RSBO

ISSN:
Electronic version: 1984-5685
RSBO. 2025 Jul-Dec;22(2):186-9

Original Research Article

Development of customized intraoral radiographic positioners using three-dimensional printing

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Received for publication: February 19, 2025. Accepted for publication: February 19, 2025.

Keywords:
three-dimensional printing; third molar, dental radiography, oral diagnosis, radiology.

Abstract

Objective: To demonstrate the use of a three-dimensional (3D) printer for the development of a customized intraoral radiographic positioner. **Material and methods:** Initially, the device was drawn as a draft and then improved using AutoCad 3D (Autodesk Inc, USA) software. After the approval of the final draft, Standard Triangle Language (STL) files were generated to enable 3D printing. The resulting STL files were 3D printed with a Flashforge Hunter printer (FlashForge, Rowland Heights, California, USA) using a specific resin (Yller, Pelotas, Brazil). **Results:** It was demonstrated the ability to create a customized intraoral positioner, using a 3D printer, which was ready for initial testing and further improvement, as well as clinical testing after the approval in Ethics Committee. **Conclusion:** A wide range of customized dental items can be 3D printed to improve their characteristics, to create prototypes for testing or even to use on a large scale without expensive and protracted production stages.

Introduction

Three-dimensional (3D) printing has been extensively applied in general manufacturing, and currently its use has been increasing in dentistry [10]. In this context, 3D printing has been integrated into clinical workflows with the advent of 3D printed models, prototypes and products that are valuable tools for surgical planning [7], pre-surgical training, prosthesis production, educational training [4], forensic science [4] and even diagnostic purposes in different areas of Dentistry [6] and Medicine[8].

Intraoral radiographic positioners are widely used in daily clinical practice [8], especially in countries where extraoral equipment, such as panoramic radiographs, are not widely available or have high costs. The primary objectives of an intraoral radiographic positioner are the appropriate positioning of the radiographic sensor or film for radiographic exposure, avoidance of repetitive exposures, standardization of radiography technique and reduction of imaging distortion [5]. However, radiographic positioners available on the market have limitations, and distinct devices have been created for specific anatomic sites [3].

Customized radiographic positioners can be created and printed by 3D printers at low cost and by a simple manufacturing process, allowing the dental practitioner or the dental radiologist to develop devices which are more suited to a specific anatomic site radiographic examination or even to create new, superior instruments not currently available on the market [9]. When the researcher or the professional that developed an idea (in this case, the idea is a radiographic intraoral positioner) has the opportunity to evaluate this idea as a 3D device, he have the opportunity to better assess his creation as well as improve it [1].

Thus, the purpose of the present study was to demonstrate another application of 3D printing in dentistry while developing a customized intraoral radiographic positioner. The intraoral radiographic positioner set printed and described as an example in this paper was created primarily with a goal of imaging the third molars or for use in patients with restricted mouth opening, since it is smaller than other positioners available on the market.

Material and methods

The idea of creating a novel intraoral radiographic positioner was conceived when it was noted that the positioner sets commercially available could not meet a specific need of the Radiology Department at São Paulo University Dentistry School. The developers aimed to use the new device in intraoral radiographs of third molars or in patients with restricted mouth opening. Initially, the device was drawn as a draft (Figure 1A) and then improved using AutoCad 3D (Autodesk Inc, USA), shown in Figure 1B. After the approval of the final draft, Standard Triangle Language (STL) files were generated for 3D printing. The resulting STL files were 3D printed with a Flashforge Hunter printer (FlashForge, Rowland Heights, California, USA) using a specific resin (Yller, Pelotas, Brazil). After printing, final adjustments and improvements were performed in the radiographic positioner. The patent for this intraoral positioner set was submitted with the support of São Paulo University (number BR 10 2017 007874-4 A2). The intraoral radiographic positioner developed was already approved Ethics committee of the same university to further tests in patients, hence, results of the use of the positioner in patients is not discussed in this article, as this study main objective is to demonstrate a different use for 3D printer in Oral Radiology.

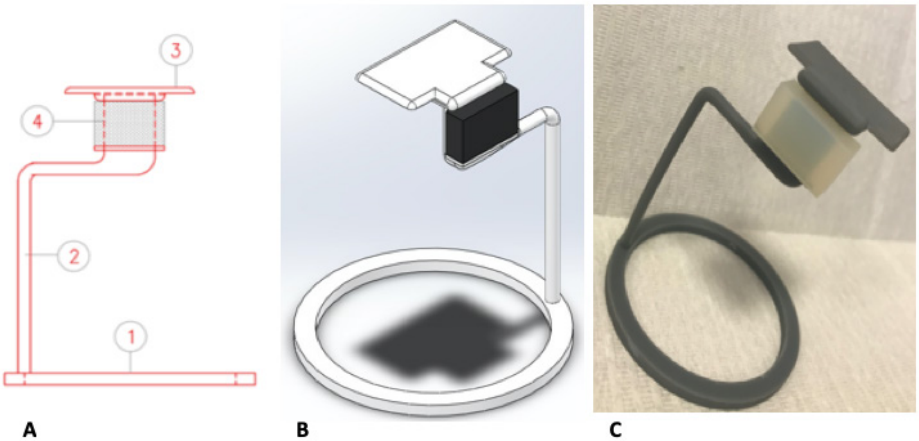

Figure 1 – Customized positioner development: A) initial two-dimensional draft; B) three-dimensional view of the device; C) device printed by a 3D printer, ready for further testing

Results

We were able to create a customized intraoral positioner set (for right and left third molar intraoral radiographs) that was ready for testing in patients with restricted mouth opening or requiring intraoral radiographs of third inferior molars, after approval in Ethics Committee. The printed positioner is shown in figure 1C. The intraoral positioner has an area designed for the occlusion of antagonist teeth (area number 4 in figure 1A), a film holder (area number 3 in figure 1A), a stem (area number 2 in figure 1A) and a rim (area number 1 in figure 1A) which is responsible for directing the X-rays while the patient is being exposed.

Discussion

The concept of 3D printing was first described and applied to rapid prototyping for medical uses in 1980, and its primary objective was to simplify the concept-to-product workflow [14]. Since then, 3D printing technology has advanced considerably from commercially available "stereo" printers [14] to commercially available 3D printers [4]. 3D printing can be used in the development of new products [2] or, as described in the present paper, customized devices. We anticipate this 3D printing process will create an opportunity to improve information sharing between professionals regarding the new devices and requirements for improvements or testing. With 3D printing, a computer file (usually an STL file) can be easily shared, and an exact replica of the original device can be printed [13], enabling researchers to share their customized and experimental product designs with other researchers [4] without losing the features of the new object or causing distortion [7].

When applied to customized radiographic positioners, the use of 3D printers allows for standardized devices, as well as fast alterations in design if improvements or modifications are needed. This convenience permits professionals to customize a wide range of devices to their requirements [7], not just intraoral radiographic positioners. Furthermore, it is possible to use 3D printed materials that can be sterilized [11] or materials that have the appropriate features to attend to the device characteristics and to enable the positioner use.

The customized intraoral radiographic positioner used as an example in this paper was developed for a specific group of patients who either need third molar radiographs or have restrictions in mouth opening. Its main feature is its small size, which allows the device to be positioned more posteriorly in the mouth, especially in the inferior arch, with a goal of imaging the third molars. Further testing will be performed at the University.

There is no positioner device created specifically for third molar intraoral radiographs. When searching the literature, it was found a single device designed for intraoral radiographs to assess distal defects after impacted third mandibular molar surgery, proposed by Ana and Mercedes in 2011 [3], but this device was a modification of a preexisting positioner using acrylic resin and individualized for each patient. The development of a positioner appropriate for third molar intraoral radiographs that could be utilized without being customized for each patient and using a 3D printer has never been demonstrated in the literature. Posteriorly, the results of this positioner in clinical practice will be published accordingly. However, the use of the 3D printing has optimized the process of creation and improvements before testing in patients.

We have successfully demonstrated a new use of 3D printing in dental radiology with the creation of a customized positioner, and it can be concluded that in the future, a wide range of customized items could be created to improve their characteristics, for prototype testing or even for large scale use without expensive and protracted production.

Acknowledgements

We'd like to thank for the following people and agencies: Mr. Antonio Munhoz Filho and Mr. Hermes Francisco dos Reis Neto; Agência USP de Inovação (patent process) for their support.

Conflicts of interest and funding statements

Authors declare no conflicts of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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