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Original Article

A novel method of 3D printing locating guide for abutment screw removal in cement-retained implant-supported prostheses



Jiali Yu ^{a†}, Yanbin Chen ^{a†}, Xiangzhen Liu ^{b*}, Rafiqul Islam ^c,
 Mohammad Khursheed Alam ^d

^a Department of Stomatology, First Affiliated Hospital, Sun Yat-Sen University, Guangzhou, China

^b Department of Stomatology, Sixth Affiliated Hospital, Sun Yat-Sen University, Guangzhou, China

^c Department of Restorative Dentistry, Faculty of Dental Medicine and Graduate School of Dental Medicine, Hokkaido University, Sapporo, Japan

^d Preventive Dentistry Department, College of Dentistry, Jouf University, Sakaka, Saudi Arabia

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Abstract *Background/purpose:* Cement-retained restorations have the advantages of passive fit, less complexity of clinical and laboratory methods, cost, esthetics, and dimensional stability over screw-retained restorations, especially in multiple abutment implant-supported prostheses. A common and difficult technical problem with cement-retained implant prostheses is abutment screw loosening. Three-dimensional (3D) printing is a technology that has been rapidly developed and has become widely accepted in dentistry. The aim of this study was to establish a novel method of using 3D implant planning guide to locate the abutment screw in cement-retained implant prosthesis.

Materials and methods: Six standard gypsum complete denture models were used to locate the abutment screw. An implant analog (4.5 mm in diameter and 12 mm in length) was placed in the drilling hole (5 mm in diameter and 14 mm in depth). After scanning with a 3D scanner, the 3D printing software was used to design the abutment screw location guide, which was printed by a resin-based 3D printer.

Results: A total of 30 abutment screws were located and removed using the guide. The locating guide's actual diameter was 2.4 mm. The drilling point was accurate and precise, and no excessive loss of the abutment was noticed.

* Corresponding author. Department of Stomatology, Sixth Affiliated Hospital, Sun Yat-Sen University, 26 Yuancun Erheng Road, Guangzhou 510655, China.

E-mail address: lxzh3@mail2.sysu.edu.cn (X. Liu).

† These two authors contributed equally to this work.

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Conclusion: The guide would help the dentist in locating the abutment screw access channel, resulting in a more precise and accurate drilling point. The guide for locating the abutment screw enhances the accuracy of screw channel access and reduces damage to the crown and abutment.

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Introduction

Cement-retained implant restoration has shown several benefits compared to their screw-retained counterparts, particularly in regard to esthetics, cost, occlusion, passive fitness and reduced chair time.¹ However, certain occasions occur when the cement-retained restoration requires removal, such as when the abutment screws are loosened, or the restoration needs to be repaired.^{2,3} The crown is frequently cemented to the abutment in this situation and the abutment screw is then accessed through the crown. The challenge here is to locate the position of the screws with minimum restoration damage, abutment and possibly implant.¹ Several authors have described methods for accomplishing this, including reviewing an implant radiograph and estimating the screws long axis position,⁴ using the photograph before the crown is cemented to record the position of the abutment,^{5,6} using a porcelain stain to mark the screw access point during fabrication,⁷ or a vacuum formed guide or template can be fabricated over the final restoration.^{8,9} Using radiographic or photographic records to estimate the implant position in two-dimensions is inaccurate.^{4–6} While marking the screw access point can be advantageous in non-esthetic locations, it has limitations when it comes to anterior restorations.⁷ It is very challenging for dentists to find the internal abutment screw channel from the cement-retained crown without pre-open hole. It is more difficult to find the abutment screw inside the long denture bridge without holes.

Preoperative three-dimensional (3D) planning technology has become more popular recently, after introducing cone-beam computed tomography (CBCT).¹⁰ 3D printing is an additive manufacturing process that uses a layer-by-layer deposition printing process to convert digital models into physical ones.¹¹ 3D printed models can provide a more efficient workflow because they can be manufactured on demand, are reliable, require less labor, and may save time.¹² On the other hand, a unique set of limitations also exhibits 3D printed model. There are several factors which may introduce errors in the accuracy of the resultant models. This includes the acquisition of data and processing of images in the hard and soft tissues, and the variety of parameters involved in manufacturing processes.¹¹ The aim of this study was to establish a novel method of using 3D implant planning guide to locate the abutment screw in cement-retained implant prosthesis.

Materials and methods

Simulation of dentition deficiency and implant implantation

Six standard gypsum complete denture models were made. In each model, the gypsum crowns of 14–16, 22–26 (FDI notation) teeth were removed. Two implant holes were drilled at 14 and 16 areas, and three holes were drilled at 22, 24 and 26 areas. The drilling depth was 14 mm, the diameter was 5 mm, and the direction was tilted about 25 degrees from the long axis of the teeth. An implant analog (Dentium, Suwon, Korea), diameter 4.5 mm and length 12 mm was placed in every hole. The gap between the analog and the hole is filled with gypsum to fix the analog.

Making denture

Each analog was connected to a rod, and after scanning with a three-dimensional scanner (Shining 3D Tech Co Ltd, Hangzhou, China), a digital record was generated (Fig. 1). Then the models were transferred to a denture manufacturer to choose the specifications on the abutment and to make cobalt chromium porcelain fused to metal (PFM) crowns or bridges without holes. On each analog, a screw retention abutment was installed, and the screws were tightened to a torque of 35Ncm and then the corresponding crowns or bridges were bonded. Soft resin gums were used to seal the denture's neck margin, making the abutment inside the denture invisible.

Design a locating guide for abutment screw

The axis of each analog was determined based on the digital records produced by the 3D scanning, which could also be considered the axis of the abutment screw. The abutment screw locating guide was designed with a 3D design software (Materialise, Leuven, Belgium) and mounted on the adjacent teeth of the denture using the axis (Fig. 2). The designed locating guide was then printed by using a resin-based 3D printer machine (Formlabs Inc, Somerville, MA, USA).

Taking out the abutment screws

Two dentists were randomly assigned to remove the abutment screws inside the denture. The guides were used to locate the abutment screws (Fig. 3).

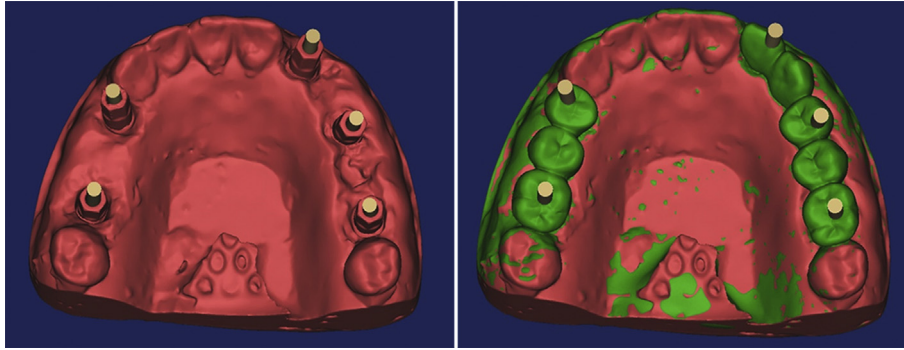


Figure 1 Superimposed 3D image indicate the path of the screw hole through the crown.

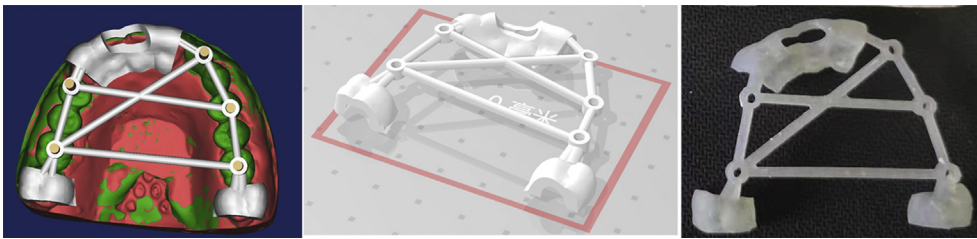


Figure 2 Designing of guide on the scanned model with dental design software.

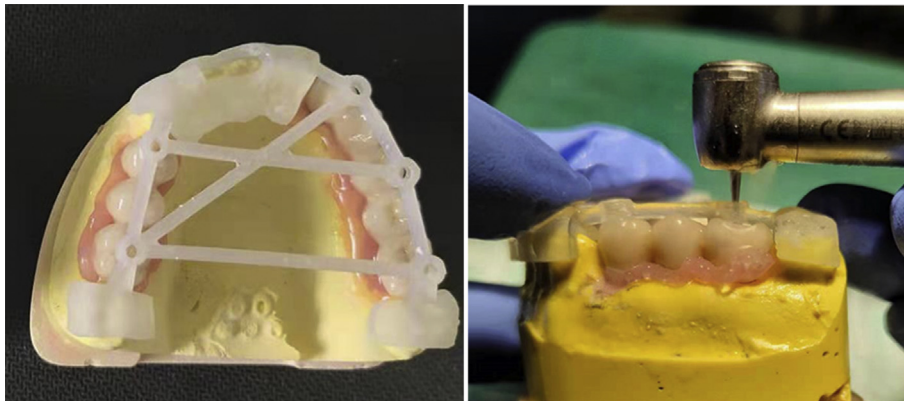


Figure 3 Evaluation of drilling screw channel in the model.

Results

A novel method has been developed to locate the abutment screw on any cemented implant-supported prosthesis by using a 3D printing guide. A total of 30 abutment screws were located and removed using the guide. The locating guide's actual diameter was 2.4 mm. In terms, no errors were seen during drill insertion. It was determined that a 2.4 mm in diameter locating guide would be the smallest size with the lowest tolerance that would be adequate for the parameters presented in this method. The drilling point was accurate and precise, and no excessive loss of the abutment was noticed.

Discussion

The differences between screw-retained and cement-retained prostheses have been documented previously.^{13–15} Although cement-retained implant crowns can achieve

better esthetics, retrievability may influence the type of restoration. Cemented prostheses are more difficult and expensive to repair than screw-retained prostheses.¹⁵ If the location of the screw access opening is unknown, it may be difficult to remove cement-retained crowns with a loosening of the abutment screw or ceramic fracture without causing irreversible crown or abutment damage. Any forced applied to remove the prosthesis can damage the implant's inner surface or fracture the abutment's screw fixation.¹⁵ The technique used in the present study would help the dentist to locate the screw access channel of abutments easily. However, accepting an implant-supported crown with screw holes might be difficult for patients who are used to traditional cement-retained PFM crowns without holes. The concept of designing a guide to locate the abutment screw inside the denture is similar to that of designing an implant guide. The difference is whether an implant is accurately placed, or an existing abutment screw is removed from the implant-supported denture.

Damage to the abutment is a significant factor during screw-hole drilling. When there are several damages to the abutment, the clinical longevity of the implant restoration can be reduced. Most of the abutment damage occurred during hole enlargement. In the present study, the guide helped to make the drilling points more precise and accurate. In addition to the esthetic issues, the screw holes on the denture can reduce the denture's strength.¹⁶

The present study has some limitations. First, the procedure was performed on the models, which may take a different time from the actual clinical situation. The time required for a clinical operation is generally accepted to be longer than the time required for a model operation. Second, the guide is based on the adjacent teeth position, and it may be necessary to remove the abutment screw several years after placement of the denture. During this time, the shape or position of adjacent teeth may change due to periodontal disease, or orthodontic treatment, affecting the accuracy of the guide. Third, this method is not suitable for edentulous implant denture because there is no supporting natural tooth to fix the guide plate.

Within the limitation of the present study, the guide for locating the abutment screw improves screw channel access accuracy and reduces damage to the crown and abutment.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

References

1. Wadhvani C, Chung KH. Simple device for locating the abutment screw position of a cement-retained implant restoration. *J Prosthet Dent* 2013;109:272–4.
2. Michalakis KX, Hirayama H, Garefis PD. Cement-retained versus screw-retained implant restorations: a critical review. *Int J Oral Maxillofac Implants* 2003;18:719–28.
3. Chaar MS, Att W, Strub JR. Prosthetic outcome of cement-retained implant-supported fixed dental restorations: a systematic review. *J Oral Rehabil* 2011;38:697–711.
4. Patil PG. A technique for repairing a loosening abutment screw for a cement-retained implant prosthesis. *J Prosthodont* 2011;20:652–5.
5. Daher T, Morgano SM. The use of digital photographs to locate implant abutment screws for implant-supported cement-retained restorations. *J Prosthet Dent* 2008;100:238–9.
6. Figueras-Alvarez O, Cedeño R, Cano-Batalla J, Cabratosa-Termes J. A method for registering the abutment screw position of cement-retained implant restorations. *J Prosthet Dent* 2010;104:60–2.
7. Schwedhelm ER, Raigrodski AJ. A technique for locating implant abutment screws of posterior cement-retained metal-ceramic restorations with ceramic occlusal surfaces. *J Prosthet Dent* 2006;95:165–7.
8. Tarlow JL. A modified technique to locate the abutment screw access opening of a cemented implant-supported restoration. *J Prosthet Dent* 2012;108:58–9.
9. Lautensack J, Weber V, Wolfart S. Template to determine the position and angulation of the abutment screw channel for implant-supported, cement-retained restorations. *J Prosthet Dent* 2012;107:134–6.
10. Albiero AM, Benato R, Momic S, Degidi M. Implementation of computer-guided implant planning using digital scanning technology for restorations supported by conical abutments: a dental technique. *J Prosthet Dent* 2018;119:720–6.
11. Etemad-Shahidi Y, Qallandar OB, Evenden J, Alifui-Segbaya F, Ahmed KE. Accuracy of 3-dimensionally printed full-arch dental models: a systematic review. *J Clin Med* 2020;9:3357.
12. Choi JW, Ahn JJ, Son K, Huh JB. Three-dimensional evaluation on accuracy of conventional and milled gypsum models and 3D printed photopolymer models. *Materials* 2019;12:3499.
13. Torrado E, Ercoli C, Mardini MA, Graser GN, Tallents RH, Cordaro L. A comparison of the porcelain fracture resistance of screw-retained and cement-retained implant-supported metal-ceramic crowns. *J Prosthet Dent* 2004;91:532–7.
14. Zarone F, Sorrentino R, Traini T, Caputi S. Fracture resistance of implant-supported screw-versus cement-retained porcelain fused to metal single crowns: SEM fractographic analysis. *Dent Mater* 2007;23:296–301.
15. da Rocha PVB, Freitas MA, da Cunha TDMA. Influence of screw access on the retention of cement-retained implant prostheses. *J Prosthet Dent* 2013;109:264–8.
16. Derafshi R, Farzin M, Taghva M, Heidary H, Atashkar B. The effects of new design of access hole on porcelain fracture resistance of implant-supported crowns. *J Dent* 2015;16:61–7.