challenging. Moreover, in implant placement we do not have a gold standard. The treatment outcome not only depends on the anatomical requirements and surgical challenges, but also on the actual needs (fixed, removable), the existing therapeutic options, the aesthetic demands and antagonistic relations. In one and the same edentulous jaw, implants can be placed in a simple and routine way or in a very sophisticated and individualised way. The approach may be one-stage surgery and placement or multi-stage. Depending on the chosen pathways, imaging requirements may be different. The current protocol has attempted to highlight the differences in planning strategies and surgical preparations.

As a concluding note, it should be said that the benefit of 3D imaging is related to 3D rendering making it possible to integrate data fully prior to surgery: in a well-performed pre-surgical planning, it is possible to integrate anatomical, pathological, biomechanical and esthetical aspects, which offers obvious advantages. In implant therapy, not only the surgical approach, but an integrated approach is warranted, in contrast to e.g. wisdom tooth removal.

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Appendix 1: Forms per patient

PATIENT INFORMATION

Patient name ______________________________

Male/Female ______________________________

Patient study ID ______________________________

Date of birth ______________________________

Grafting procedure before implant placement? ☐ Yes ☐ No

Date of implant placement ______________________________

Surgeon ______________________________

△ Please add implant location (1.2, 1.4, …) when applicable (measurements).

PRE-OPERATIVE EVALUATION

PLANNING ON PERI-APICAL OR PANORAMIC RADIOGRAPH IN DIGORA

Questions

1. On a scale of 1-5, how convinced are you that these 2D images will give you enough information to perform a surgery without complications?

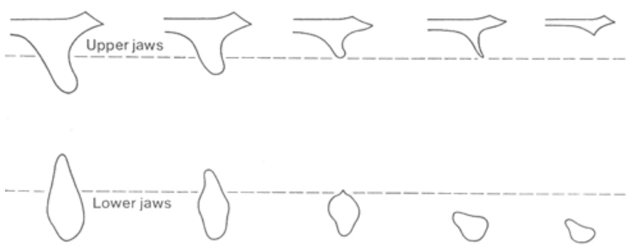
   1= Very convinced/confident; 2= Convinced/confident; 3= No opinion
   4= Doubtful/unsure; 5= Very doubtful/unsure
   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
2. On a scale of 0-5, how confident are you that you can perform the implant surgery only with 2D images?

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
3. What type of implant would you choose?

   ____
4. Bone quality

   ☐ 1 ☐ 2 ☐ 3 ☐ 4
5. Jaw shape

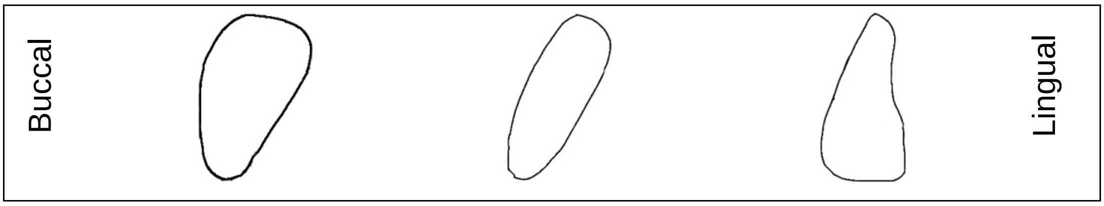
   

   Upper jaw: ☐ A ☐ B ☐ C ☐ D ☐ E

   Lower jaw: ☐ A ☐ B ☐ C ☐ D ☐ E
6. Trabecular bone quality

   ☐ Dense homogeneous ☐ Heterogeneous ☐ Sparse homogeneous

7. Bone morphology



☐ Type I ☐ Type II ☐ Type III

8. Is there any bone pathology visible? ________________ ☐

   Yes ☐ No

   If yes, specify ________________________________

9. Is there a need for a bone augmentation procedure? ☐ Yes ☐ No
10. Do you expect good primary stability? ☐ Yes ☐ No
11. Do you expect uneventful surgery? ☐ Yes ☐ No

Measurements

1. Implant length ________________________________
2. Implant diameter ________________________________
3. Distance implant midline and adjacent tooth (or implant) midline ____________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …

4. Angulation implant midline and adjacent tooth (or implant) midline ____________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …

Planning on CBCT in OnDemand

Questions

1. On a scale of 1-5, how convinced are you that these 3D images will give you enough information to perform a surgery without complications?

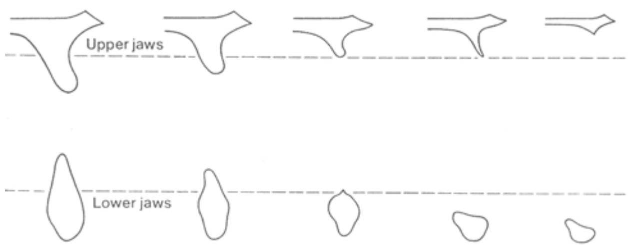
   1= Very convinced/confident; 2= Convinced/confident; 3= No opinion
   4= Doubtful/unsure; 5= Very doubtful/unsure
   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
2. On a scale of 0-5, After evaluating these CBCT images, how confident are you that you can perform the implant surgery?

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
3. What type of implant would you choose?

   ____
4. Bone quality

   ☐ 1 ☐ 2 ☐ 3 ☐ 4
5. Jaw shape

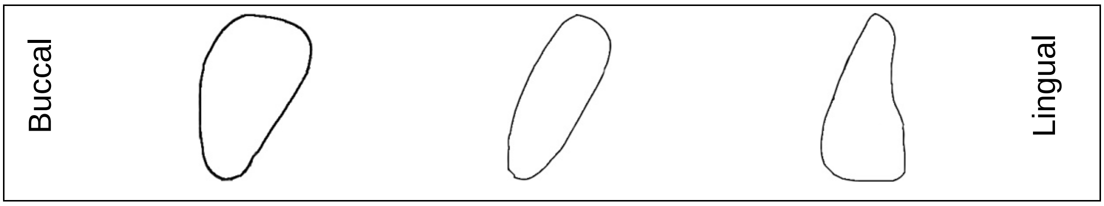
   

   Upper jaw: ☐ A ☐ B ☐ C ☐ D ☐ E

   Lower jaw: ☐ A ☐ B ☐ C ☐ D ☐ E
6. Trabecular bone quality

   ☐ Dense homogeneous ☐ Heterogeneous ☐ Sparse homogeneous

7. Bone morphology



☐ Type I ☐ Type II ☐ Type III

8. Is there any bone pathology visible? ☐ Yes ☐ No

   If yes, specify ____________________

9. Is there a need for a bone augmentation procedure? ☐ Yes ☐ No
10. Do you expect good primary stability? ☐ Yes ☐ No
11. Do you expect uneventful surgery? ☐ Yes ☐ No

Measurements

1. Implant length ____________________
2. Implant diameter ____________________
3. Distance implant midline and adjacent tooth (or implant) midline____________________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …
4. Angulation implant midline and adjacent tooth (or implant) midline ____________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …

PERI-OPERATIVE EVALUATION

SURGICAL FILE

Questions

1. Time of surgery (from first cut) ________________________________
2. Implant type ________________________________
3. Implant length ________________________________
4. Implant diameter ________________________________
5. Surgical events

Deviation from the planned procedure: implant (type), bone graft,…?

☐ Yes ☐ No

If yes, specify ________________________________

____

____

Dehiscence? ☐ Yes ☐ No

Fenestration? ☐ Yes ☐ No

Suboptimal primary stability? ☐ Yes ☐ No Remark: __________

____

Mandibular canal perforation (LJ)? ☐ Yes ☐ No

Sinus perforation (UJ)? ☐ Yes ☐ No

Malpositioning (according to biomechanical / aesthetic requirements)?

☐ Yes ☐ No

Remarks ________________________________

____

SURGEON'S OPINION

Questions

1. Did the diagnostic system, CBCT, provide you with diagnostic information that you did not have otherwise?

   ☐ Yes ☐ No

2. Did your surgical approach change because of the diagnostic information your received through the CBCT images?

   ☐ Yes ☐ No

3. Would you use this diagnostic system again for similar treatment conditions?

   ☐ Yes ☐ No

4. Comments: ____

   ____

   ____

POST-OPERATIVE EVALUATION

PERI-APICAL OR PANORAMIC RADIOGRAPH WITH IMPLANT

Measurements

1. Distance implant midline and adjacent tooth (or implant) midline_______________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …

2. Angulation implant midline and adjacent tooth (or implant) midline _____________

   △ Select adjacent: 1. Closest proximity 2. Mesial.

   Mark T (tooth) or I (implant) and M (mesial) or D (distal). E.g. TD, ID, TM, …

PATIENT FILE

Questions

1. Pain

Duration medication: ______________________________________ days

Duration sensation: ______________________________________ days

2. Neurosensory disturbances? ☐ Yes ☐ No

   If yes, specify ____

   ____

   ____

   Duration ____

3. Blue spots duration ____
4. Swelling duration____
5. TMJ pain after surgery ☐ Yes ☐ No

Appendix 2: Observer agreement

This appendix provides the analysis of observer agreement for implant length, implant diameter and distance from implant to neighbouring element, showing the analysis for 2D and 3D images separately.

1. Implant length

Table 9: Interobserver correlation based on Spearman's ρ for 2D images

Spearman's ρ p-value	**Observer1**	**Observer2**	**Observer3**	**Observer4**	**Observer5**	**Observer6**
Observer1		0.44 <0.0001	0.29 <0.001	0.12 0.16	0.27 0.001	0.21 0.03
Observer2	0.44 <0.0001		0.36 <0.0001	0.18 0.03	0.13 0.11	0.13 0.16
Observer3	0.29 <0.001	0.36 <0.0001		0.46 <0.0001	0.33 <0.0001	0.53 <0.0001
Observer4	0.12 0.16	0.18 0.03	0.46 <0.0001		0.4 <0.0001	0.29 0.001
Observer5	0.27 0.001	0.13 0.11	0.33 <0.0001	0.4 <0.0001		0.28 0.002
Observer6	0.21 0.02	0.13 0.16	0.53 <0.0001	0.29 0.001	0.28 0.002	

Table 10: Interobserver correlation based on Spearman's ρ for CBCT images

Spearman's ρ p-value	**Observer1**	**Observer2**	**Observer3**	**Observer4**	**Observer5**	**Observer6**
Observer1		0.54 <0.0001	0.23 0.003	0.29 <0.001	0.44 <0.0001	0.28 <0.001
Observer2	0.54 <0.0001		0.24 0.002	0.32 <0.0001	0.18 0.02	0.32 <0.001
Observer3	0.23 0.003	0.24 0.002		0.25 0.001	0.31 <0.0001	0.17 0.03
Observer4	0.29 <0.0001	0.32 <0.0001	0.25 0.001		0.30 <0.0001	0.42 <0.0001
Observer5	0.44 <0.0001	0.18 0.02	0.31 <0.0001	0.30 <0.0001		0.39 <0.0001
Observer6	0.28 <0.001	0.32 <0.001	0.17 0.03	0.42 <0.0001	0.39 <0.0001	

2. Implant diameter

Table 11: Interobserver correlation based on Spearman's ρ for 2D images

Spearman's ρ p-value	Observer1	Observer2	Observer3	Observer4	Observer5	Observer6
Observer1		0.03 0.74	-0.02 0.80	0.04 0.62	0.04 0.66	0.08 0.36
Observer2	0.03 0.74		0.19 0.02	0.08 0.32	0.35 <0.01	-0.07 0.46
Observer3	-0.02 0.80	0.19 0.02		0.43 <0.01	0.25 <0.01	0.11 0.21
Observer4	0.04 0.62	0.08 0.32	0.43 <0.01		0.10 0.23	-0.14 0.12
Observer5	0.04 0.66	0.35 <0.01	0.25 <0.01	0.10 0.23		-0.10 0.29
Observer6	0.08 0.36	-0.07 0.46	0.11 0.21	-0.14 0.12	-0.10 0.29	

Table 12: Interobserver correlation based on Spearman's ρ for CBCT images

Spearman's ρ p-value	Observer1	Observer2	Observer3	Observer4	Observer5	Observer6
Observer1		0.30 <0.01	-0.06 0.47	0.06 0.42	0.11 0.18	0.13 0.10
Observer2	0.30 <0.01		0.08 0.31	0.06 0.46	0.27 <0.01	0.02 0.80
Observer3	-0.06 0.47	0.08 0.31		-0.02 0.79	0.02 0.84	-0.28 <0.01
Observer4	0.06 0.42	0.06 0.46	-0.02 0.79		0.24 <0.01	0.22 <0.01
Observer5	0.11 0.18	0.27 <0.01	0.02 0.84	0.24 <0.01		0.02 0.83
Observer6	0.13 0.10	0.02 0.80	-0.28 <0.01	0.22 <0.01	0.02 0.83	

3. Distance implant - neighbouring element

Table 13: Interobserver correlation based on Spearman's ρ for 2D images

Spearman's ρ p-value	Observer1	Observer2	Observer3	Observer4	Observer5	Observer6
Observer1		0.15 0.10	0.29 <0.01	0.42 <0.0001	0.58 <0.0001	0.53 <0.0001
Observer2	0.15 0.10		0.12 0.18	0.07 0.48	0.14 0.11	0.08 0.35
Observer3	0.29 <0.01	0.12 0.18		0.75 <0.0001	0.56 <0.0001	0.60 <0.0001
Observer4	0.42 <0.0001	0.07 0.48	0.75 <0.0001		0.65 <0.0001	0.63 <0.0001
Observer5	0.58 <0.0001	0.14 0.11	0.56 <0.0001	0.65 <0.0001		0.82 <0.0001
Observer6	0.53 <0.0001	0.08 0.35	0.60 <0.0001	0.63 <0.0001	0.82 <0.0001	

Table 14: Interobserver correlation based on Spearman's ρ for CBCT images

Spearman's ρ p-value	Observer1	Observer2	Observer3	Observer4	Observer5	Observer6
Observer1		0.38 <0.0001	0.34 <0.0001	0.45 <0.0001	0.24 <0.001	0.28 <0.001
Observer2	0.38 <0.0001		0.2 0.01	0.41 <0.0001	0.32 <0.0001	0.20 0.01
Observer3	0.34 <0.0001	0.20 0.01		0.33 <0.0001	0.35 <0.0001	0.39 <0.0001
Observer4	0.45 <0.0001	0.41 <0.0001	0.33 <0.0001		0.21 0.006	0.30 <0.001
Observer5	0.24 0.004	0.32 <0.0001	0.35 <0.0001	0.21 0.006		0.27 <0.001
Observer6	0.28 <0.001	0.20 0.01	0.39 <0.0001	0.30 <0.001	0.27 <0.001	

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