Trueness evaluation of the internal and marginal fit of zirconia crown produced using Digital Light Processing stereolithography and additive manufacturing technology (pilot test)

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Abstract

Purpose: The purpose of this study was to analyze the trueness of zirconia crowns produced using subtractive and additive manufacturing with Digital Light Processing(DLP) andstereolithography(SLA).

Materials and methods: Set a maxillary right first molar as an abutment. After scanning the model, design anatomical crown using software to obtain an STL file. It is manufactured by subtractive and additive manufacturing(DLP, SLA) using stl files (n=3). STL files are obtained by scanning the internal surface and margins of the produced crown. After setting the design STL as reference data using the geomagic verify, the STL file produced by subtractive manufacturing(SM group) and the STL file produced by two additive manufacturing method are superimposed. Analyze the trueness using the obtained RMS value.

Result: The obtained RMS value was 18.8±4.06㎛, 17.73±0.6㎛, 16.56±1.6㎛ for internal, external surface and margin of the crown produced using subtractive manufacturing and 27.26±1.86㎛, 26.73±2.73㎛, 38.4±1.66㎛ / 40.26±4.06㎛, 72.13±0.46㎛, 60.26±5.8㎛ for internal,

external surface and margin of the crown produced using additive manufacturing(DLP, SLA)separately.

Conclusion: Compared to the additive manufacturing technology, the accuracy of the crown produced using subtractive manufacturing was higher, but three groups are within the clinicaltolerance.

Keyword : Zirconia, ZrO2 paste, 3D printing, trueness, Digital Light Processing(DLP),stereolithography(SLA)

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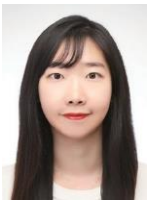
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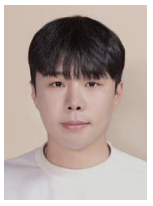
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Study Methods and Material

1. What to Study and Model

Dental model (D85DP-500B.1, Nissin Dental, Japan) with the upper right molar teeth, was used as the main model. With using CAD softwares (3Shape Dental Designer, Copenhagen, Denmark) , We have designed dental restorations based on anatomical forms and produced 3 units by each of 3 types of dental restorations – DA group(DATRON D5, Datron Dynamics Inc, Milford, USA) carved by CAM systems, IN group (ZIPRO Dental, AON Co., Ltd., Korea) printed by 3D-printing system and CE group(CERAMAKER 900, 3DCeram Co).

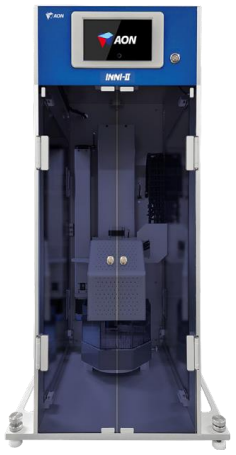

Figure 1. 3D printer: ZIPRO Dental

Figure 2. Zirconia Slurry

2. Analysis Method

We have created STL files after respectively scanning the inner and outer sides of the two groups of dental restorations produced by model scanners (Identical Blue, Medit, Seoul, and Korea). The STL file was evaluated for accuracy while being edited and compared the inner side, the outer side, and the margin with each other.

Study Result

According to the result of analysis, the mean and standard deviation of the inner, outer, margin RMS value of DA group carved and processed from the inner part were 18.8±4.06μm, 17.73±0.6μm, 16.56±1.6μm, and the IN group made by DLP method of additive processing was 27.26±1.86μm, 26.73±2.73μm, 38.46μm,
CE groups manufactured by SLA method were 40.26±4.06μm, 72.13±0.46μm, and 60.26±5.8μm (Figure 3). DA group showed the highest accuracy, followed by IN group and CE group. (Figure 4).

Group/Item	External surface	Internal surface	Margin
DATRON	18.8±4.06	17.73±0.6	16.56±1.6
AON	27.26±1.86	26.73±2.73	38.4±1.66
3D CERAM	40.26±4.06	72.13±0.46	60.26±5.8

Figure 4. RMS RESULT

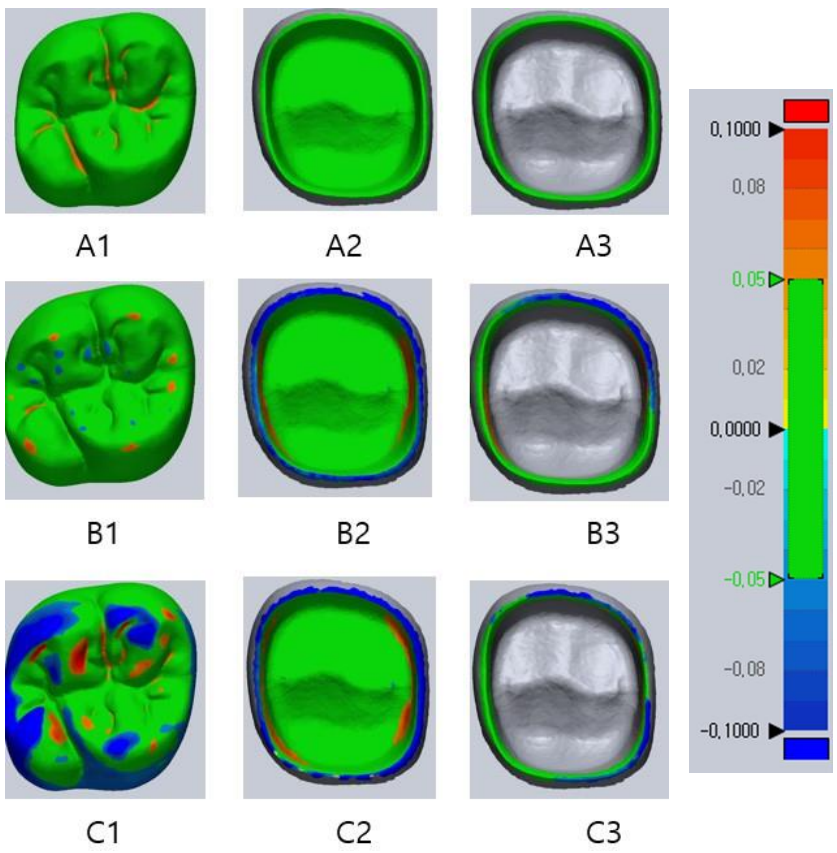

Figure 4. Color-coded difference images for qualitative deviation analysis(A1 – external surface of DA, A2 – internal surface of DA, A3 – margin of DA / B1 - external surface of IN, B2 — internal surface of IN, B3 — margin of IN / C1 - external surface of CE, C2 – internal surface of CE, C3 – margin of CE)

Conclusion

Currently, additive processing in the dental field is used in the production of a wide range of dental products, including orthodontic models and manufacturing of resin and metal products. Nonetheless, additive processing of ceramic materials has not yet been commercialized. In addition, recent studies have reported that although studies on the accuracy of additive processing methods of resin or metal materials have been actively reported, few studies have been conducted on accuracy using ceramic materials. Due to the lack of prior studies on additive processing of ceramic materials, this study first evaluated whether crowns made using SLA-type 3D printers and newly developed DLP-type printers are technologies that can replace cutting processing. It is meaningful in terms of performing accuracy study, 3-demensional comparison and analysis after producing Zirconia crowns by SLA printers on sale, newly developed DLP printers, and existing carving processing methods.
As a result of this study, crowns made by carving and machining with milling equipment appeared the highest accuracy, and SLA printers of 3D CERAM showed the lowest accuracy. As shown in Color-coded difference images of Figure 4, the color deviation images of the DA and IN groups showed approximately identical, particularly on the outer surface, but a slight negative gap was found in the inner region. In the CE group, large gaps were found overall, and negative and positive gaps were simultaneously seen on the outside. Although the gap numbers of dental restorations manufactured by additive processing was larger than those produced by milling equipment, those numbers ended up to be clinically acceptable for all three groups of dental restorations manufactured by milling processing, the additive processing with DLP, and SLA method. If those numbers ended up beyond clinical limits, this would result in a secondary simple cavity, inflammation of periodontal tissue and so on. That's why we evaluated the relatively important inner and margin, since it is also important to anatomically reproduce the appearance of the teeth on the confluence surface and exterior of the crown, accuracy analysis on the exterior was conducted. Because ceramic additive processing can be applied to various fields, interest in additive processing materials continues to increase. The dental sector also prefers ceramic materials for aesthetic reasons, **and it is believed that it will not be unreasonable to apply them to clinical applications because the gap levels of dental restorations produced by the additive processing are within the tolerance range like the gap levels by milling processing.**

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