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A Precise and Simple Implant Template Guided by Cone Beam Computer Tomography

Kaijuan Wang Rao [1,2]
Jia Xu[1,2,*]
Wenqiong Luo[1,2]
Dingfu Nan[3]
Muren Hasi[3]

[1]State Key Laboratory of Oral Diseases, National Center for Clinical Research in Oral Diseases, West China Hospital of Stomatology, Sichuan University, China
[2]Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University, China
[3]Department of Stomatology, Inner Mongolia International Mongolian Medical Hospital, China

Abstract

Purpose: This study was to introduce a novel method of an accurate simple template with cone beam computer tomography (CBCT)-assisted guided templates, and to test the feasibility and accuracy of this method.

Methods: We modified the simple guide template with a titanium bar and 4 small steel balls. According to the CBCT and the position of balls, clinicians corrected the locations of the bar to indicate implant position. To evaluate the deviation between planning, implant and the actual implant, patients were scanned again with the CBCT system and software matching was applied.

Results: The angular and position deflection was little. Deviation at entry point was 0.2 mm and the max error point of the head of implantation was 0.5 mm.

Conclusion: This novel approach achieved accurate positioning, as well as reduced the cost and the treatment period. By this way, we achieved the integration of "remedy-oriented" implant design and anatomical structure, bone mass.

Keywords

Dental implant, Surgical template, Cone beam computer tomography

Introduction

Dental implants have been the preferred option among traditional prosthodontics worldwide due to their superior functionality and aesthetics. However, the widespread use of dental implants has been accompanied by an increase in surgical and prosthetic complications as a result of inappropriate diagnoses and implant placement [1]. Hence, there is a demand for the development of new and advanced dental implant techniques. Because the oral cavity is a relatively restricted space, a high degree of accuracy in implant placement is critical for a successful prosthesis-guided implant. The use of implant templates has significantly increased accuracy and has reduced the incidence of complications [2]. To date, there are two main types of implant templates: digital guide templates and simple guide templates. The digital guide template is based on computed tomography data, designed using professional software, and processed by computer-aided design and computer-aided manufacturing (CADCAM) or by 3D printing. To ensure accuracy, there are several requirements for template production: (1) the templates must be stable and rigid when placed in the correct position, (2) the size of the guide template should be moderate and easy to operate, (3) the guide template should be transparent to facilitate adjustment, and (4) the guide template must be able to be disinfected [3,4]. Despite the popularity of the digital guide template in the digital age, most clinicians still use the simple guide template because it is cost-effective and it takes less time to produce. But, none of the traditional simple guide templates take anatomy into account. The positioning and angulation of implants using simple guide templates rely on a doctor's experience rather than on cone beam computed tomography (CBCT) evaluation of the available bone. Hence, the traditional simple guide template has no surgical guiding significance. In this study, we aimed to develop an improved simple template that guides surgery based on CBCT data by setting markers for accurate directional positioning of dental implants without increasing the cost.

Methods

Fabrication of the precise and simple cone beam computer tomography (CBCT) template involves the following steps:

1. Take a mould of the dentition of the patient to make wax teeth and fabricate a polyvinyl chloride vacuum-formed retainer.

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***Corresponding author:**

Kaijuan Wang Rao, B.D.S
State Key Laboratory of Oral Diseases
National Center for Clinical Research in Oral Diseases, West China Hospital of Stomatology
Sichuan University, USA, Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University
14# Third Section, Renmin Nan Road, 610041
Chengdu, China
Tel: 86-18224468610
E-mail: 1312489790@qq.com

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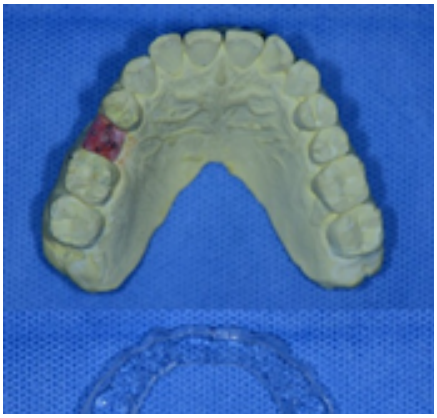
2. Make a hole on the occlusive surface of the vacuum retainer into which a 2.2 mm diameter titanium bar can be inserted.
3. Heap the surfaces of the edentulous arches flat with wax, and place four small steel balls (1 mm diameter) around the titanium bar as reference markers.
4. The positions of the four balls are obtained by infusing the defective dental area of the retainer with silicone rubber. Then, another four markers are placed in the retainer to obtain a radiographic guide template (Figure 1a).
5. The patient undergoes a CBCT scan with this radiographic guide template. Using the CBCT scan containing the four markers, dentists can measure the distances from the markers to the ideal position of the implant, which allows for three dimensional directional adjustments of the titanium bar (Figure1b).
6. Set the 2.2 mm diameter titanium bar using a 2.2 mm inner diameter titanium tube and fill the retainer with self-setting resin. Then, after pulling out the titanium bar the template is finished (Figure 1c).

To evaluate the accuracy of the precise and simple implant template guided by CBCT, we measured the deviations between the pre-operative plans and the post-operative results by comparing pre-operative and post-operative CBCT scans.

Results

The implant surgery was succeeded. The implant was in a perfect three-dimensional angle as showed (Figure 2) Deviation at entry point was 0.2mm. The max error point of the head of implantation was 0.5 mm.

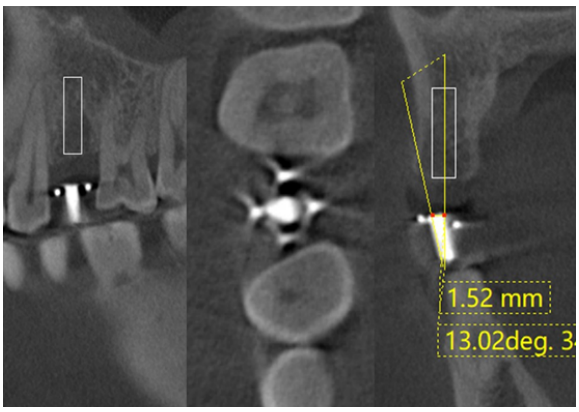


After taking the mould of the dentition of the patient, a vacuum-formed retainer was made. The surfaces of the edentulous arches were smoothed out with wax, and four small steel balls (1 mm diameter) were placed around the titanium bar. The position of the four balls was duplicated in the retainer, and then another four balls were placed in the corresponding position.

Figure1: The precise and simple implant template fabrication process

Discussion

As 3D print surgical templates are becoming increasingly available [5-7], implant surgeries using 3D print surgical templates are becoming routine procedures. A 3D printing machine can manufacture patient-specific guides, which is especially useful when using master sleeves with minimal space between small diameter implants [8]. In addition, improved performances of some metallic materials [9] have popularized the manufacturing of surgical guides using a metal 3D printer. However, it requires considerable time and expense to fabricate an accurate surgical guide template.On the contrary, as a classic tool, the simple guide template cannot adjust for the direction of the implantation and it cannot achieve accurate



Buccal lingual deviations can be found clearly and can be measured by the software, helping the doctor adjust the direction of titanium bar according to the location of 4 markers.

Figure 2: The CBCT image of patients wearing the implant template.

Figure 3: Finishing the precise and simple guide template

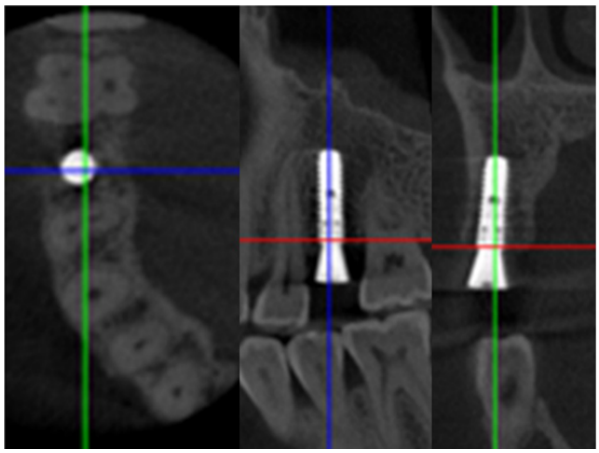


Figure 4: With the guidance of the precise and simple implant template, the implant was in a perfect angle from three dimensions

orientation through CBCT. In our method, for the first time, markers and CBCT are combined with the simple template to achieve precise implantation.

Accuracy is the key for guided implant placement. In a meta-analysis of accuracy and clinical applications of computer-guided

template-based implant dentistry, Schneider D [10] found that the overall mean error was 1.07 mm (95% CI: 0.76–1.22 mm) at the entry point (eight studies, 321 sites), 1.63 mm (95% CI: 1.26–2 mm) at the apex (seven studies, 281 sites), and 5.261 (95% CI: 3.94–6.581) for angulation (eight studies, 321 sites). In our study, we found similar positional and angular deviations, and we found that reproducible and stable positioning of the template during the CBCT scan and the surgery are the most common sources of the deviations. The cost and the treatment period were reduced as well. Thus, the precise and simple implant template guided by CBCT that we developed is feasible and conducive for use in most clinics and hospitals.

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Ethical approval

The Human Research Ethical Committee was registered and approved in this study.

Patient consent

The author of this paper had obtained written informed consent for publication in print and electronic form from the patient.

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