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A stereolithographic template for computer-assisted teeth preparation in dental esthetic ceramic veneer treatment

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Abstract

Objective: This article describes a digital dental esthetic ceramic veneer treatment workflow using a stereolithographic template for teeth preparation.

Clinical Considerations: We have presented the case of a 33-year-old woman with dental fluorosis who wanted an esthetic ceramic veneer treatment. A digital smile design was created on a virtual patient, and a virtual diagnostic wax-up was made. Based on the suggested ceramic material thickness, virtual teeth preparation was performed on the diagnostic wax-up. A special-teeth preparation template was then created digitally and fabricated using a stereolithographic technique. This template guided the teeth preparation using a special bur with a stopper. The veneers were fabricated by CAD/CAM and delivered good esthetics and function.

Conclusions: The stereolithographic tooth reduction template helps realize digital restorative planning. It provides better control of the reduction depth of the labial and incisal preparation, making the operation simpler.

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Clinical significance: The digital dental esthetic ceramic veneer treatment workflow described here using a stereolithographic template for teeth preparation helped with the accurate control of reduction depth for minimally invasive teeth preparation, making the operation simpler, which is a significant improvement over the previous methods.

Keywords

Stereolithographic template, digital dentistry, drilling template, tooth preparation, esthetic restoration, 3D printing

Introduction

Teeth preparation is a critical step for the success of dental ceramic veneer treatment.[1,2] Preparation performed in the enamel is believed to maintain an optimal bond with ceramic veneer and decrease stress in the porcelain, and care should be taken to control the depth of enamel reduction to fulfill the enamel preservation.[3] Varies techniques have been proposed to control the reduction depth during preparation for ceramic veneers.[4] The most simple technique is creating reference grooves/dimples on the teeth surface by using the bur itself. Knowing the diameter of the bur used, dentists can create grooves or dimples with certain depth by submerging pats of the bur into teeth surface.[5] This technique should only be applied when the targeted restorative space (TRS) is the same as the existing teeth.[6] Magne et al.

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introduced a guidance technique, in which silicone indices were made from a wax-up to control the reduction depth.[7] In this technique, the TRS was created after considering the proposed restoration and restorative material. Therefore, the preparation control was driven by the TRS and provided more conservative preparation compared to that guided by the initial tooth surface.[8] Another technique was reported by Gürel. He described an esthetic pre-evaluative temporary approach, in which a trial restoration (mock-up) was performed on the abutment tooth using an acrylic resin before the actual preparation.[9] The trial restoration allowed a preoperative evaluation of esthetics and a predictable outcome. However, the mock-up application required some tooth structure reduction in subtractive cases.[10,11] Combined utilization of silicone indices and mock-up is commonly applied in clinics, which can overcome the limitations described.[12] With the development of digital techniques, new preparation methods, such as robot tooth preparation and digital designed preparation guides, may provide better control of the reduction depth during tooth preparation.[13-15]

Surgical templates are devices designed by image processing and preoperative planning using computer-aided design (CAD) software and then fabricated by milling or printing.[16] The surgical templates have been widely used in various dental surgeries such as dental implant placements and second-stage surgeries,[17] endodontic

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treatments[18] and apical surgeries,[19] gingival displacements,[20] and corticotomy in orthodontics.[21] The recent digital technology allows the surgical template to be designed from a diagnostic wax-up to control the reduction depth of the preparation.[11] This article presents a stereolithography (SLA) template, which was developed from a diagnostic wax-up using the dental CAD software to control the reduction depth of the labial and incisal preparations for ceramic veneer treatment.

Case Report

A 33-year-old woman presented with the chief complaint of discolored teeth and abrasion of the upper incisors (Figure 1). Clinical examination showed that the patient's maxillary anterior teeth were discolored and worn. The permanent maxillary right canine was missing, and a primary canine was present at the site. She was diagnosed with moderate dental fluorosis. After discussing the risks and benefits of our different treatment options, the patient chose to get an implant for the right maxillary canine and ceramic veneers on the other maxillary anterior teeth.

An intraoral scanner (3Shape TRIOS, Denmark) and a face scanner (3DMD, US) were used for intraoral and face scans, respectively. A cone-beam computed tomography (CBCT) scan (3D Accuitomo 170; J. Morita) was used to generate digital data for the skeletal maxilla and facial soft tissue. These digital images were imported into dental CAD software (Exocad 2018, Germany) and superimposed to create a 3D

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virtual patient. This virtual patient was mounted on the virtual articulator using the technique reported by Lepidi et al., and a virtual diagnostic wax-up was created (Figure 2).[22] To convert the virtual wax-up into definitive restoration, a digital template for the teeth preparation was designed as follows:

1. Based on the suggested thickness of the lithium disilicate ceramic veneers, virtual teeth preparation was taken on the diagnostic wax-up.

The digital model with diagnostic wax-up was imported into CAD software (Materialise Magics 23, Belgium). To virtually prepare the teeth, the labial and incisal surfaces of the wax-up were selected and shifted inward by using the “Offset” tool. The shift depth was set at 0.5 mm for the cervical third, 0.7 mm for the middle third, and 1.0 mm for the incisal third of the teeth. The virtually prepared surfaces, especially the transitional areas of different depths, were then selected and smoothed by the “Smooth” tool (Figure 3).

2. Guide tubes for surgical templates were designed during the virtual teeth preparation.

First, virtual cylinders of 4 mm height and 1.2 mm diameter were created to simulate the calibrated bur. Subsequently, the cylinders were placed on the labial and incisal surfaces of the virtually prepared teeth as closely as possible. Then the upper half of each virtual cylinder was shifted outward 1 mm to form a ring outside the

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cylinder. Finally, the virtual cylinders were subtracted from the rings by using the tool of Boolean calculation, leaving the guide tubes. These tubes were divided into two evenly distributed groups and exported as Standard Tesselation Language (STL) files (Figure 4).

3. Fabrication of the teeth preparation template

Both groups of guide tubes were imported into the Exocad dental CAD software. A primary tooth-supported template was first designed on the initial tooth model by using the bite splint module of the CAD software, which was then merged with the two groups of guide tubes. The two surgical templates were saved as STL files and fabricated using a stereolithography 3D printer (ProJet MJP 3600, the United States), and resin material (VisiJet S300, the United States) (Figure 5).

The teeth were prepared using the stereolithographic template. The templates were seated and evaluated for intraoral fit and stability. A calibrated bur (HX-1, Gaofeng Medical Equipment (Wuxi) Co.,Ltd, China) with depth scales and a stopper was used in this case. The bur was placed through the holes on the guide until the stopper touched guide surface, creating dimples with designed depth on the tooth surface, seven dimples were created on the buccal surface of each tooth. Subsequently, the bottom of the dimples was marked with a pencil. A straight carbide bur (HX-4, Gaofeng Medical Equipment (Wuxi) Co.,Ltd, China) was used to prepare the tooth,

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using the marked dimples as depth guides, as reported by Cherukara.[23] The remaining tooth tissue between the dimples was removed and finished at the moment of the pencil markers disappeared. A 0.5 mm wide subgingival chamfer finish line was conducted by a tapered carbide bur (HX-2, Gaofeng Medical Equipment (Wuxi) Co.,Ltd, China) with a diameter of 1.0 mm and shape of chamfer of 135°. Finally, the shoulder and tooth surfaces were finished and polished (Figure 6). A digital impression of the prepared teeth was then made using an intraoral scanner. Both the virtual and actual teeth preparation models were imported into the Exocad CAD software to measure any deviation. After confirming that the deviation in the labial and incisal reduction depth was within 0.3 mm, the digital impression was sent to a chairside CAD/CAM machine (Cameo N4, China) and lithium disilicate ceramic veneers were milled. After checking the marginal fit and optical properties, the veneers were cemented with a resin luting agent (RelyX Veneer Cement; 3M ESPE) as per the manufacturer's recommendation (Figure 7).

Discussion

The present clinical report describes a stereolithographic template that helped with depth control during the labial and incisal reduction of teeth for the preparation of porcelain veneers (Figure 8).

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A major benefit of the digital guided teeth preparation by SLA templates is the control of reduction depth during tooth preparation. Cho et al. have reported that a surgical template could help clinicians in controlling the depth of labial reduction since the template could measure a reduction as small as 0.1 mm.[13] Silva et al. also introduced a 3D-printed template for digital guided tooth preparation, and the surgical templates could manage the reduction depth in a more controlled and precise manner.[11] Taken together, the SLA template can be designed to facilitate the intra-enamel preparation, in which the depth of enamel reduction is presented by merging the virtual preparation and the original teeth models. Besides, the SLA templates provide excellent accuracy in controlling the depth of enamel reduction during the preparation.

Another advantage of the digital guided teeth preparation by SLA templates is the simpler chairside operation in clinics. The SLA templates spare the clinician from the complicated process of performing silicone indices and mock-ups.[12] In this process, much attention should be taken to avoid the poor mixture of the acrylic resin and the dislodge of mock-up from the teeth surface. The auto-stop calibrated bur stops uniformly at the 4 mm scale at each site, even though different preparation depths were designed at various sites, making the operation more straightforward for the clinicians.

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The digital-guided teeth preparation by SLA templates is especially suitable for contour-subtractive cases because performing an intraoral trial restoration precisely without reducing the tooth structure is challenging when the trial restoration is smaller than the existing tooth. Patients with multiple abutment teeth are also suitable for template-guided teeth preparation because the long-scale silicone indices may accumulate more dimensional errors.

However, though the stereolithographic template facilitates the chairside operation accurately, it takes more effort in the digital design phase in the lab. Besides, reduction depth of the shoulder and proximal preparation are guided by the bur rather than the templates, other templates can be designed for them.

Conclusion

This clinical report proposes a workflow for a digital-oriented dental esthetic veneer treatment using a stereolithographic template for teeth preparation. The template helps control the reduction depth of labial and incisal preparation, making the operation simpler.

Conflict of interest

The authors declare no potential conflict of interest.

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Figure legends

Figure 1 (A) Pretreatment facial photograph. (B) Pretreatment intraoral photograph.

Figure 2 (A) 3D virtual patient model. (B) Virtual diagnostic wax-up in virtual patient.

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Figure 3 (A) The labial and incisal surfaces of the existed maxillary anterior teeth on the wax-up were selected and shifted inward by using the “Offset” tool. (B) Virtual prepared teeth and wax-up.

Figure 4 The virtual cylinders of 4 mm height and 1.2 mm diameter were created and placed on the labial and incisal surfaces of the virtually prepared teeth. Then the upper half of each virtual cylinder was shifted outward 1 mm to form a ring outside the cylinder. Then the virtual cylinders were subtracted from the rings, leaving the guide tubes. These tubes were divided into two evenly distributed groups.

Figure 5 A primary tooth-supported template was first designed on the initial tooth model by using the bite splint module of the CAD software, which was then merged with the two groups of guide tubes. The stereolithography templates were fabricated by a 3D printer.

Figure 6 (A) The templates were seated and evaluated for intraoral fit and stability. (B) A calibrated bur with a stopper at 4 mm was placed through each guide tube of the templates in turn until the stopper touched the template. (C) The bottom of the holes was marked with a pencil. (D) The remaining tooth tissue between the holes was removed, and the shoulder and tooth surface were polished and finished.

Figure 7 (A) Facial evaluation post-treatment. (B) Intra-oral evaluation post-treatment.

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Figure 8 The digital workflow for dental esthetic ceramic veneer treatment using a stereolithographic template for teeth preparation.

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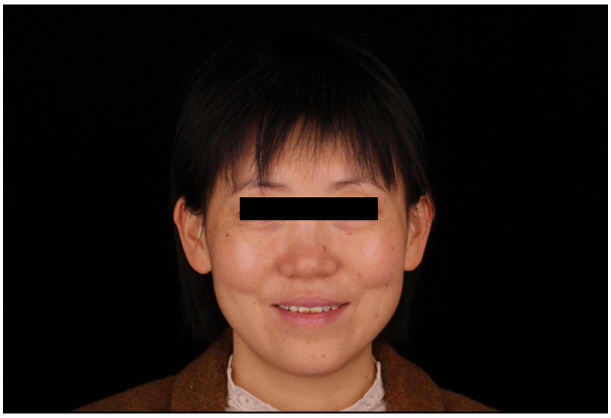

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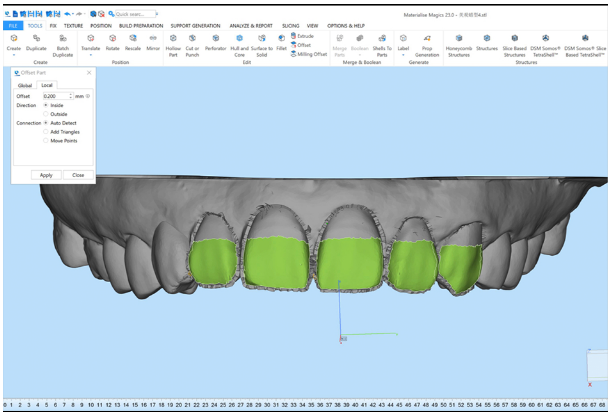

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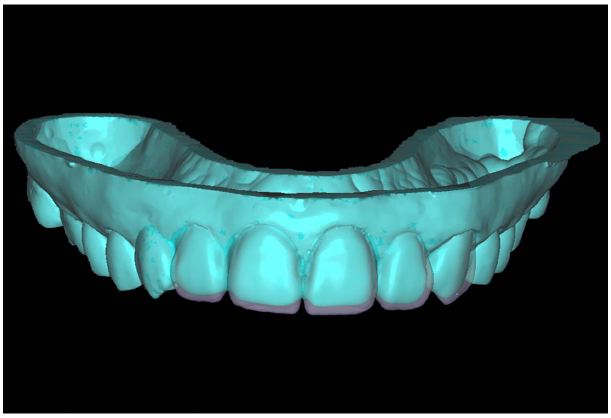

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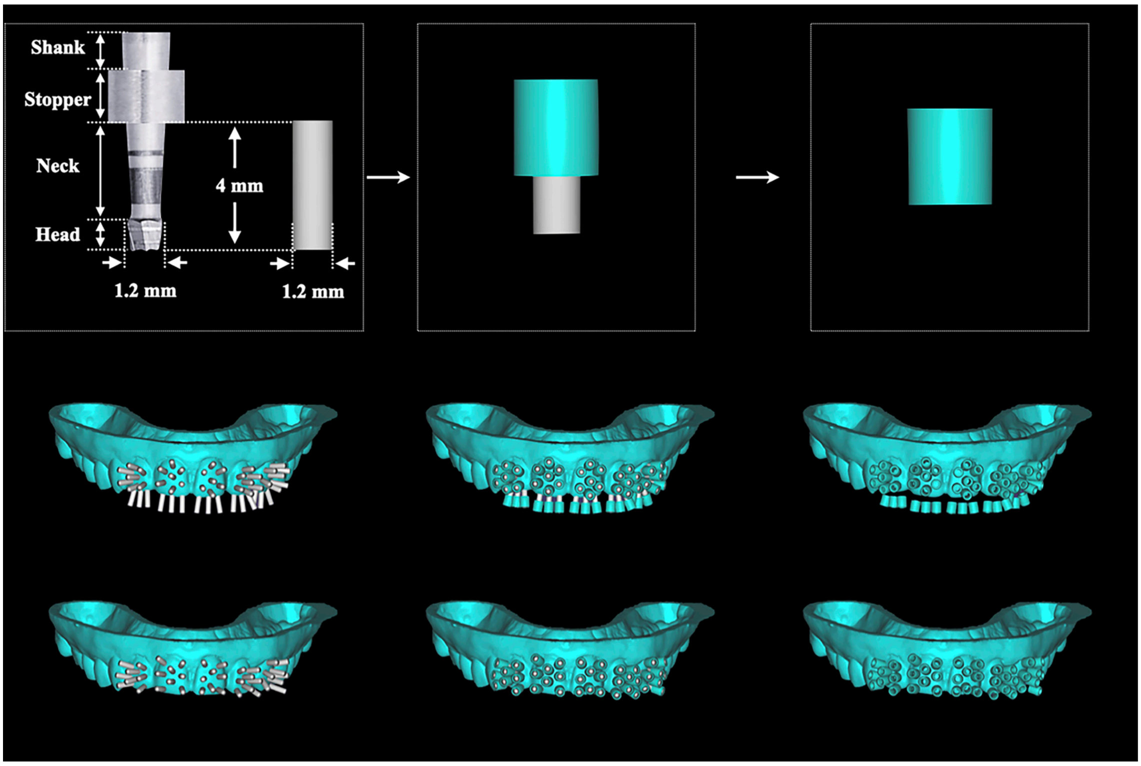

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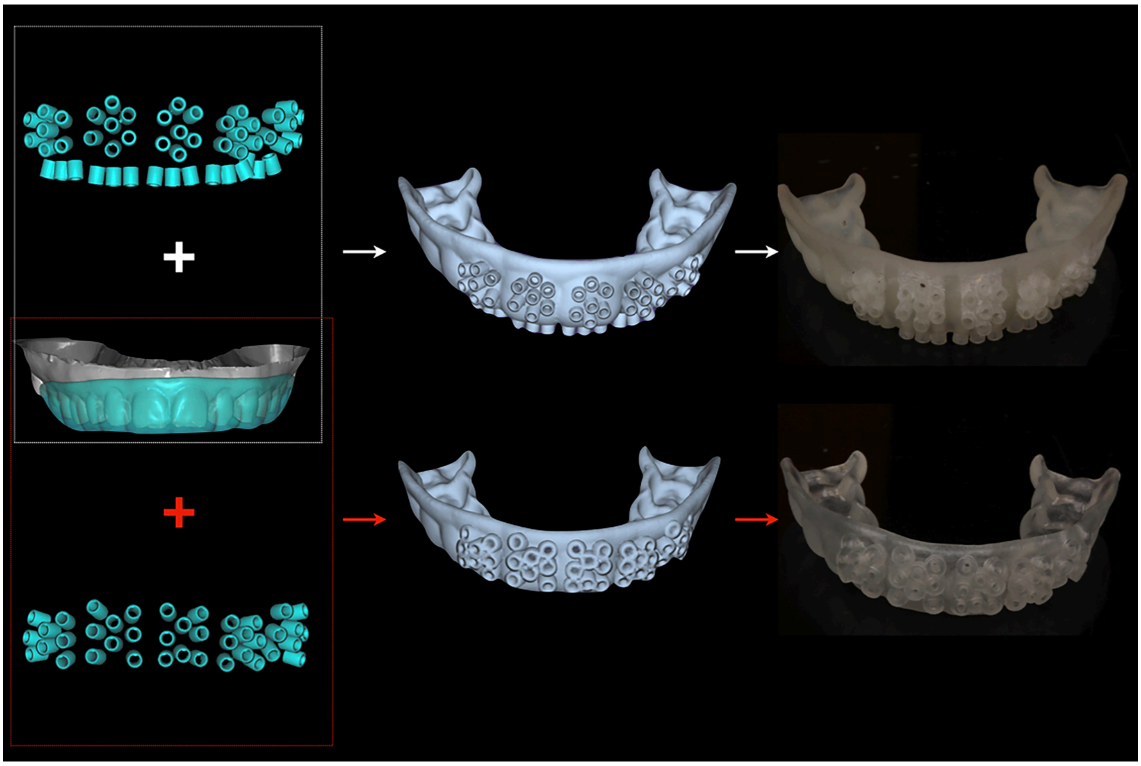

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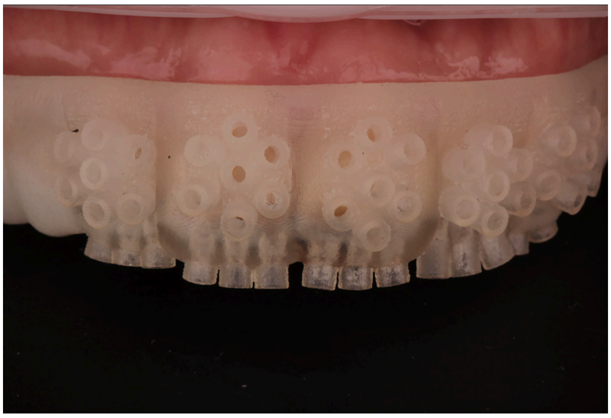

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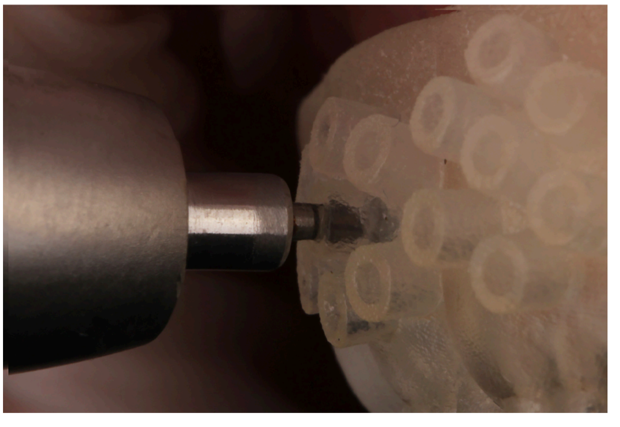

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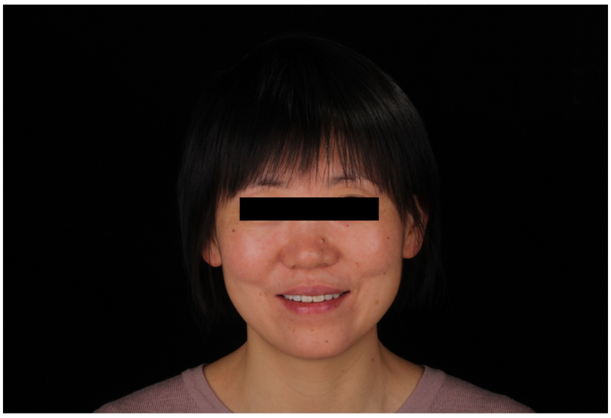

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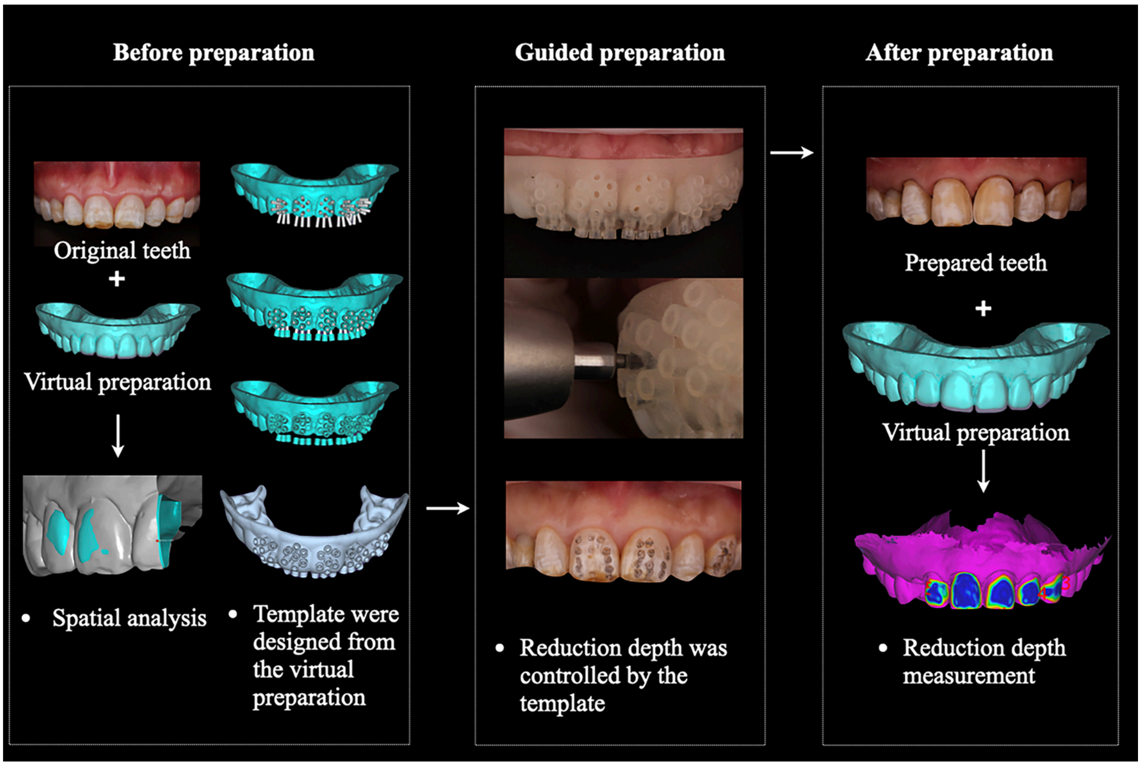

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