Precise Fit in Joint between Metal and Resin Model Using 3D Printer

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Objective: It is intended to observe a precise fit in metal articulator that could be joined to RP model, and report a result so that this can be clinically applied in practice.

Methods: A fit region between resin and metal in articulator is fastened by full polymerization after first flasking in liquid unsaturated polyester. Experimental method is as follows. A resin block is cut by using High Speed Precision Cut-Off, and is polished by using Automatic Specimen Polisher, and then it is cleaned after being put in Ultrasonic Cleaner. With regard to the manufactured specimen, a gap was observed in metal-resin joint by using a scanning electron microscope. Specimens were manufactured by using 50, 60 and 70 series anodized aluminum, 50, 60 and 70 series aluminum plated with electroless nickel, S45C metal plated with chromium, S45C plated with electroless nickel, and MC nylon.

Results: The bonding gap value between the Resin model and MC Nylon was the lowest, and the gap value between the Resin model and Aluminum 60 series anodized metal was observed to be high.

Conclusion: It was observed that a gap ($50.02 \pm 7.44 \mu\text{m}$) in joint between resin model and MC Nylon was the smallest and a gap ($120.25 \pm 11.92 \mu\text{m}$) between resin model and 60 series anodized aluminum metal was the biggest.

Keywords: mounting, model, gap

Introduction

Unlike the lab work that relies on manual labor in the dental prosthesis manufacturing process, the need for new equipment is emerging as precision prosthetics are manufactured by controlling the processing machine with digital data in recent years. With the development of Oral Scanner, it is transmitted

as a digital file in the process of dental prosthetics, and during the design and milling process, the existing impression-taking model-making process is eliminated, and the development of materials is facilitated by a revolutionary work shift that becomes a model-making through 3D printing. It is required as the highest priority [1]. However, in the process of manufacturing dental prostheses, mounting (articulator attachment) is difficult to manufacture as the articulator, which was used exclusively for the existing gypsum model, is used for the resin model through the 3D printer. RP refers to a technology that creates a cross-section from a 3D CAD model and produces a physical model in a layered manner. This technology has started to be used in the engineering field to verify the feasibility and accuracy of product designs, and recently, it has been used

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by mechanical methods such as short modeling time, variety of materials available, various post-processing techniques, and conventional milling. Because of the many advantages that only additive manufacturing techniques can provide, such as the ability to fabricate difficult or impossible things, the field of their use is gradually expanding [2].

The articulator reproduces the continuous positional relationship of the maxillary dentition, enabling anatomical and functional occlusal relationships in the diagnosis and treatment of occlusion and prosthesis production [3]. As the existing gypsum model using an impression body is converted to a 3D printed model using the Intra Oral Scanner, a resin model, it is necessary to develop a resin model articulator (articulator for mounting the resin model). In particular, in the case of CAD/CAM and 3D scanners, the entry into the global market is expected to be very fast due to the high domestic related technology. to be. In order to minimize errors in the digital work process, there is a need to develop a model articulator for a 3D printer that can properly reproduce the oral environment. In order to apply the RP model more effectively to the dental prosthetic field, the role of the articulator and the material that can acquire the correct occlusal relationship within the allowable range is important. Therefore, in this study, we want to observe the precision fit between the resin model model and the metal through the 3D printer and report the results that can be applied to actual clinical practice.

Materials and Methods

1. Experimental method

For the production of precision-fitting specimens, metal and resin-fitted parts are first immersed in liquid unsaturated polyester (Epovia, Cray Vally Inc), then completely poly-

merized and fixed.

The test method is to cut the resin block using High Speed Precision Cut-Off (Accutom-5, Struers, Denmark), polish it using Automatic Specimen Polisher (Rotapol 2, Struers, Denmark), and then put it in the Ultrasonic Cleaner and wash it. do. The metal-resin bonding site gap was observed using a scanning electron microscope (FE-SEM, MBM11100, Nikon, Japan) of the cleaned specimen.

For specimens, 50, 60, and 70 series treated with aluminum anodizing, 50, 60, 70 series treated with aluminum electroless nickel, and S45C metal series with chromium and electroless nickel surface treatment, MC nylon were manufactured (Table 1).

2. Statistical analysis

One-way ANOVA and Tukey HSD post-hoc test were performed for the results of the precision fit values for each group using SPSS Ver 13.0 for windows (SPSS INC., U.S.A). The significance level was verified to be less than or equal to 0.05.

Table 1. Group of specimens

Group	n
Alumium anodizing	
50 Anodizing	5
60 Anodizing	5
70 Anodizing	5
Alumium electroless nickel	
50 Electroless nickel	5
60 Electroless nickel	5
70 Electroless nickel	5
S45C	
Chromium	5
Electroless nickel	5
MC nylon	5

Figure 1. Representative images of (SEM photomicrographs, magnification 1000×).

Results

The precision fit was observed with a microscope at 1000× magnification to measure and analyze the gap between the articulator metal and the resin bonding site (Figure 1).

The bonding gap value between the Resin model and MC Nylon ($50.02 \pm 7.44 \mu\text{m}$) was the lowest, and the gap value between the Resin model and Alumium 60 series anodizing-treated metal ($120.25 \pm 11.92 \mu\text{m}$) was observed to be high.

Statistical significance (ANOVA test) was shown between Electroless Nickel and Alumium group 50 Anodizing in S45C group, Chromium in S45C group, and MC Nylon group, and no statistical significance was shown between other groups (Table 2).

Conclusion

As the dental prosthesis manufacturing process is changed to a digital method, the existing analog model production (plaster) method will be replaced by a 3D printer production method, and the demand and utilization of the resin model will increase.

From a technical point of view, the articulator for mounting a resin model using a 3D printer can minimize errors in the digital work process by simplification of the drilling process and shortening of the production time compared to the manual labouring work, thereby improving the oral environment.

Because it can be reproduced appropriately, an articulator for mounting a resin model using a 3D printer is needed to enhance physical stability and bonding strength in the production of prostheses [4]. In the existing method, the dental model and the articulator were attached using a chemical bonding method using plaster as a medium, but the convenience of work can be expected by attaching the model and the articulator through the mechanical bonding method using the key and key-way method (Figure 2).

Table 2. The mean value of precise fit (Unit: μm)

Group	Precision fit	
	Mean	SD
Alumium anodizing		
50 Anodizing	81.56 ^a	13.88
60 Anodizing	120.25 ^{b,c}	11.92
70 Anodizing	83.70 ^{a,b}	18.41
Alumium electroless nickel		
50 Electroless nickel	109.67 ^a	5.45
60 Electroless nickel	105.34 ^{a,b,c}	17.40
70 Electroless nickel	95.28 ^{a,b,c}	18.43
S45C		
Chromium	62.05 ^a	15.36
Electroless nickel	54.23 ^c	12.81
MC nylon	50.02 ^a	7.44

Same lowercase letter is no significant. ^{abc}The same characters are not statistically significant by Tukey multiple comparison.

Figure 2. Comparison of the existing articulator attachment method and the developed product attachment method.

Figure 3. For mounting (A) using conventional analog plaster and resin model using 3D printer Articulator (B, C).

The development of the articulator for mounting the resin model will be used to break away from the old articulator in the dental industry, which is changing from the existing analog production method to the digital production method, and to accurately reproduce the condition of the jaw bone in the patient's mouth. During occlusal mounting, it is easier to attach and detach than the existing method through the mechanical bonding method of the resin model and the articulator in the conventional bonding method of gypsum and gypsum, and it is suitable for digital manufacturing methods such as bonding strength and accuracy, so it is possible to manufacture higher quality prostheses (Figure 3).

Understanding the principles and applications of the system to adapt to the rapid dissemination of digital technology and materials and to use them accurately in appropriate cases should be prioritized. In addition, since the combination of systems and materials that are currently distributed is in the process of developing digital dental technology, it is necessary to recognize and use the disadvantages and limitations of each system, and studies to supplement these limitations should be continued [5].

The limitation of the study is that the effect of the environmental conditions in the oral cavity, the movement of the mandible and the masticatory strength, which are practically important in measuring the precision fit of the resin model and the metal articulator, was not reproduced. If it becomes possible to reproduce and link the exact movement pattern of the temporomandibular joint and mandible of the patient, it will be possible to manufacture a more accurate prosthesis and to apply it to more areas. Research should be continued by supplementing these points. Detailed experimental studies on the materials of the resin model and metal articulator that are

widely used in clinical practice will be required.

The 3D printed resin model and the precision fit of several types of metal were experimentally observed. As a result of the experiment, the bonding gap value ($50.02 \pm 7.44 \mu\text{m}$) between the Resin model and MC Nylon was the lowest, and the resin model and the Alumium 60 series anodizing-treated metal had the highest value ($120.25 \pm 11.92 \mu\text{m}$).

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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References

1. Dimitrov D, Beer N, Hugo P, Schreve K, Three Dimensional Printing. *Comprehensive Material Processing* 2014;10: 217-50.
2. Wang Z, Wang X, Liu S : Research on improving rapid prototyping, Wang Z, Wang X, Liu S : Research on improving rapid prototyping, *Proceedings of 1998 IEEE International Conference on Robotics and Automation*.1998;1:314-17.
3. Chang-Geun Yoon, *Crown & bridge prosthodontics*, University Seorim, 2016.
4. DeLong R., Heinzen M., Hodges JS., Ko C-C., Douglas WH. Accuracy of a system for creating 3D computer models of dental arches. *J Dent Res* 2003;82:438-42.
5. Kim Ryoo-Woon, Jang Geun-Won, Heo Yu-Ri, Son Mee-Kyoung. Understanding and Application of Digital Impression in Dentistry. *Journal of Dental Materials* 2014;41:253-61.