Three-dimensional accuracy evaluation of Zirconia prosthesis manufactured by Digital Light Processing(DLP) and Stereolithography (SLA) method (pilot test)



Ha-Bin Lee Mi-Jun No Ji-Hwan Kim*

Department of Dental Laboratory Science & Engineering College of Health Science, Korea University.
**Corresponding author: E-mail: kjh2804@korea.ac.kr*

Introduction

Advances in computer technology have facilitated digital revolutions in many industries by automating and simplifying existing production processes. In the dental field, digital innovations have driven "Digital Workflow", the culmination of the process of obtaining patient data and working with them to produce a prosthesis, and this new approach has improved not only the work efficiency, but also the longevity and accuracy of the prosthetics.

Zirconia blocks allegedly appearing its aesthetic and excellent mechanical properties, has been carved and manufactured to produce prosthetics by CAD/CAM systems. Therefore, additive processing methods by the 3D printer recently started to be introduced to the dental sector. It is an additive way where a design file in STL format is converted into a sliced file and the output is built up layer by layer with Zirconia slurry and then the desired shape is completely 3D-printed. It is well known to minimize material consumption and capable of printing the hidden area, complex structures in a high degree of precision. Thanks to the advantages, the number of cases where prosthetics are produced by 3D printer is gradually increasing and effectively it becomes to seize a big interest from the market. However, while only 3D printing with using resin and metal materials has been prevailingly performed for research and development and finally commercialized, 3D printing with using ceramic materials is not matured yet, is stepping forward on a research and development stage before commercialization in requiring more study on the fitness and mechanical properties, and so on. Although DLP(Digital Light Processing) method has been newly introduced in 3D printing technology, no research report re assessment of fitness of 3D printing technology is published yet.

Materials and Methods

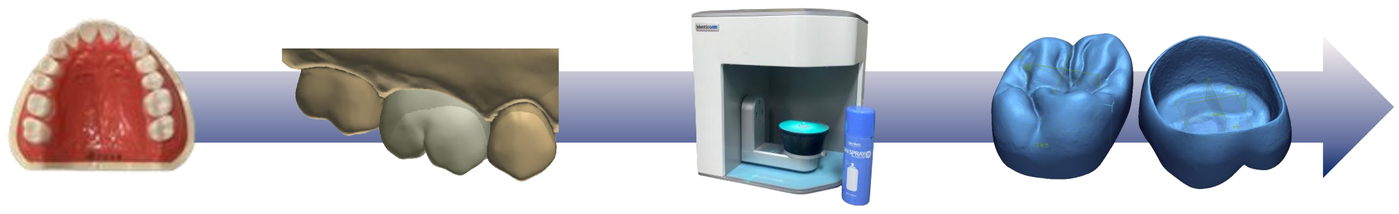

Figure 1.Workflow

With using dental model (D85DP-500B.1, Nissin Dental, Japan) prepped with the 1st upper right molar, prosthetics in an anatomical form was designed with CAD software(3Shape Dental Designer, Copenhagen, Denmark).

By 3 methods including CAM system as milling machine (DATRON D5, Datron Dynamics, Inc, Milford, USA), 3D printer as DLP (ZIPRO Dental, AON Co., Ltd, Korea), 3D printer as SLA(CERAMAKER 900, 3DCeram Co), 5 samples for each of 3 methods are produced and are named as DA, AON, 3DC in order.

STL files obtained by scanning each of the three groups of prosthetics using a model scanner (Identica Blue, Medit, Seoul, Korea) were edited and overlapped on the inner, outer, and margin areas with using the three-dimensional evaluation software(GeomagicVerify, 3D Systems Inc., Rock Hill, SC, USA). After getting RMS value with using the following formula, we measured trueness.

$$RMS=\frac{\sqrt{\sum_{i=1}^{n}\left(X_{1,i}-X_{2,i}\right)^2}}{\sqrt{n}}$$

Figure 2. 3D printer; ZIPRO Dental

Result

According to Trueness analysis, the average of DA group's inner, outer, and margin RMS value was 15.08 μm, 17.46 μm, 17.02 μm, and AON group made by additive DLP method was 30.4 μm, 26.68 μm, 39.8 μm, and 3DC group made by SLA method was 40.36 μm, 72.96 μm, 55.02 μm. The DA group showed the highest accuracy in all parts of the interior, exterior, and margin, followed by the AON group and the 3DC group with the lowest accuracy.

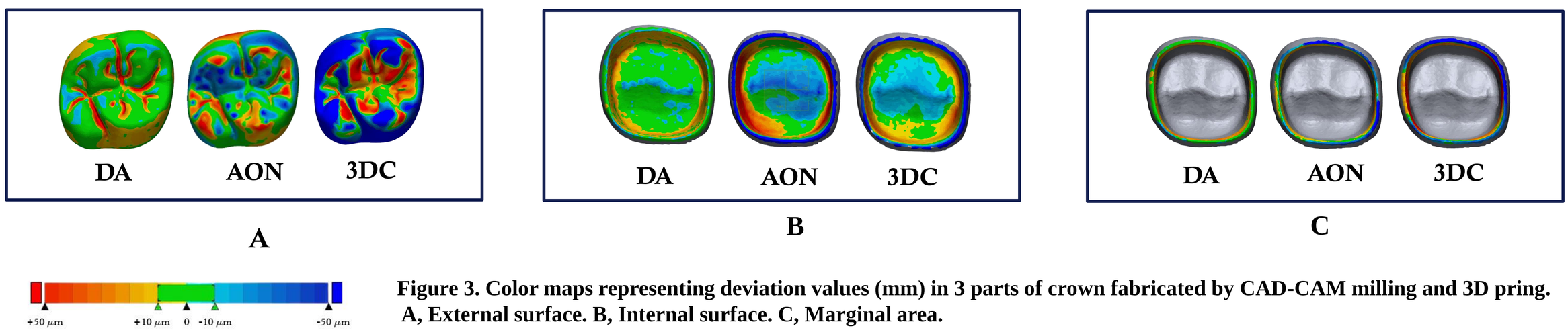

Figure 3. Color maps representing deviation values (mm) in 3 parts of crown fabricated by CAD-CAM milling and 3D pring. A, External surface. B, Internal surface. C, Marginal area.

Discussion & Conclusion

Currently, additive processing is widely used in dentistry, including orthodontic models and the production of resin and metal prosthetics. Nonetheless, additive processing with ceramic materials has not been commercialized yet.

As per study by Galante Ret al. analyzing papers re dental ceramic additive processing for last 10 years, studies re accuracy of resin or metal materials were briskly reported, but accuracy studies with using ceramic materials have been hardly reported. Hence, due to the lack of prior studies re additive processing of ceramic materials, this study is aimed to evaluate whether or not the newly developed DLP-type ceramic additive processing can be a replacement for the existing milling process. In this study, prosthetics produced by milling processing appeared the highest accuracy, followed by DLP and SLA methods. All three groups ended up to be clinically acceptable. If it goes beyond clinical limits, this can result in secondary dental caries and inflammation of periodontal tissue. In this regard, the relatively important inner and margin were evaluated, and the accuracy analysis of the exterior of the crown was conducted because it is also important to anatomically reproduce the appearance of the teeth. Now that the dental sector prefers ceramic materials for aesthetic reasons, we understand that it is worth applying them to clinical cases because the accuracy levels of prosthetics produced by additive processing method in DLP with 3D printer are clinically acceptable like those by milling method.

Reference

1. Van Noort, R. (2012). The future of dental devices is digital. Dental materials, 28(1), 3-12.
2. Methani, M. M., Revilla-León, M., & Zandinejad, A. (2020). The potential of additive manufacturing technologies and their processing parameters for the fabrication of all-ceramic crowns: A review.
   Journal of Esthetic and Restorative Dentistry, 32(2), 182-192.
3. Wang, W., Yu, H., Liu, Y., Jiang, X., & Gao, B. (2019). Trueness analysis of zirconia crowns fabricated with 3-dimensional printing. The Journal of prosthetic dentistry, 121(2), 285-291.
4. Dawood, A., Marti, B. M., Sauret-Jackson, V., & Darwood, A. (2015). 3D printing in dentistry. British dental journal, 219(11), 521-529.