Durability of Tungsten Carbide Burs for the Fabrication of Titanium Crowns using Dental CAD/CAM

Yasuhiro HOTTA¹, Takashi MIYAZAKI¹, Toshihisa FUJIWARA², Shoko TOMITA², Akiyoshi SHINYA², Yasuhisa SUGAI³ and Hideo OGURA⁵
¹Department of Oral Biomaterials and Technology, Showa University School of Dentistry, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142-8555, Japan
²Digital Process Ltd., 2-9-6 Nakamachi, Atsugi-shi, Kanagawa 243-0018, Japan
³Department of Crown and Bridge, School of Dentistry at Tokyo, The Nippon Dental University, 1-9-20 Fujimi, Chiyoda-ku, Tokyo 102-8159, Japan
⁴ADVANCE Co., Ltd., 5-7 Nihonbashi-kobunacho, Chuo-ku, Tokyo 103-3354, Japan
⁵Department of Dental Material Science, School of Dentistry at Niigata, The Nippon Dental University, 1-8 Hamaura-cho, Niigata City, Niigata 951-8580, Japan
Corresponding author, E-mail:hotta@dent.showa-u.ac.jp

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The purpose of this study was to evaluate the durability of tungsten carbide burs for the fabrication of titanium crowns using two dental CAD/CAM systems (DECSY, Digital Process, Japan and Cadim, Advance, Japan). A tungsten carbide bur in each system was examined and used without fracture to fabricate 51 titanium crowns. For both systems tiny chips were found on the bur blade at the 11th machining. These chips gradually enlarged as the number of machining times increased. At the first machining no significant difference in the average surface roughness was found on the crown between the two systems (1.6μm for DECSY and 1.2μm for Cadim). The cutting grooves became dull and the average surface roughness increased as the number of machining times increased. It is concluded that the tungsten carbide bur for both systems can be used to fabricate up to 51 titanium crowns.

Key words: CAD/CAM, Titanium, Durability

INTRODUCTION

In recent years, many dental CAD/CAM systems have been commonly used to fabricate dental prostheses¹⁻⁶. These CAD/CAM systems are expected to improve the environment in dental laboratories and to reduce costs in production. Also, many kinds of materials are available to fabricate dental prostheses using these CAD/CAM systems. Especially, sintered alumina and Zirconia, which were considered difficult to process, were available for bridge prostheses in molar teeth⁷⁻¹⁰.

Many papers have already reported the accuracy of fabricated prostheses¹¹⁻¹⁴. These reports indicate that the dental CAD/CAM system has sufficient performance in the manufacturing of dental prostheses, and the demand for the dental CAD/CAM systems arose for clinical use. In recent years, titanium has been introduced for crown and bridge materials in dental practice. Although the accuracy of these titanium crowns has been reported by some studies¹⁵⁻¹⁷, the durability of the tungsten carbide burs has not been well demonstrated. However, the costs of fabricated crowns were greatly influenced by the durability of the tungsten carbide burs. The purpose of this study was to evaluate the durability of tungsten carbide burs for the fabrication of titanium crowns using two dental CAD/CAM systems.

MATERIALS AND METHODS

A conical die mold (base diameter: 9.65 mm, height: 6.50 mm, taper: 1/10) made of brass was used as an original model for the fabrication of a titanium crown (Fig.1, 2). The shape of the original model was copied using a silicone impression material.

![Fig. 1 Metal and stone dies.](image-url)
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Results

Fig. 2 Dimension of conical die.

(DUPLICONE, SHOFU Inc., Japan), and 36 stone dies were prepared. Each stone die was used to digitize its dimension after every tenth machining time. Titanium crowns were fabricated using two dental CAD/CAM systems (DECSY, Digital Process Ltd., Japan and Cadim, ADVANCE Co., Ltd., Japan). Digitized data were designed for crown form, and converted to NC data of automatic machining. JIS class 2 titanium blocks were used for machining materials, the shapes of which were designed originally for each system. A tungsten carbide bur of each system was examined to check whether the bur could be used without fracture to fabricate up to 51 titanium crowns. This number was determined by more than doubling the number specified by the maker. Three sets of burs were tested for each system. The following evaluations were made on the bur blade and the surface of the titanium crowns.

SEM observation of the bur blade
For every tenth machining time from the first to the 51st, the shape of the bur blade was observed using an SEM (S-2500CX, Hitachi High-Technologies Co., Japan).

Surface roughness and topography
The average surface roughness and the maximum surface roughness of the titanium crowns were measured using a profilometer (Surfcom 480A, TOKYO SEIMITSU Co., LTD., Japan). The measuring direction and the conditions of the data acquisition are shown in Fig. 3. The results of surface roughness were evaluated using Tukey's Multiple tests (α = 0.05). The surface topography of the fabricated crown on the same point of surface roughness was observed using a photomicrograph at a magnitude of 100 times (ECLIPSE E600, Nikon Co., Japan).

RESULTS

All three sets of burs for both systems could be used without fracture to fabricate 51 titanium crowns. For the DECSY system, many burs were found at the corner of the shoulder at the 51st machining. On the surface of the first crown, different types of cutting grooves were found between the two systems. Fig. 4 shows the fabricated crowns by DECSY. It has straight cutting grooves on the occlusal surface. On the other hand, the crowns by Cadim have radial cutting grooves (Fig. 5). The SEM photomicrographs of the representative bur blades are shown in Figs. 6-8. For both systems, tiny chips on the bur blade were found at the 11th machining. These chips gradually enlarged as the number of machining times increased. The surface topographies of the fabricated crowns are shown in Figs. 9 and 10. The cutting grooves became dull and the average surface roughness increased as the number of machining times increased.

The results of the surface roughness of both systems are shown in Figs. 11 and 12. The average surface roughness of the first crown was 1.6 μm for DECSY and 1.2 μm for Cadim. At the first machining, no significant difference in the average surface roughness was found between the two systems (p > 0.05). At the 31st, 41st, and 51st machinings, the average surface roughness for both systems was significantly higher than that at the first (p < 0.05). After the 31st machining, no significant change was
found for both systems ($P > 0.05$). In the results for maximum surface roughness, no significant change was found for DECSY ($P > 0.05$). However, after the 21st machining for Cadim, significant change was found from the first machining ($P > 0.05$).

**DISCUSSION**

From the SEM observation, especially on the DECSY system, enlargement of the chips on the bur blade was remarkable. This may be due differences in the machining systems. The DECSY system uses two kinds of cutting tools for machining, coarse ($\phi$ 3.0 mm) and fine ($\phi$ 1.6 mm). On the other hand, the Cadim system uses only one type ($\phi$ 2.0 mm). In addition, the milling pathway of the DECSY system is in one direction whereas that of the Cadim system is radial from the center of the crown. The former milling pathway may be unfavorable for cutting the details of the crown, especially the line angle of the crown inside.

In consideration of the surface roughness results, it is very likely that the change in the average surface roughness is related to the enlarged chips on the bur blade. Although change in the roughness was found for both systems, the increase in the roughness was very small for both systems, which may be acceptable for polishing. Therefore, the tungsten carbide burs of the two systems could be used to fabricate at least 51 crowns. However, the accuracy of the crowns after a number of machinings should further be investigated.

**CONCLUSION**

It is concluded that the tungsten carbide burs for both systems can be used to fabricate up to 51 titanium crowns. The damage to the blade increases with the increase of the machining times, but this increase could be acceptable for the polishing. A
Fig. 6  SEM photomicrographs of the representative bur blades.
(DECSY: coarse machining bur with a diameter of 3.0 mm)

Fig. 7  SEM photomicrographs of the representative bur blades.
(DECSY: fine machining bur with a diameter of 1.6 mm)
Fig. 8 SEM photomicrographs of the representative bur blades.
(Cadim: machining bur with a diameter of 2.0 mm)

Fig. 9 Representative surface topography of the crown. (DECSY)
Further study is necessary to check if the fit of the crowns is influenced by the increase in the number of machining times.

REFERENCES
DURABILITY OF TUNGSTEN CARBIDE BURS


