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MICROSCOPIC EVALUATION OF THE QUALITY OF DENTAL REPLACEMENT

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Abstract. The permanent tooth replacements including metal-ceramic crowns are a convenient solution for the renewing of the original function of the whole set of teeth as well as of the natural appearance. Development and preparation of suitable tooth replacement presents a real challenge for dental engineers as the replacement has to meet all the conditions and requirements of the dental medicine as well as patient's needs and wishes.

The preparation of the metal-ceramic crown is a sophisticated process and the dental engineer has to prepare always a unique replacement on demand. In dental medicine there is a wide spectrum of inorganic and organic materials used for manufacturing of dental replacements. Each of the material has specific properties leading to distinct applications. Besides the material properties, the attention has to be paid to the aesthetic function and biocompatibility of the material to ensure the complete restoration of the whole set of teeth.

Keywords: metal-ceramic crown, dental replacement, microstructure.

1. Introduction

The presented paper focuses on investigation of the randomly selected tooth replacements which were no longer suitable to be used in mouth cavity in a satisfying and predetermined way. From the aspect of materials engineering, the mentioned dental condition or phenomenon is based on the critical state of the dental replacement and it can be the cause of the occurrence of many other critical states.

The given critical states lead to degradation of tooth replacements and it can even end in tooth replacement's fracture causing the functional and aesthetic defect as well. [1–4].

The main scope of the performed microscopic observations was to identify the initiation stimulus for rupture of a tooth replacement – the child patient's crown, which was used as tooth replacement after the injury. In relation to the given metal-ceramic crown (of the type seen in the 1), there was the rupture of the ceramic layer and its subsequent delaminating. The crown was supplied without any specific information (producer, chemical composition, life duration, etc.)

2. Materials

The metal-ceramic crown is a complex composite material with chemical composition given in the Table 1 and 2. The identification of the phase composition was evaluated using scanning electron microscope (SEM) JSM-7600F (JEOL, JP) with energy dispersive spectroscopy (EDS) X-Max 50 mm^2 (Oxford Instruments, GB) was used.The metallographic preparation of samples was performed in a standard and normalized way in order to carry out the microscopic investigation of the microstructure of used materials in their cross-sections (Fig. 2). Metallographic preparation was made in standard way – selection of the material from the defect and from the intact location followed by grinding, polishing and etching.

According to the fact mentioned herein before, the precise investigation of ceramics and metal microstructure were carried out. The detailed images (Fig. 3) revealed the sites with the altered roughness. The occurrence of cavities was identified in sites where the metal was in contact with the ceramic layer and it led to the rupture of the ceramic layer.

Based on the microscopic observations, the penetration of ceramic material into the irregular areas of metal originating from the manufacturing process has been identified. That led to the deteriorative effect in relation to the metal – ceramics contact (Fig. 4).

The microscopic observation of the metal alloy quality revealed that the low-quality heterogeneous metal alloy was used for manufacturing of selected metal-ceramic crown which caused defects in contact layer between metal and ceramic material during manufacturing. Besides the distribution of individual phases,

Weight %	O	Si	Sn	K	Co	Al	Cr	Zr	Ti	Na
Sample nr.1 – ceramic	34,2	14,8	8,5	6,4	6,3	5,2	2,9	2,7	2,6	2,2

TABLE 1. Chemical composition of the ceramic part of the crown obtained by EDX analysis

Weight %	Co	Cr	W	O	Si	V	S	Al	K
Sample nr.1 – metal	57,2	22,7	6,9	2,1	1,4	0,6	0,5	0,5	0,3

TABLE 2. Chemical composition of the metal part of the crown obtained by EDX analysis

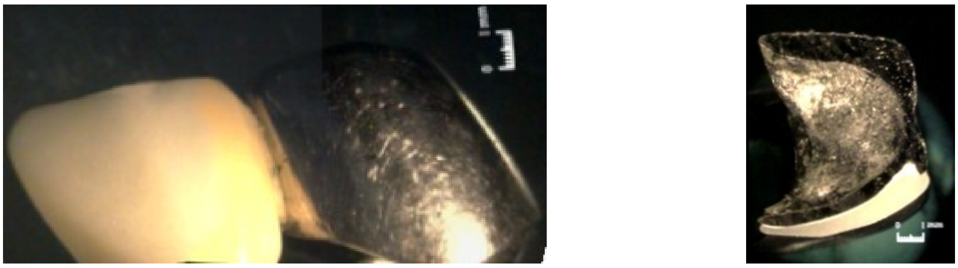

FIGURE 1. Metal-ceramic crown, detail.

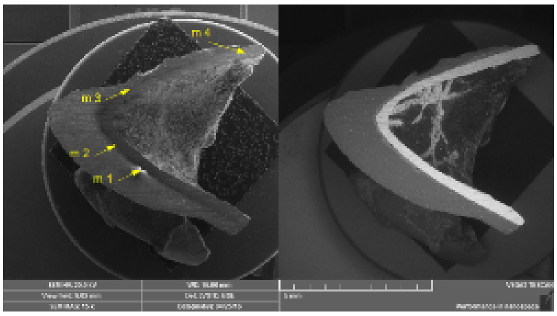

FIGURE 2. Metal-ceramic crown - detailed image.

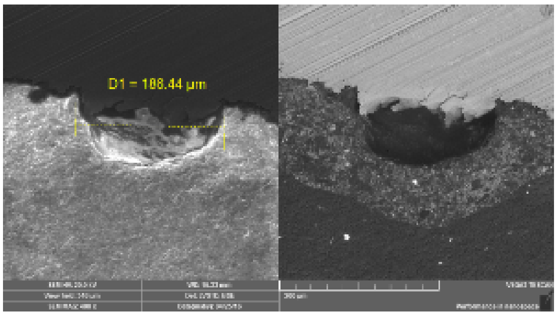

FIGURE 3. Rupture in the site of the metal-ceramic material contact.

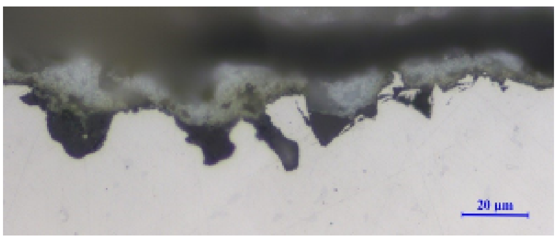

FIGURE 4. Penetration of ceramic material.

the low quality of materials was confirmed by chemical composition. The character of the microstructure (Fig. 5) exhibits the imperfect primary crystallisation of Co-Cr alloy with the occurrence of undesired phases. [5–8].

3. Conclusion

Based on the microscopic evaluation, it can be concluded that individual microstructure of the metal alloy and contact layer between metal alloy and ceramic material indicates that evaluated metal alloy was not suitable for manufacturing of tooth replacement. The most significant evidence was obtained from the contact layer between metal and ceramic material where cavities were observed. The cavities are a source of oxidation which can lead to further degradation of the metal alloy.

With the reference to the obtained results, we can come to the conclusion that the low quality materials used for manufacturing process of the metal-ceramic crown had caused defects that led to the degradation of the replacement. Moreover, there was a danger of damaging other teeth as well as danger of ingestion or inhaling parts of metal or ceramic material. The work is showing an example that may occur in practice thus a regular inspections of patients tooth replacements are recommended.

4. Results

Regulatory requirements for control samples preparation during the manufacturing of the replacements should be initiated despite the fact that preparation of samples for potential defect detection control may not be economical manufacturing process even though it is in the best interest of the patients.

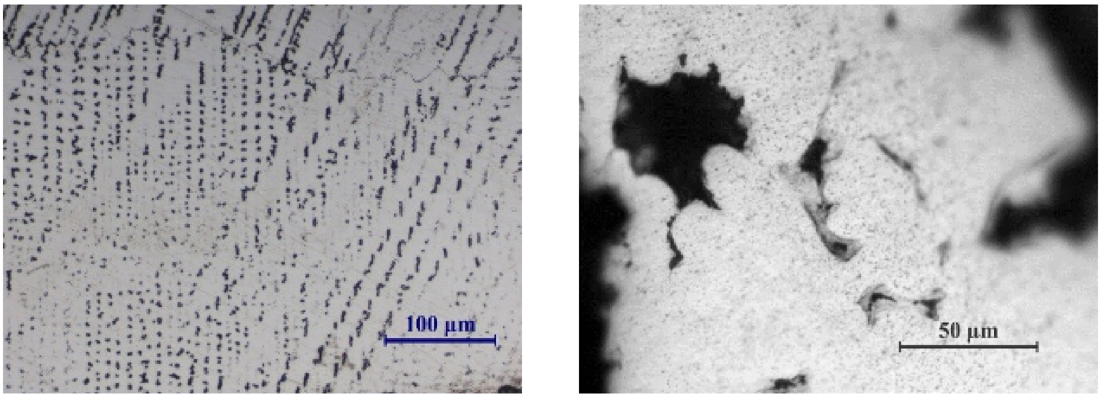

FIGURE 5. Microstructure of Co-Cr alloy .

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References

[1] Y. Wang. Bioadaptability: An innovative concept for biomaterials. *Journal of Materials Science & Technology* **32**(9):801 – 809, 2016. Bioadaptation of Biomaterials, DOI:http://dx.doi.org/10.1016/j.jmst.2016.08.002.

[2] H. Hubálková, J. Krňoulová. *Materiály a technologie v protetickém zubním lékařství.* Galén, Praha, 2009.

[3] R. G. Craig, J. M. Powers. *Restorative dental materials.* Mosby, St. Louis, Missouri, 11th edn., 2002.

[4] H. Hubálková, J. Charvát, T. Dostálová. *Faktory ovplyvňujúce životnosť fixnej zubnej náhrady.* Progresdent, 5th edn., 2004.

[5] J. Giacchi, C. Morando, O. Fornaro, H. Palacio. Microstructural characterization of as-cast biocompatible Co-Cr-Mo alloys. *Materials Characterization* **62**(1):53 – 61, 2011. DOI:http://dx.doi.org/10.1016/j.matchar.2010.10.011.

[6] J. Giacchi, O. Fornaro, H. Palacio. Microstructural evolution during solution treatment of Co-Cr-Mo-C biocompatible alloys. *Materials Characterization* **68**:49 – 57, 2012. DOI:http://dx.doi.org/10.1016/j.matchar.2012.03.006.

[7] J. E. Lemons, F. Misch-Dietsch, M. S. McCracken. Biomaterial for dental implants. In *Dental Implant Prosthetics*, chap. 4, pp. 66–94. Mosby, St. Louis, Missouri, 2015.

[8] J. B. Suzuki, D. Lynn, L. D. Terracciano-Mortilla, C. E. Misch. Maintenance of dental implants. In *Dental Implant Prosthetics*, chap. 34, pp. 964–981. Mosby, St. Louis, Missouri, 2015.