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A Study of Plaque Adhesion during Implant Treatment of Missing Molars

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Abstract

Purpose: In implant treatment, the abutments and superstructures form a transmucosal area. In addition to providing appropriate cleaning instructions to patients, its material properties must be carefully considered. It is not clear how much plaque adhesion occurs at each site during treatment process, and the effect of materials on plaque adhesion. **Methods:** In this study, 33 patients, 13 maxillary cases and 20 mandibular cases, who had implants placed in the missing molars were evaluated for the plaque adhesion of provisional restorations made of acrylic resin and monolithic zirconia final restoration after a period of more than 4 weeks. In addition, oral hygiene instructions were thoroughly given for 12 cases at the time of staining after the provisional restorations, and re-evaluated in 4 weeks. **Results:** About 20% of the buccal-lingual area of the prosthetic device fabricated with acrylic resin showed plaque staining, whereas about 40% of the area of the mesial and distal. On the other hand, for the zirconia final restorations, the percentage of staining was about 5% for buccal and lingual surface and 10% for mesial and distal surface. The stained area ratio of the provisional restoration correlated with the zirconia superstructure area ratio. Even with careful oral hygiene, it became clear that the amount of plaque adhesion due to the difference in materials could not be overcome. **Conclusion:** The zirconia superstructure is extremely good from the viewpoint of plaque adhesion, but cases with a large stained area at the time of provisional restoration should be carefully followed up.

Keywords

Superstructure, Dental Plaque, Yttria-Stabilized Zirconia, Polymethyl Methacrylate

1. Introduction

Biocompatible materials are required for abutments and superstructures, but at the same time, it is necessary to ensure cleanability. In a comparative study of abutments in animal experiments, it was reported that titanium and zirconia showed less degeneration of the surrounding tissue than gold alloy, and in a comparison of zirconia and titanium [1], it was suggested that zirconia was superior in terms of ensuring cleanability [2], but there was no difference in long-term follow-up [3] [4]. Zirconia is the hardest dental material, but if it is polished to a mirror-like surface, it does not wear down the opposing teeth and bacteria adhesion is low, so it is increasingly used as a superstructure [5]. In recent years, multi-layered zirconia blocks have become commercially available, and the former zirconia-porcelain layering is changing to monolithic zirconia restoration [6]. Although zirconia may be the least problematic material in terms of plaque adhesion due to its low bacterial adhesion [7], the tendency of plaque adhesion by site has not been investigated. Therefore, the purpose of this study was to evaluate the plaque adherence of patients with missing upper and lower molars treated with dental implants by changing from acrylic provisional restoration to zirconia final restorations during the treatment process, and to obtain clinical information.

2. Materials and Methods

Thirty-three patients who came to the Asahi University Medical and Dental Center for implant treatment between December 2019 and December 2021 had bone level internal implants (Nobel internal or Straumann bone level) placed in their missing molar area were included in this study. All participants agreed to implant treatment and participation in this study and signed the consent form. The healing period was set more than 2 months for all patients. After impressions were taken with intraoral scanner (TRIOS3, 3 Shape), provisional restorations made of polymethyl methacrylate (PMMA) (CSC PMMA Block, CARES solution center, Tokyo JAPAN) were screw-retained to the implants. At least 4 weeks after the delivery, the provisional restorations were carefully removed, and the buccal, lingual, mesial, and distal surfaces of the prosthesis were photographed with a digital camera to check the plaque adhesion using plaque staining solution (Merssage PC Pellet, Shofu, Kyoto, JAPAN) (**Figure 1**). The image analysis software (NIH Image) was used to calculate the area ratio of plaque adhesion on each surface. The final restorations were fabricated by CAD/CAM using yttria-stabilized tetragonal zirconia (Y-ZIR) with screw retaining, and analyzed the same way as the provisional restorations. The Friedman test was used to compare each surface, and the Wilcoxon signed rank test was used to compare between provisional restorations (PMMA1) and zirconia (Y-ZIR).

In 12 of the 33 cases, patients were thoroughly given cleaning instruction at the time of first provisional evaluation (PMMA1), and staining was performed again (PMMA2), and the completion of zirconia prosthesis (Y-ZIR) was statisti-

cally examined. The protocol of the study is summarized in Figure 2.

This study was conducted under the approval of the Ethics Committee of Asahi University School of Dentistry (No. 11000341-30011).

3. Results

Table 1 shows the status of plaque adhesion on each surface of the provisional fabricated with PMMA and the final restorations fabricated with zirconia in 33 cases. The buccal and lingual surfaces of PMMA showed an adhesion rate of about 20% of the total area, while the mesial and distal surfaces showed an adhesion rate of more than 40%. A Mann-Whitney U test comparing PMMA and Y-ZIR showed a significant decrease in all aspects. On the other hand, a Friedman test comparing each surface of each prosthetic device showed that the

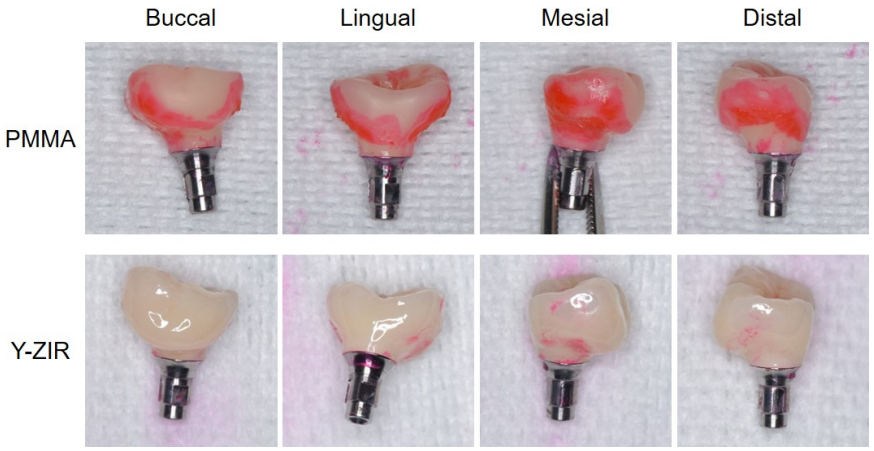

Figure 1. An example of photographs of plaque staining used in the analysis. The superstructure was carefully removed from the implant and stained with dye. Both provisional (PMMA) and final restoration (Y-ZIR) were made by CAD/CAM manufacturing.

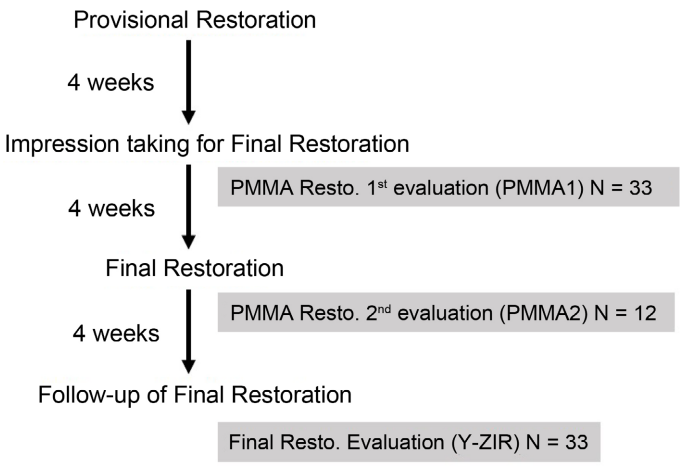

Figure 2. Research protocol of the study. Provisional restorations were evaluated on a final impression visit (PMMA1) and final restoration delivery (PMMA2). The final restoration was evaluated on a follow-up visit (Y-ZIR). At least 4 weeks were set before each evaluation.

PMMA had a predominantly large area of adhesion on the mesial surface compared to the buccal-lingual surface. In contrast, for Y-ZIR, the difference between the buccal and mesial surfaces was significant, but the difference between the buccal and lingual surfaces was relatively unclear (Table 2).

In 12 of the 33 cases, plaque adhesion was evaluated at first evaluation (PMMA1), and then cleaning instruction was given and the plaque was evaluated again (PMMA2), and the change in the mean stained area after more than 4 weeks of wearing the final zirconia prosthesis (Y-ZIR) is shown in Figure 3.

Table 1. The percentage of plaque-stained area on each surface for provisional restoration (PMMA1) and zirconia final restoration (Y-ZIR).

	Buccal	Lingual	Mesial	Distal	Average
PMMA1 N = 33	20.2 ± 13.2	26.8 ± 18.6	41.7 ± 15.6	40.2 ± 18.7	32.3 ± 12.3
Y-ZIR N = 33	2.8 ± 4.6**	5.8 ± 8.9**	10.1 ± 10.0**	10.8 ± 9.6**	7.5 ± 6.4**

Wilcoxon signed rank test was used to compare the values. **p < 0.001.

Table 2. Statistical values comparing the plaque-stained areas between the surfaces.

	PMMA1			Y-ZIR		
	Lingual	Mesial	Distal	Lingual	Mesial	Distal
Buccal	0.673	<0.01**	<0.01**	0.406	<0.01**	<0.01**
Lingual	-	<0.01**	<0.01**	-	0.149	0.028*
Mesial	-	-	0.994	-	-	0.920

Scheffe's pair complarison after Friedman test: *p < 0.05, **p < 0.01.

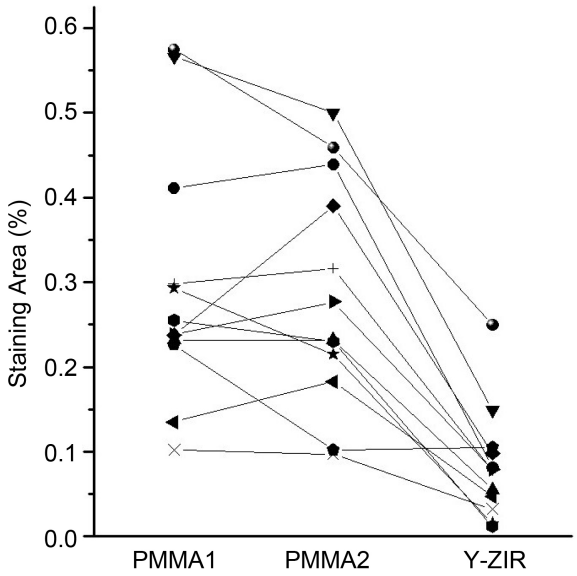

Figure 3. Average values of plaque staining for provisional (PMMA1), 2nd evaluation (PMMA2) and final restoration (Y-ZIR). The average value of each surface was calculated and used for analysis. There was a close correlation between PMMA1, PMMA2 and Y-ZIR. The tendency of plaque accumulation did not change even if the material was changed. R-squares: PMMA1-2: 0.854, PMMA1-ZIR: 0.766, PMMA2-ZIR: 0.651.

There was no difference between PMMA1 and PMMA2, although there was a difference between Y-ZIR and PMMA2 in the comparison between each group. Even if the material of the implant superstructures changed from PMMA to zirconia, there was a close correlation between the two (r-squares: PMMA1-PMMA2: 0.854, PMMA1-Y-ZIR: 0.766, PMMA2-Y-ZIR: 0.651).

4. Discussion

With the development of CAD/CAM processing technology, the use of ceramics such as zirconia and alumina as part of the superstructure or abutment has become common in implant prosthetic treatment. In addition, the development of highly aesthetic zirconia blocks has made it possible to use only zirconia as a prosthetic material using staining method. In recent years, many studies have been reported on the use of zirconia as a prosthetic material for implants, and it has been reported that the problem of low-temperature degradation of zirconia can cause peri-implant mucositis and peri-implantitis due to plaque adhesion [8] [9] [10]. The average amount of plaque adhesion was reduced by 77% upon changing zirconia superstructure. However, subjects who had high plaque adhesion in the provisional restoration still had relatively high plaque adhesion in the zirconia superstructure. Kanao *et al*. examined the plaque adhesion and inflammation of different mucosal contact surface materials in full-arch implant superstructure devices, and described the superiority of titanium over reinforced photopolymerized resin for mucosal contact surfaces [11]. And they also indicated that the pontic area of PMMA is relatively easy to control plaque for a short period. However, the results of current study showed that PMMA in crown-shaped implant superstructures is difficult to control, especially in the mesial and distal surfaces, and that the effect of cleaning instruction is small. In a study comparing titanium and zirconia in full-arch implant superstructure, the superiority of zirconia was reported, although there was no difference in terms of inflammation [2]. Since the present study was conducted in a series of well-progressed cases and did not include cases with signs of inflammation, future follow-up is necessary to determine whether the cases with large stained areas progressed to pathological ones.

The results of the present study indicate that consideration must be given to plaque control in upper and lower molar implant prosthodontic treatment during provisional restoration, and that PMMA is less effective in teaching plaque control. The stained area of PMMA to zirconia prosthetic devices decreased significantly, but did not affect the ranking of the adhesion area. The difference between patients is difficult to distinguish because the amount of plaque adhesion is too small in zirconia. Above all, measuring the plaque control of each patient during the use of a provisional restoration may be very effective in evaluating the patient-specific plaque control factors. Considering the short history of zirconia as a superstructure material and the low-temperature degradation [12] and acid degradation [13], it will be necessary to evaluate this area periodically

in the future.

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Conflicts of Interest

The authors declare no conflicts of interest associated with this paper.

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