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Quality control of a metallic dental bur with a diamond coating

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Abstract
During operation, sterilization and disinfection, the surface working part of dental burs deteriorates. In this study a commercial metallic dental bur with extra coarse gradation (177-250 μ of ceramic embankment), made of a stainless steel were covered with a nickel-diamond composite was examined. The working part of the tool is round-end taper shaped and is intended for crown and bridge preparation. Analysis of microstructure was carried out using Jeol JSM-6610 LV scanning electron microscope with EDX analyzer. After 3 months of operation, the bur can be used for further work in the dental surgery.

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1. Introduction

Diamond is one of the top most technologically advanced materials currently known. It has a unique combination of excellent physical and chemical properties such as high hardness, low friction coefficient, high wear resistance and chemical inertness (Stein et al., 2002; Ahmed et al., 2000). Diamond coatings are commonly used in biomedical applications and cutting tools. The conventional method for production of diamonds burs consist in platting small industrial or mineral diamond particles on metal matrix using, e.g. stainless steel, cemented carbides and various metal alloys using suitable binder material (Ahmed et al., 2004; Sein et al.,. 2004).

A formal International Standards Organization (ISO) coding system has been established to simplify identification of all burs. An example of ISO coding system is presented in Figure 1 and Table 1.

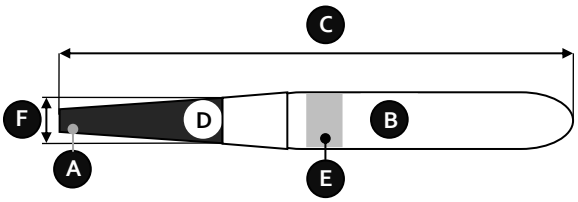

Fig. 1. ISO coding system for burs

Table 1. Identification of ISO coding system for burs

Mark	Description
A	material of the working part
B	type of shank
C	total length of bur
D	head shape
E	grain size
F	size, largest diameter of the working part

Diamond drills are designed for grinding and are characterized by various head shapes (Fig. 2). Moreover diamond burs have various degrees of graininess, which are marked with different colours of stripes on the burs. These colours indicate the aggressiveness of the burs. Numerical values mean the size of a single diamond grain deposited on a dental bur (Tab. 2) (Paszenda and Tyrlik-Held, 2003).

Diamond burs have several limitations associated with heterogeneity of the crystallites, decreased cutting efficiency, short life and the difficulty of automation (Song and Yin, 2012; Biel-Gołaska and Kalemba, 2008).

An additional problem is the sterilization of diamond burs. This procedure reduces their efficiency of cutting by affecting the matrix binding the diamond particles to the bur shaft, causing the loss of diamond particles. Dental tools must be ultrasonically cleaned. Cleaning solutions have pH 11 and

need long exposure times to effectively destroy all microorganisms, and this lengthy exposure may produce instrument corrosion (Borges et al., 1999).

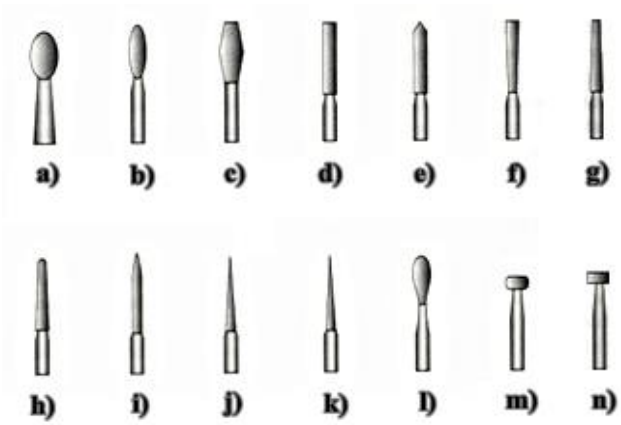

Fig. 2. Diamond burs: a) round b) football c) barrel d) flat-end cylinder e) beveled-end cylinder f) inverted cone g) flat-end taper h) round-end taper i) flame j) needle k) interproximal l) pear m) donut n) wheel

Table 2. Types of diamond embankments

Gradation	Color bar	Ceramic embankment (μm)
Super Fine	Yellow	44-62
Fine	Red	74-88
Regular	Blue	125-125
Coarse	Green	125-149
Extra Coarse	Black	177-250

Regardless of the type and use dental burs must have a specific characteristics:

- high reliability
- safety of use for patients and operators
- ease of operation
- corrosion resistance
- ergonomic nature and aesthetics of design and manufacture (Gwoździk et al., 2014, Pieniak and Niewczas, 2012, Milewski and Hille, 2012).

2. Experimental

The subject of the research is a commercial metallic dental bur with extra coarse gradation (177-250 μ of ceramic embankment). The working part of the tool is round-end taper shaped and is intended for crown and bridge preparation. Burs made of a stainless steel were covered with a nickel-diamond composite.

The tool was operated and subjected to sterilization for 3 months.

The structure and shape of the dental bur was determined by a microscope OLYMPUS SZ31. Analysis of microstructure was carried out using Jeol JSM-6610 LV scanning electron microscope with EDX analyzer.

3. Results and discussion

Stereoscopic image of dental bur with round-end taper head after the 3-month operation was presented in Figure 3. The influence of corrosive factors and the mechanical wear of the working part of the bur were not revealed during the macroscopic examinations.

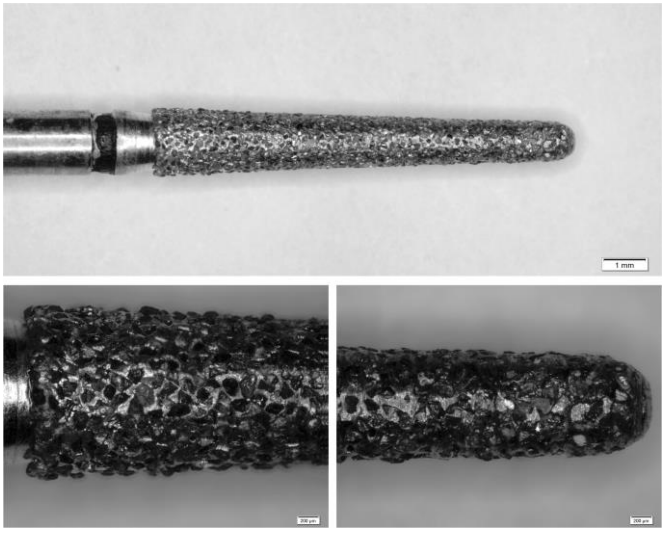

Fig. 3. Stereoscopic image of dental bur after the 3-month operation

The bur was also subjected to metallographic examinations using a scanning microscope with EDX analyzer. The chemical composition of a dental bur is shown in Figure 4.

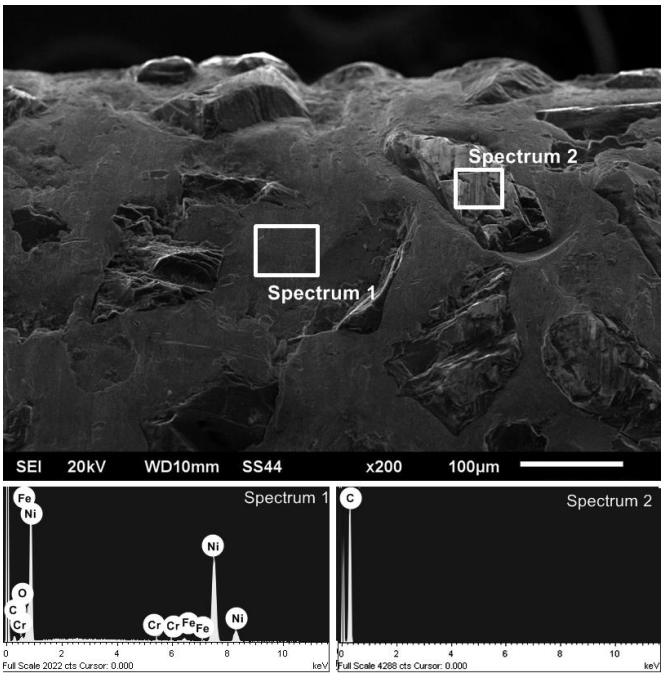

Fig. 4. The chemical composition of a dental bur with a nickel-diamond composite

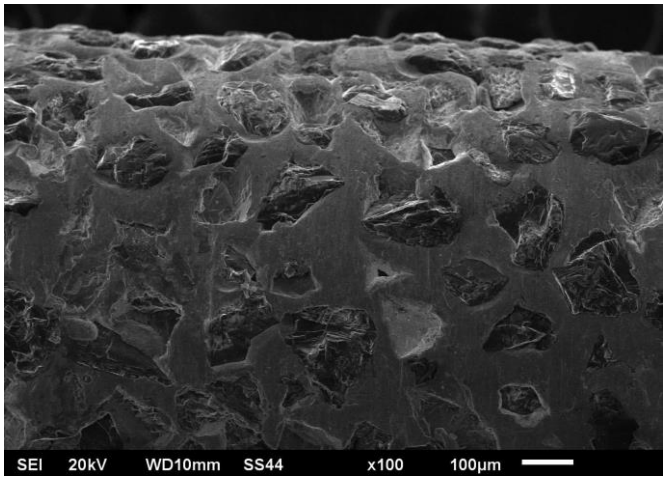

Fig. 5. Degradation of the working part of a round-end taper shaped dental bur

After 3-month operation the tool had sufficient sharpness, however the diamond was partially worn. The degradation of the working part of the tool occurred in the form of spalling and blunting (Fig. 5.) and also in the entire loss of the diamond phase (Fig. 6).

A white deposit appeared on the surface of the dental tool. Microscopic examination with EDX analysis revealed that it most likely originates from tooth dust.

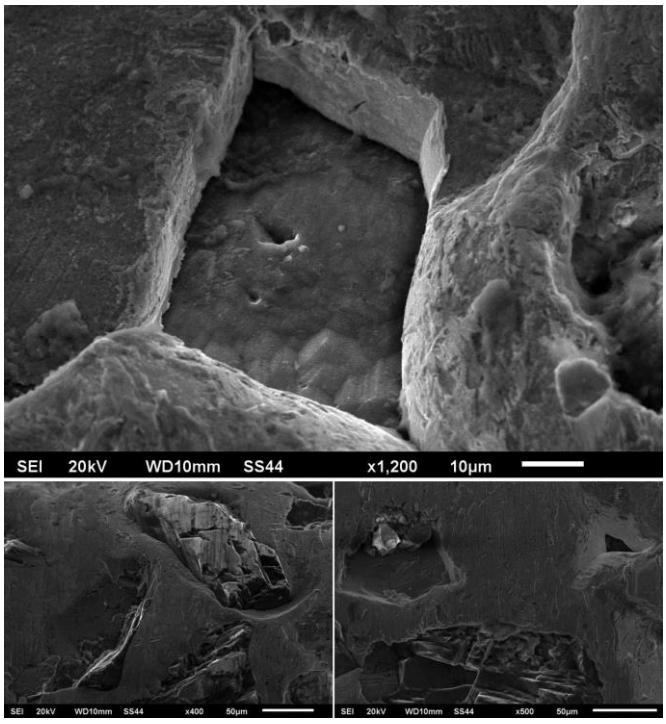

Fig. 6. Worn diamond coating of a dental bur after 3 months use

The tested dental bur was ultrasonically cleaned. The tool was exposed to long-lasting effect of cleaning agents, which have pH 11. This long exposure times are necessary to effectively destroy all microorganisms, but this lengthy exposure may produce instrument corrosion. In order to confirm the presence of corrosion products for the bur after 3-month operation, an elemental analysis from large tool areas was carried out. The presence of corrosion products has not been revealed.

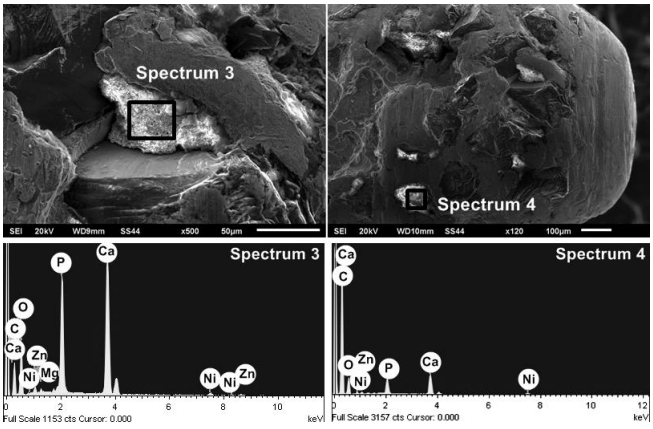

Fig. 7. EDX analysis of white dust on the surface of the bur intended for crown and bridge preparation

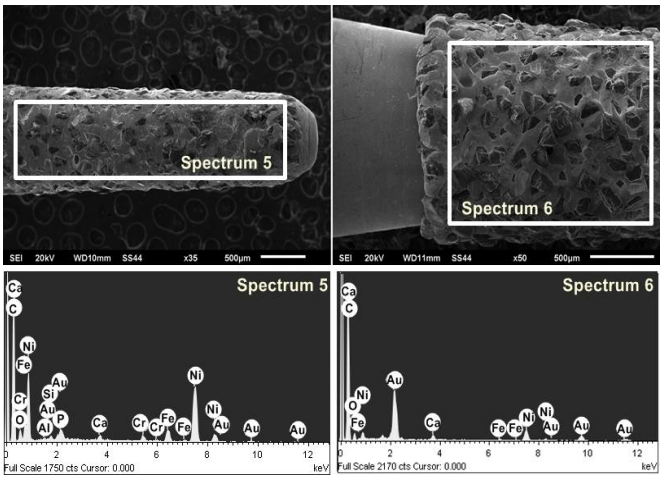

Fig. 8. Tests confirming the lack of corrosion products on the surface of the dental tool

4. Summary and conclusion

A commercial metallic dental bur with a nickel-diamond composite coating used in dentistry was examined. The working part of the tool is round-end taper shaped with extra coarse gradation. The operation consisted of a daily use for crown and bridge preparation followed by sterilization, during 3 months.

The obtained test results show:

- a few signs of wear, however, the bur had sufficient sharpness for further use,
- a white coating appeared on the tool (probably coming from the tooth dust),
- that diamond phase was partially worn. In the working part this phase was both partially blunted, spalled and there were losses of all diamond in some places,
- absence of corrosion products.

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金刚石涂层金属牙科钻的质量控制

關鍵詞

牙钻
金刚石涂层
牙科工具
质量控制

摘要

在操作过程中，灭菌和消毒过程中，齿轮表面的工作部分变差。 在这项研究中，研究了一种用镍 - 金刚石复合材料覆盖的，由不锈钢制成的具有超级粗糙级配（177-250微米的陶瓷路堤）的商用金属牙科钻头。 该工具的工作部分是圆头锥形，用于制备冠桥。 使用具有EDX分析仪的Jeol JSM-6610 LV扫描电子显微镜进行显微组织的分析。 经过3个月的手术后，牙钻可以用于牙科手术的进一步工作