Fabrication of titanium restoration by means of calcium aluminate-bonded magnesia investment material and one-chamber arc casting apparatus

Mika Furuchi1,2, Yoshimasa Takeuchi1,2, Atsushi Kamimoto1,2, Hideo Matsumura3), Hideyuki Imai4) and Hiroyasu Koizumi5)

1) Department of Comprehensive Dentistry and Clinical Education, Nihon University School of Dentistry, Tokyo, Japan
2) Division of Dental Education, Dental Research Center, Nihon University School of Dentistry, Tokyo, Japan
3) Department of Fixed Prosthodontics, Nihon University School of Dentistry, Tokyo, Japan
4) Dental Technician School, Nihon University School of Dentistry, Tokyo, Japan
5) Department of Dental Materials, Nihon University School of Dentistry, Tokyo, Japan

Abstract: Cast titanium restoration for molars has high biocompatibility and is covered by the Japanese national health insurance. Titanium casting requires specific investment material and casting apparatus. A cast restoration for the mandibular left second molar was fabricated using titanium in this study. A wax pattern fabricated on a definitive cast was invested in calcium aluminate-bonded magnesia investment material. Titanium was cast using an argon gas pressure one-chamber casting apparatus. No defects were observed on the surface and the hole was clearly reproduced. A smooth surface on the restoration was obtained by polishing at low speed. Reproducibility and polishing properties of the titanium restoration fabricated in this study were comparable to those of conventional dental metal restorations.

Keywords: argon gas, calcium aluminate-bonded magnesia investment material, one-chamber arc casting apparatus, polishing, restoration, titanium

Introduction

Restorations or fixed dental prostheses made with titanium provide sufficient marginal or internal fit and clinical performance owing to high biocompatibility [1,2]. Restorations of titanium are fabricated by casting or computer aided design/computer aided manufacturing (CAD/CAM). The use of CAD/CAM is increasing recently in Japan [3]. Casting has been studied over a long period of time.

Specific casting apparatus and investment materials are required for casting titanium because of the high melting point and oxidation reactivity [4]. Three types of casting apparatus—centrifugal casting apparatus, two-chamber arc casting apparatus, and one-chamber arc casting apparatus—have developed for casting titanium [4]. Castability of titanium is reported to be influenced by investment material, casting apparatus, and their combinations [5].

Silver-palladium-copper-gold alloy has been widely used for restorations and prostheses in Japan. However, the price of both palladium and gold increased significantly in 2019. On March 31, 2020, insurance ceased to cover restorations using nickel-chromium alloy. As an alternative, cast titanium because of the high melting point and oxidation reactivity over 1,600°C, a high oxidation reactivity, and a low density, which causes insufficient casting pressure [4]. Vacuum pressure and centrifugation were used to provide sufficient pressure to cast titanium. A vacuum pressure casting apparatus was used in this study. Alloy is melted by arc in the argon atmosphere to prevent the reaction with oxygen until the casting is completed. Calcium aluminate-bonded magnesia investment material was used in this study, as it has fewer defects by magnesia investment material in combination with a vacuum pressure casting apparatus as reported by Ida...
Investment material was easily removed by blasting with glass beads after casting, that may indicate the investment material did not bond to the alloy. No casting defects were observed on the surface of the restoration. Mechanical polishing was used in this study, whereas chemical polishing is also provided for titanium. The restoration was polished with instruments, each of which are commonly used for conventional dental materials. A smooth surface was obtained owing to polishing at low speed, which prevents heat accumulation.

Reproductivity and polishing properties of the titanium restoration fabricated in this study were comparable to the conventional dental metal restorations.

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Conflict of interest
The authors have no conflict of interest to declare.

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Table 1 Materials used for titanium casting

| Material                  | Lot number          | Type                  | Heat rate | Water/Powder ratio |
|---------------------------|---------------------|-----------------------|-----------|-------------------|
| Investment material       | Symbion TC (Nissin Dental Products Inc., Kameoka, Japan) | high-purity argon gas pressure, one-chamber | 6˚C/min; hold temperature 850˚C; holding time period, 60 min; mold temperature 25-150˚C | 0.2 |
| Refractory material       | MgO, Zr             | CaAl2O3, others       |           |                   |
| Binder                    | CaAl2O3             |                       |           |                   |
| Casting apparatus         | Symbion Cast (Nissin Dental Products Inc.) | direct current arc     |           |                   |
| Argon gas pressure        | 0.2 MPa             |                       |           |                   |
| Titanium ingot            | CP titanium JIS2 (Nissin Dental Products Inc.) |                       |           |                   |
| Weight                    | 14 g, 30 g, and others |                       |           |                   |

Table 2 Materials used for grinding and polishing of the restoration

| Abrasive medium | Carborundum Point (Shofu Inc., Kyoto, Japan) | SiC |
|-----------------|----------------------------------------------|-----|
| Grinding        | Universal Rubber Cylinders White-Course7104 (Dedeco International Inc., Long Eddy, NY, USA) | SiC |
| Polishing       | Universal Rubber Cylinders White-Course7114 (Dedeco International Inc.) | SiC |
|                 | Browne Silicone Points Hard (Shofu Inc.) | SiC |
|                 | Pivot Brush (Shofu Inc.) | - |
|                 | Felt Wheel (Shofu Inc.), Selebright (Selec Ltd., Osaka, Japan) | Al2O3 |

SiC, silicon carbide; Al2O3, aluminium oxide