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USE OF PLASTIC MATERIAL AND TRIPLE SCAN IN THE PREPARATION OF SURGICAL GUIDES FOR THE DENTAL IMPLANT TREATMENT - CASE REPORT

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Summary:

The use of surgical guides in implant treatment increases the accuracy of the dental implant positioning compared with manual methods. Regardless of how they are made, deviations of implants from their intended position are established in all kinds of surgical guides. This article considers the use of plastic material and new scanning technique for the production of CAD/CAM surgical guides that aim to overcome the deficiencies of the currently applied technologies in the production of surgical guides.

Materials and methods: The study shows the techniques used to overcome degraded by metal artifacts CBCT images in implant treatment of patients with partial edentulism, and located medially to the defect metal-ceramic crowns. When planning implant treatment, a triple scan method has been implied. At the beginning, CBCT scan of the patient with a silicone impression material is made in the zone of interest. Secondly, CBCT scan only of the silicon impression is made, and thirdly - intraoral scanning of the patient with an intraoral scanner. Virtual analogues have been created of images from the three scans and have been repositioned one over another; as thereby an intraoral image have been accurately positioned over the CBCT image of the patient. Virtual planning of the implant positioning has been performed, and a model of surgical guide has been made for their placement. The guide has been printed with an SLA 3D printer technology of photopolymer with dualistic characteristics-rigid in the working part and plastic in the fixing part. Through it, implants have been placed to the treatment planning. Postoperative CBCT has been done on the patient to measure the implant deviation to their position in the treatment planning.

Results: Axes angular deviation of the planned and placed implants has not been established. Average linear displacement of 240 μ (+/- 40 μ) has been found.

Conclusions: Using the triple scan method is possible to overcome the poor image quality of the metal (metal-ceramic) structures artifacts in CBTC scan of patients for implant treatment. Using semi-plastic material for printing of the surgical guide allows its good fixation intraoperative and the accurate guidance of the implant drill that provides the implant placement with clinically negligible deviation from their intended position.

Keywords: CAD/CAM surgical guides, CBCT, dental implant, intraoral scanner,

INTRODUCTION

With the increasingly widespread use of implant treatment, the expectations of its results increase. Its planning takes substantial part of it and largely determines the final result [1]. Modern digital technology allows this process to be performed entirely in the digital environment without the need for physical models. Future prosthetic constructions are generated with software, and the position of the future implants is planned according to them, and the available bone tissue. Their position is translated intraoperative with surgical guides, as with virtual 3D printing, their virtual model becomes a physical one. The use of surgical guides when inserting the dental implants leads to their more accurate positioning in comparison with manual methods [2, 3, 4].

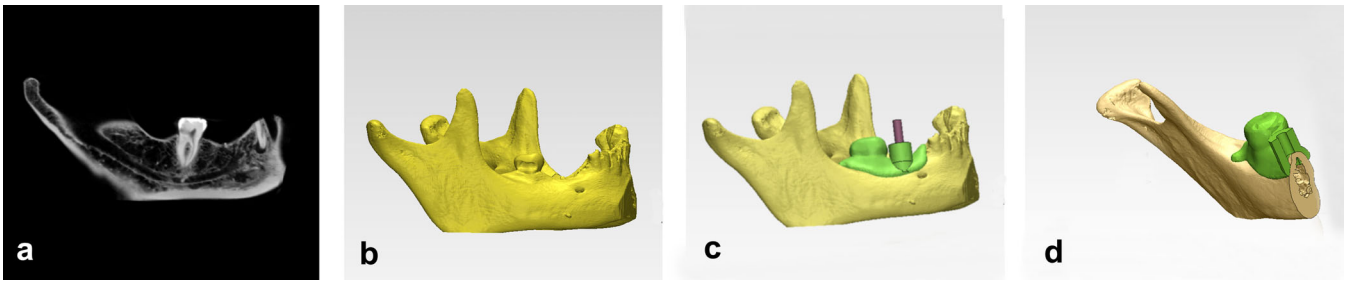
The production of these CAD/CAM surgical guides include the use of so called double scan method [5], its virtual creation based on CBCT images of the patient, its plastic model and its printing. Although this approach is a qualitatively new level compared to laboratory methods of surgical guides' production, it has several drawbacks:

Detail of CBCT images is low - they are used to create a virtual anatomical model for planning the implant positioning and a contact surface of the surgical guide is carried out on them (Fig.1)

Detail of the CBCT depends on the scan resolution and varies between 150 and 600 μ. The uneven absorption of X-rays from different hard tissue (bone, enamel, and dentin) is an additional complication. Therefore, virtual models, created directly from X-ray images of patients, have uneven surface and guides created on them could not be adjusted exactly on their real anatomical analogue. This is compensated by the double scan technique whereby a gypsum cast from the patient is scanned, and positioned on the X-ray images of the patient. Spatial variations that could occur from possible deformation of the patient's impression and its cast can not be avoided.

An alternative to casts could be the use of intraoral scanners whose images are superimposed on the CBCT study. Scientific data on the use of this approach are scarce. In fact, only 3 articles have been found describing individual cases [6, 7, 8]. Here again two scans are performed,

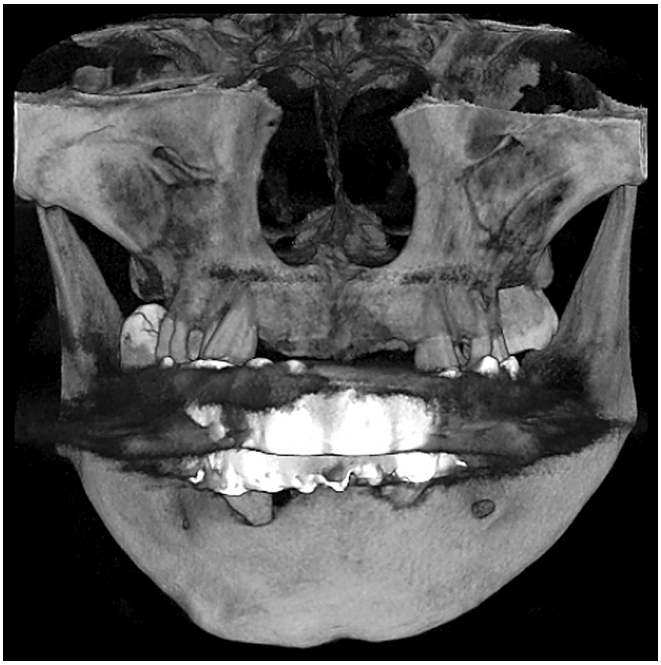
Fig. 1 a, b. CBCT image and its virtual analogue; **c, d.** Virtual surgical guide created in the images of a and b.



but the second one is not a CBCT of the plastic model, but an intraoral scanner.

2. The classical approach is difficult or impossible for application where metal artifacts mask the X-ray anatomy in which to be repositioned the image of the impression model (Fig.2). The reason is that anatomical markers are lost, according to which are adjusted to fit the virtual images of the model, and the X-ray image of the patient. There is a very big risk both models not to be fully compliant and hence to obtain an implant variation.

Fig. 2. Crown contours, which are the anatomic markers, are invisible due to so called "scattering" caused by the presence of metal-ceramic constructions.



3. The printed surgical guide is hard (rigid). Because of the absence of any plasticity, its fixing part is arranged above the equatorial area (in tooth-supporting guides) and this leads to micro movement of the guide, and deviation respectively in its use.

We believe that the above three issues are the main reason for registered by researchers many deviations in the use of surgical guides to the planned ones in the implant positioning [9, 10, 11, 12, 13, 14].

The study offers if not a decision, then at least an attempt to overcome these shortcomings in the planning and use of surgical guides for dental implant treatment.

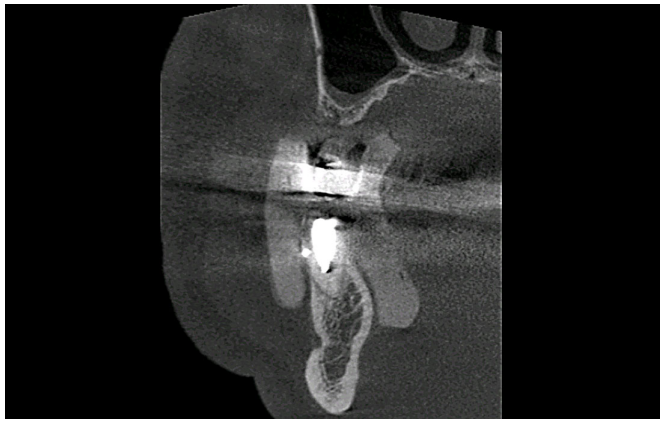
MATERIALS AND METHODS:

Implant treatment has been conducted on a 52-year-old male, nonsmoker, in good general health with distal unlimited partial edentulism in the field from 46 and 47. The patient had no contraindications to treatment (radio- or chemotherapy, chronic systemic diseases or bruxism). After the initial view and discuss, we proceeded to treatment planning.

Since from the clinical view, it has been found that medially located to the edentulous area teeth have metal-ceramic constructions, it has been decided to apply the method of triple scan to overcome artifacts that these crowns would cause scan of the patient in CBCT.

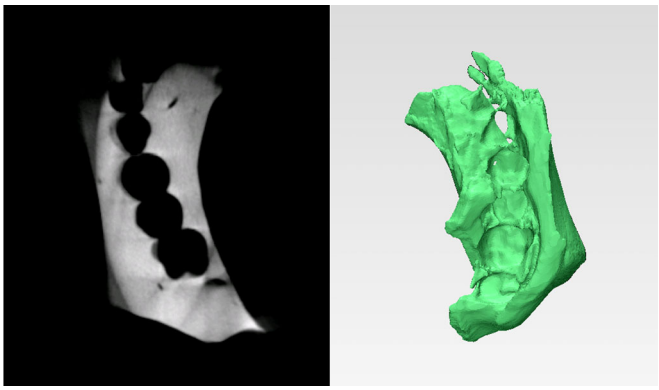
The first scan is CBCT of the patient (ProMax 3D Mid, Planmeca). The special feature of this scan is that it is made with C-silicone impression material (Zetaplus, Zhermack®) in the patient's mouth (Fig. 3).

Fig. 3. CBCT of patient. Despite artifacts of metal-ceramic crowns, the outlines of silicone impression material are seen clearly.



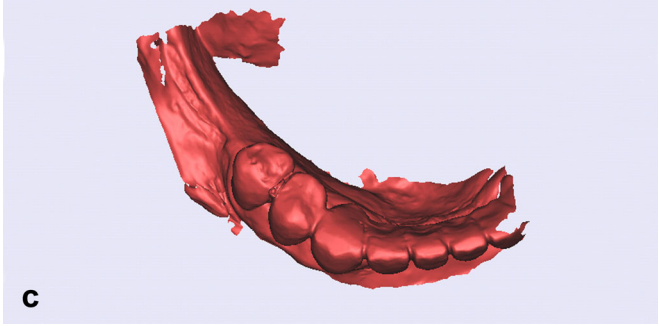
The second scan is on the impression itself, and it has been made with the same CBCT system. It is used to make a virtual model of the impression in a STL format (Fig. 4)

Fig. 4. CBCT of the silicone impression and its virtual analogue in a STL format.



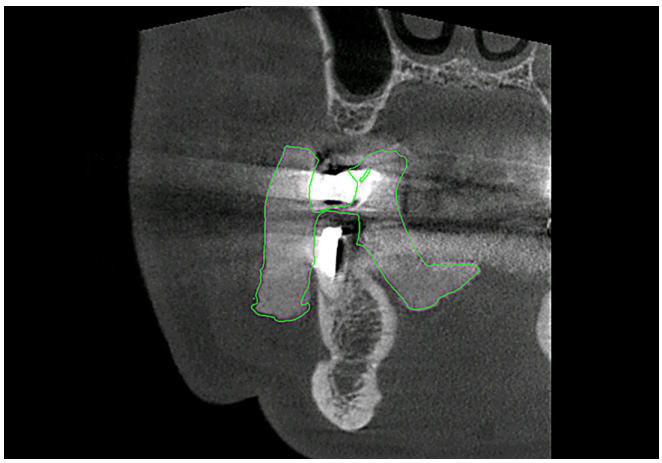
The third scan has been made with a precise intraoral scanner (TRIOS® 3, 3SHAPE). It serves as a high-quality digital impression from the zone of interest. It also creates a virtual model in a STL format (Fig. 5).

Fig. 5 a. Image of intraoral scanner of the two jaws in the zone of interest; **b.** Image of the lower jaw; **c.** STL model of the same jaw.



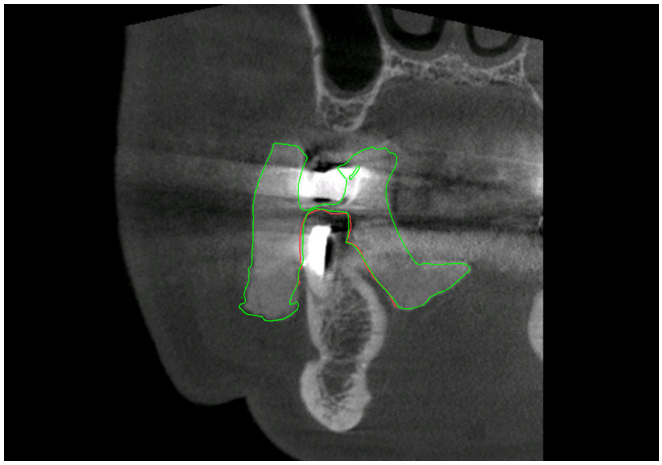
As the silicon impression contours of the first scanner are clearly visible, its virtual replica of the second scanner is easily positioned on it (Fig. 6)

Fig. 6. STL model contours of the silicon impression are visible with green color positioned on its shadow of the first CBCT. Crown contours are already well defined thanks to that reposition.



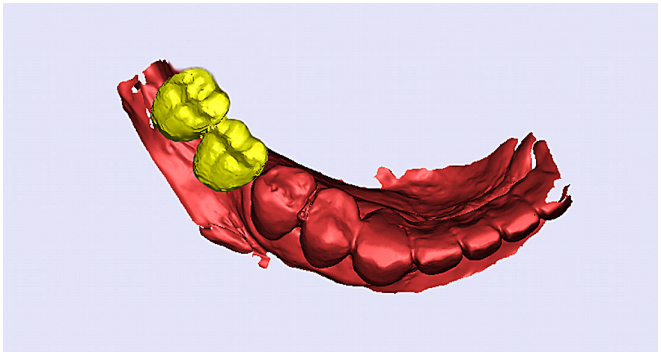
The intraoral scanner STL model is positioned on the crown contours of the repositioned already silicone impression (Fig.7).

Fig. 7. Intraoral scanner STL model contour is marked with red.



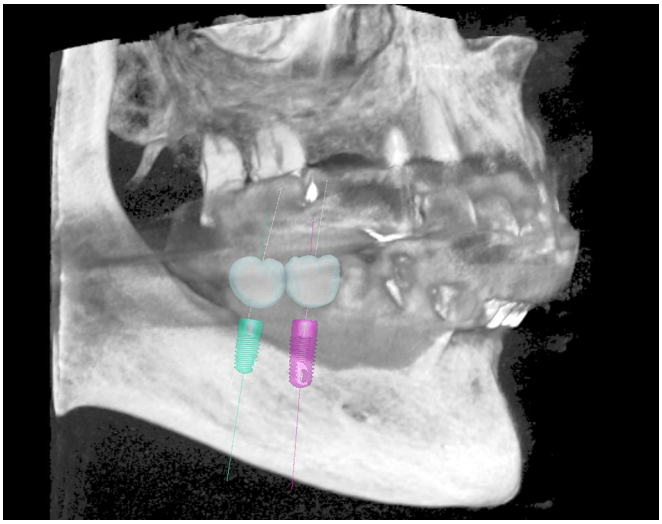
The intraoral scanner image has high resolution (about 20 μ in this case), this is the reason it recreates the actual anatomy very accurately in the zone of interest. It gives the opportunity to build up virtual wax-up, digital-up (dig-up) (Fig.8)

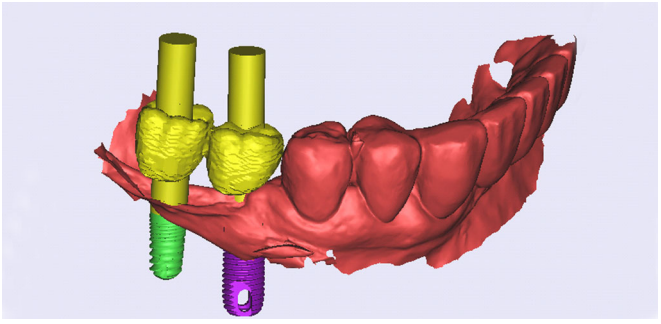
Fig. 8. Dig-up



This dig–up allows us to define the best of prosthetic and osseointegration view to future implants. Their size, angle and depth of positioning (Fig.9)

Fig. 9. Digital view of the future position of the implants.

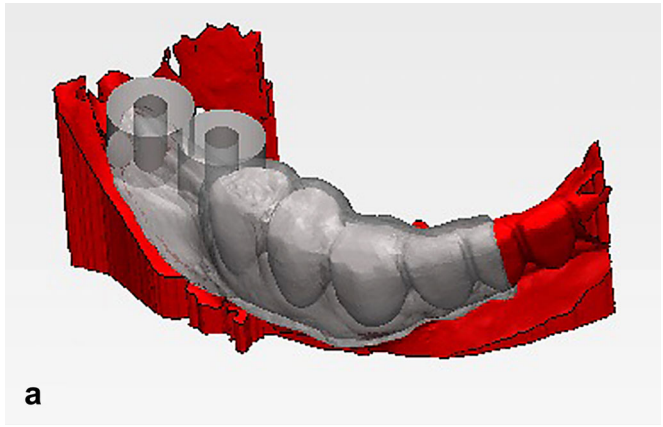


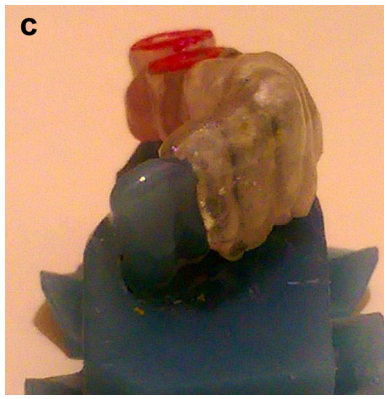


In the case we chose in the zone of 46, an implant with sizes 4,2 x10 mm to be placed, and in the zone of 47 - implant with sizes 4,2 x 8 mm (Legacy 3, Implant Direct).

In CAD software, based on this implant positioning, a guide, which has been created and printed with semi plastic material SLA technology (DentalXlab Guide, Dentalxlab). This guide of printing depth from 0,8 to 1 mm is semi plastic and its fixing part tightly cover the retention, under equatorial areas of crowns. Meanwhile in thickness more than 1 mm, such as its working areas are (areas where sleeves for drill guidance are) it is rigid and allows stable movement of the osteotomy drill (Fig.10).

Fig. 10 a. Digital design of the guide; **b.** Printed guide; **c.** Finished guide over the dental cast



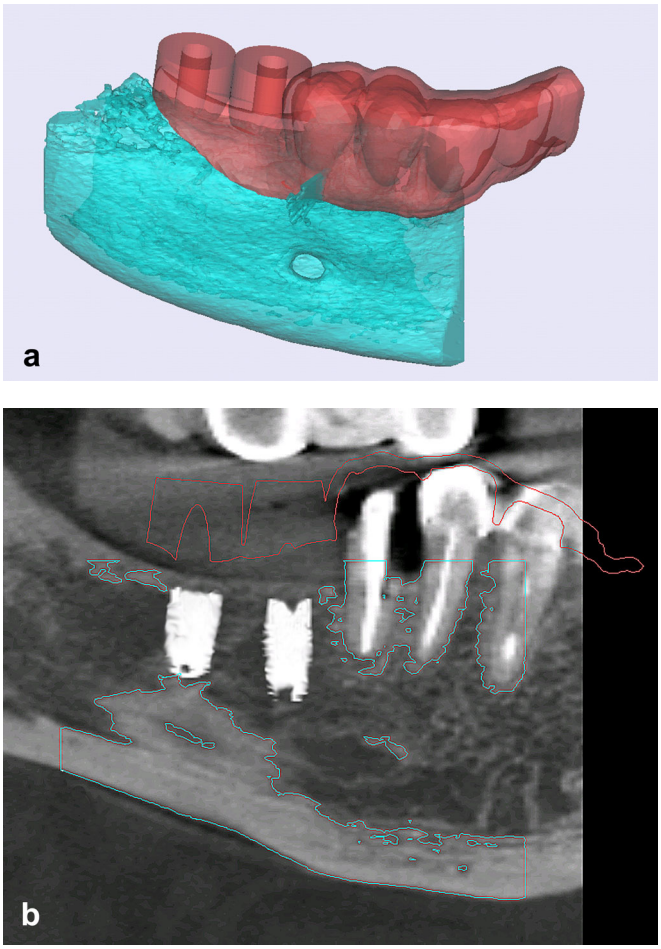


The guide has been used for the pilot drill. Osteotomy has been transgingival as the extension of the bone bed has been carried out manually.

Postoperative period has passed without complications and a control CBCT has been made a week after the intervention.

To compare the implant positioning with the planned one, a bone STL model has been made with preoperative scan. This model along with the guide have been superimposed on the bone outlines from the second scanner. For starting point for measurements of deviations has been used a central axis of the guide's working part, as they have been made along the planned implants axes. The angular deviation and linear deviation of the central axis guide to the implant axis have been measured (Fig. 11).

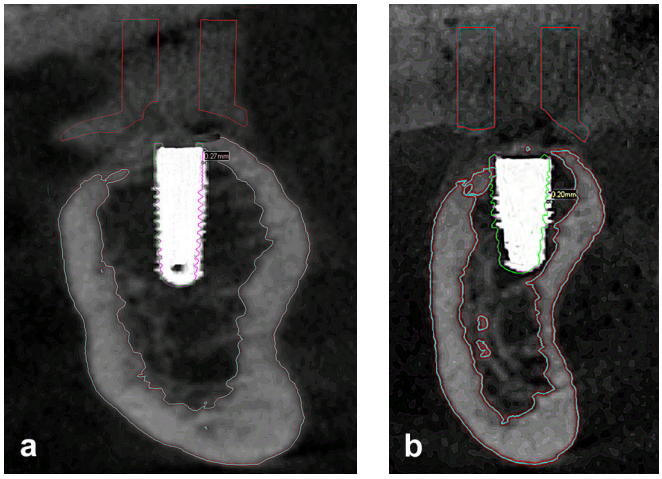
Fig. 11 a. STL model of the jaw in the implant zone with a guide's model; **b.** Blue contour shows the positioning model of the jaw from the first CBCT on the bone outlines in the second CBCT. Guide's outlines are marked with the red contour.



RESULTS

In the implant in the area of 46, no angulation has been established, linear displacement in the vestibular direction of approximately 280 μ has been reported (Fig.12a). An implant in the area of 47 hasn't been also angulated to the intended position. Linear displacement of 200 μ has been also measured in the vestibular direction. (Fig.12b)

Fig. 12 a, b. Distance between outlines of the planned implant (green) and placed implant (radiopacity) is measured .



CONCLUSIONS:

Using the triple scan technique, inaccuracies caused by metal artifacts are overcome in the creation of digital models when planning implant treatment. This technique allows the integration of high-quality images of intraoral scanners in the planning process. Since they are with high detail, the created on these surfaces surgical guides show very good agreement with the actual anatomical structures on which they are fixed intraoperative.

Semi plastic materials used in the surgical guide printing are fixed many stably on teeth as they cover under equatorial areas. However, in the working areas of the guide (where the leading sleeves are located), they are rigid and do not allow deformation and deviation in drill guidance in osteotomy.

Registered deviations can be explained by the fact that the surgical guide has been used for keeping only the pilot drill, and the expansion of the osteotomy bed has been completed manually.

The method described shows that although registered deviations, they could be reported as clinically negligible as they are below 500 μ and in horizontal direction, as deviations of angulation and depth have not been registered. Described approach would be a decision of the 'extremely difficult' in the words of Van Assche [15] task to reduce the accuracy of surgical guides below 500 μ.

Of course, we need further research to confirm the clinical relevance of the described approach.

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