THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

A modified implant abutment holder fabricated with fused deposition modeling to improve the transfer process for implant-supported restorations

Yanping Liu, DDS,[a] Ye Lin, MD,[b] and Ping Di, MD[c]

ABSTRACT

Ingestion or aspiration of an implant abutment can occur in patients during the process of abutment transfer for implant-supported restorations, especially in the posterior region. A technique of fabricating an abutment holder is described to prevent ingestion or aspiration by computer-aided design (CAD) and fused deposition modeling (FDM). The modified abutment holder has a serrated handle for a firm grip and a barrel-shaped fixed portion that firmly secures the abutment. The modified holder is more secure than the conventional hexagon screwdriver. Furthermore, abutment holders can be easily manufactured by using 3D printers and repeatedly used for multiple implants restoration without substitution. (J Prosthet Dent 2021;125:411-4)

The placement and removal of implant abutments is a repetitive process for implant-supported restorations.[1-3] The abutments, abutment screws, and even abutment holders could be accidently dropped into the patient's mouth during abutment transfer,[4,5] presenting a risk of accidental ingestion or aspiration.[6] Ingestion or aspiration can result in obstruction, infection, cough, fever, pneumonia, hemoptysis, and atelectasis.[7,8]

Commercially available hexagon screwdrivers are primarily used to transfer the abutment and screw it to the implant in accordance with the principle of mechanical interlocking.[9] Although efforts are taken by clinicians to prevent the dropping of abutments during the transfer process, accidental swallowing or aspiration of abutments still occurs.[10] Therefore, a modified abutment holder, different from the hexagon screwdriver, is proposed to improve clinical safety while partially retaining the functions of a screwdriver.[11,12] Additionally, the modified abutment holder improved the process of abutment transfer to its correct location. The modified abutment holder was designed by using computer-aided design (CAD) and fabricated with medical grade polylactic acid (PLA)-based material by using a 3D printer by fused deposition modeling (FDM).[13] The modified abutment holder was used to transfer the abutments during the clinical procedures.

TECHNIQUE

1. Create a cylinder (height=10 mm, diameter=10 mm) and 6 similar cuboids (length>10 mm, width>2 mm, and height=2 mm) by using a reverse engineering software program (Geomagic Studio 12.0; Raindrop). Transform the features into a virtual polygon. Subsequently, move the virtual cuboids and place them around the cylinder (Fig. 1A).
2. Subtract the overlaps between the cylinder and cuboids by using a Boolean operation to generate the main body of the handle (Fig. 1B). The gear design of the handle improves manual fastening of the abutment.
3. Generate a thin cylinder (height>10 mm, diameter=2 mm) and overlap it over the handle; subtract the thin cylinder to form a hole. A piece of dental floss can be threaded through this hole to retrieve the abutment holder if accidently dropped (Fig. 1C).

Supported by the Capital's Funds for Health Improvement and Research (grant number 2018-2-4102).
[a]PhD candidate, Department of Oral Implantology, Peking University School and Hospital of Stomatology, Beijing, PR China.
[b]Professor, Department of Oral Implantology, Peking University School and Hospital of Stomatology, Beijing, PR China.
[c]Professor, Department of Oral Implantology, Peking University School and Hospital of Stomatology, Beijing, PR China.

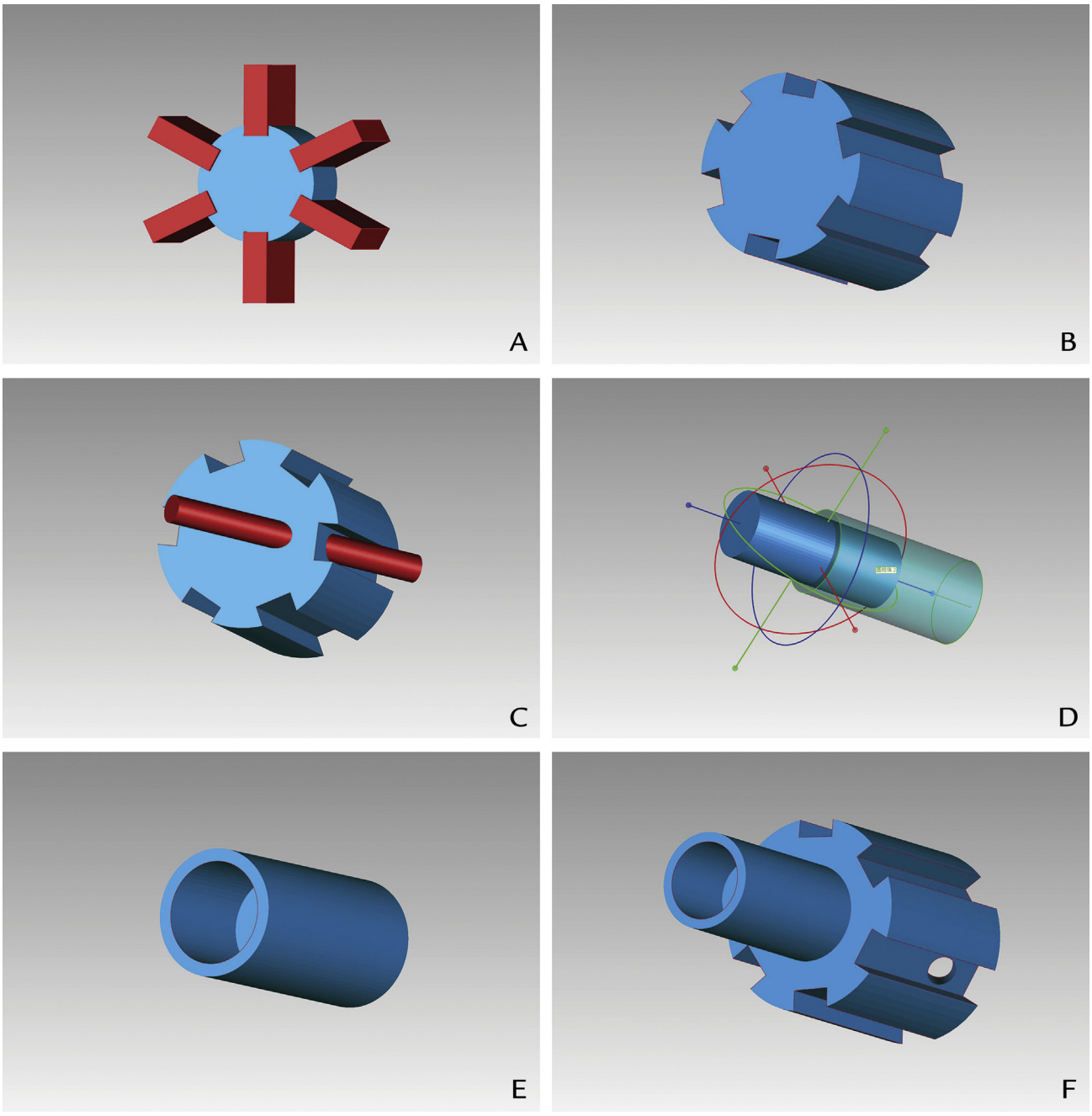

Figure 1. Design processes of modified implant abutment holder by using computer-aided design. A, Place virtual cuboids around cylinder. B, Subtract overlaps between cylinder and cuboids from cylinder to generate handle body. C, Subtract thin cylinder from handle to thread dental floss. D, Generate 2 cylinders with different diameters and superimpose their axes. E, Form fixed portion of abutment. F, Combine handle portion with fixed portion.

4. Generate 2 cylinders with different diameters and superimpose their axes. The diameter of the thinner cylinder is determined for each treatment according to the size of the abutment. The diameter of the thicker cylinder should exceed that of the thinner cylinder by 2 mm. Remove the thinner cylinder (Fig. 1D). Subtract the overlap between the cylinders from the thicker cylinder to form a fixed portion of the abutment (Fig. 1E). Fix the wall thickness of the fixed portion of the abutment at 2 mm; a featheredge would make it fragile and a thicker edge might obstruct the path of insertion of the abutment.
5. Combine the handle portion with the fixed portion by using a Boolean operation. Create the virtual abutment holder with CAD technology (Fig. 1F) and

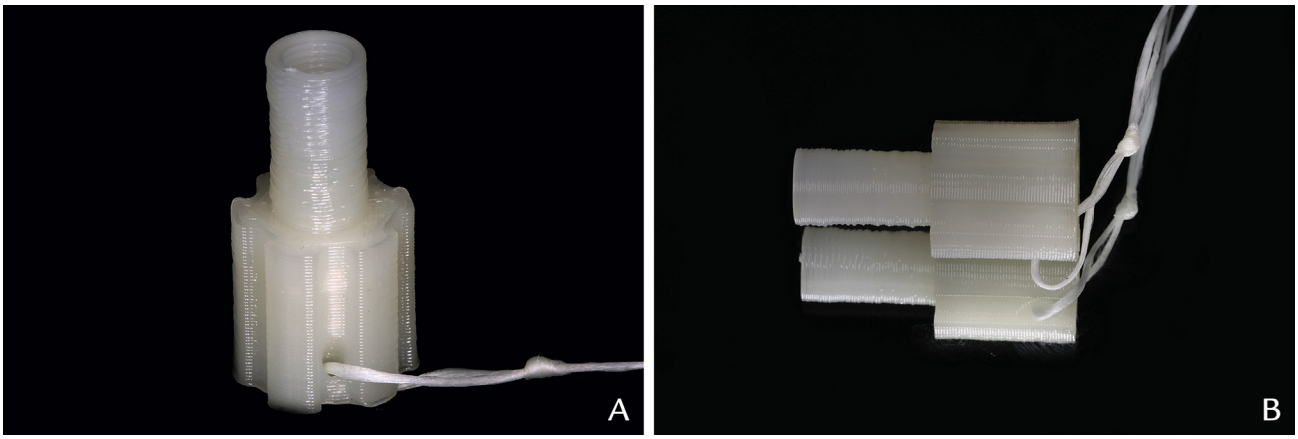

Figure 2. Modified abutment holder fabricated by fused deposition modeling. A, Front view. B, Side view.

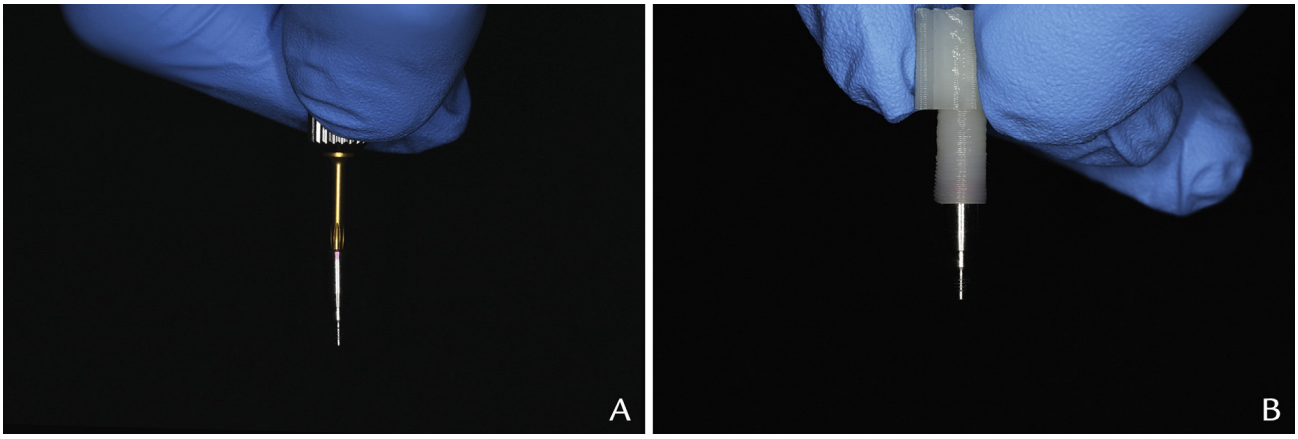

Figure 3. A, Conventional hexagon screwdriver. B, Modified holder.

save the file in standard tessellation language (STL) format.

6. Transfer the STL file to the control center of a fused deposition modeling (FDM) 3D printer (Lingtong III; SHINOTECH) to fabricate the abutment holder with PLA filaments (Fig. 2). The nozzle diameter of this FDM printer is 0.3 mm. Set the thickness of the layer to 100 μm. Maintain the printing temperature at 200 °C.
7. Figure 3A shows a conventional hexagon screwdriver (Screwdriver Machine UniGrip; Nobel Biocare) with an implant fastened to it, which is unstable during abutment transfer procedure.
8. Fasten the abutment firmly by its fixed portion with the substantial FDM abutment holder (Fig. 3B) and transfer the abutment to the correct location in the oral cavity. Steadily and swiftly screw the interim abutment to its limit with the FDM holder.
9. Thereafter, mount the hexagon screwdriver and torque wrench on the abutment and rotate the screwdriver until the torque is 10 Ncm.

DISCUSSION

The retention principle of the modified FDM abutment holder differs from that of conventional hexagon screwdrivers.[14] This holder uses friction and elastic forces to retain abutments. The frictional force is generated because of the positive pressure exerted by the interface of the thread walls with the fixed portion to the abutment. The elastic force is generated by the shape memory effect and microelastic property of the thermoplastic material.[15] The FDM fabrication, which involves sequential buildup of the thermoplastic substance layer by layer, is suitable for fabricating abutment holders.[16] Moreover, the retention force can be adjusted by modulating the 3D-printing parameters according to clinical requirements. A limitation of the FDM abutment holder is the barrel shape of the fixed portion, which may not be suitable for all implant systems, such as holding irregular or noncylindrical abutments. In such situations, the redesigning of other individual fixed portions will be required.

PLA is a reasonably priced renewable material,[17] and PLA abutment holders are disposable, which reduces the risk of cross infection. The advantage of this modified abutment holder is that it prevents the risk of accidental swallowing of abutments, particularly in the placement of multiple abutments in the premolar and molar region. The modified abutment holder might reduce the chairside time by improving the efficiency of the transfer process, although this should be explored in a clinical study.

SUMMARY

This article describes a technique that facilitates the safe transfer of abutments onto the corresponding implants, minimizing accidental aspiration or swallowing of abutments. This modified abutment holder has a handle and a fixed portion, which are fabricated by using CAD and FDM. The handle is specially designed, with an easy grip that prevents accidental slippage of the abutment. The fixed portion is fastened to the bottom of the abutments to prevent accidental aspiration or ingestion.

REFERENCES

1. Molina A, Sanz-Sánchez I, Martín C, Blanco J, Sanz M. The effect of one-time abutment placement on interproximal bone levels and peri-implant soft tissues: a prospective randomized clinical trial. Clin Oral Implants Res 2017;28:443-52.
2. Canullo L, Bignozzi I, Cocchetto R, Cristalli MP, Iannello G. Immediate positioning of a definitive abutment versus repeated abutment replacements in post-extractive implants: 3-year follow-up of a randomised multicentre clinical trial. Eur J Oral Implantol 2010;3:285-96.
3. Testori T, Weinstein T, Scutellà F, Wang HL, Zucchelli G. Implant placement in the esthetic area: criteria for positioning single and multiple implants. Periodontol 2000 2018;77:176-96.
4. Souza FÁ, Statkievicz C, Guilhem Rosa AL, da Silveira Bossi F. Management of accidental swallowing in implant dentistry. J Prosthet Dent 2015;114:167-70.
5. Yoon SH, Jung S, Kang T, Yang HC. Swallowing of dental implant: complication of transnasal endoscopic removal from maxillary sinus. J Oral Implantol 2019;45:219-22.
6. Kuo SC, Chen YL. Accidental swallowing of an endodontic file. Int Endod J 2008;41:617-22.
7. Ireland AJ. Management of inhaled and swallowed foreign bodies. Dent Update 2005;32:83-6.
8. Feinberg MJ, Knebl J, Tully J, Segall L. Aspiration and the elderly. Dysphagia 1990;5:61-71.
9. Mizumoto RM, Jamjoom FZ, Yilmaz B. A risk-based decision making tree for managing fractured abutment and prosthetic screws: a systematic review. J Prosthet Dent 2018;119:552-9.
10. Kim A, Ahn KM. Endoscopic removal of an aspirated healing abutment and screwdriver under conscious sedation. Implant Dent 2014;23:250-2.
11. Lang LA, May KB, Wang RF. The effect of the use of a counter-torque device on the abutment-implant complex. J Prosthet Dent 1999;81:411-7.
12. Wadhwani C, Chung KH. Simple device for locating the abutment screw position of a cement-retained implant restoration. J Prosthet Dent 2013;109:272-4.
13. Stansbury JW, Idacavage MJ. 3D printing with polymers: challenges among expanding options and opportunities. Dent Mater 2016;32:54-64.
14. Alikhasi M, Kazemi M, Jalali H, Hashemzadeh S, Dodangeh H, Yilmaz B. Clinician-generated torque on abutment screws using different hand screwdrivers. J Prosthet Dent 2017;118:488-92.
15. Wu W, Ye W, Wu Z, Geng P, Wang Y, Zhao J. Influence of layer thickness, raster angle, deformation temperature and recovery temperature on the shape-memory effect of 3D-printed polylactic acid samples. Materials (Basel) 2017;10:970.
16. Romanov V, Samuel R, Chaharlang M, Jafek AR, Frost A, Gale BK. FDM 3D printing of high-pressure, heat-resistant, transparent microfluidic devices. Anal Chem 2018;90:10450-6.
17. Lasprilla AJ, Martinez GA, Lunelli BH, Jardini AL, Filho RM. Poly-lactic acid synthesis for application in biomedical devices - a review. Biotechnol Adv 2012;30:321-8.

Corresponding author:
Dr Ping Di
Department of Oral Implantology
Peking University School and Hospital of Stomatology
22 South Zhongguancun Ave, Haidian District
Beijing 100081
PR CHINA
Email: diping@bjmu.edu.cn

Acknowledgments
The authors thank Oral Digital Medical Technology and Materials National Engineering Laboratory, Peking University School of Stomatology, for kindly providing the computer-aided design software program and 3D printing equipment.

https://doi.org/10.1016/j.prosdent.2020.01.029