

## ASPECTS OF EXPLOITATION STABILITY OF SELECTED DENTAL PROSTHETIC BRIDGES

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**Abstract:** The paper presents results of microscopic observations of selected porcelain bridges prepared on metallic base. The aim of microscopic observations was the identification of example wear types which have appeared during dental prosthetic bridges exploitation. The main attention was directed to wear forms that are quite often present in case of such prosthetic elements. The wear types comparative analysis was evaluated. The most frequent types of wear are: material's cracking, abrasive wear. Also, the metal corrosion and wear by dental plaque at prosthetic bridge surface were observed.

### 1. INTRODUCTION

Fixed prosthetic restorations such as crowns and bridges restore loss of human mastication organ functions. The main tasks of prosthetic dental bridges are: replenishment (restoration) of missing teeth with a simultaneous correction of speech disorders caused by loss of teeth, improvement of food mastication conditions and keep safe mastication organs and whole organism from harmful after-effects of loss a natural teeth. Total or partial defects in dentition do not cause only disorders in proper food chewing or speech disorders. Stomatognathic system disorders, loss of self-confidence and avoiding contact with other people are also of great importance. These aspects favour for the spread of mental complexes forming. Restoration of missing teeth and further rehabilitation proceedings partly eliminate disorders mentioned above (Maślanka, 2000; Shield, 1968).

Clinical investigations indicate that fixed prosthetic restorations, particularly bridges are exploited much longer than was previously thought. The mean clinical usefulness period of fixed prostheses ranges from 15 to 25 years (Maślanka, 2000). Only after such period of time, more than half of the originally deposited replenishment were lost, repaired or replaced by new constructions.

It can be assumed that the greatest impact on the durability and reliability of dental bridges have factors such as: material, manufacturing technology, design and service conditions. Particularly important is proper construction. However it is known from experience, that often only after the damage of dental bridge there is a possibility of verification the correctness of its implementation. On the other hand, in the manufacturing process of dental prosthetics components, many errors can be traced, but it seems that the most important are (Spiechowicz, 1980, 2010):

- improperly selected material,
- inappropriate design,
- improperly selected manufacturing parameters.

Also, abnormal service conditions in the oral cavity have a huge impact on shortening the time of use. The most negative exploitation factor is treatment the bridge with too high forces and pressures.

In a general context, the main exploitation conditions with more or less influence on the bridge condition, are (Shillingburg, 1994):

- occlusion,
- bruxism,
- mechanical stress,
- temperature factors,
- diet,
- oral hygiene.

Some of these factors have low-order effect on the bridges than others because of impact specificity. Fluctuations and temperature changes in the mouth are too small to have a significantly negative impact on the durability of dental bridges. Similar situation is in case of the human diet. Materials for the construction of bridges are selected in this way that they show satisfactory resistance to environmental effects of saliva and food. This is rather individual matter, because literature reports are known, about the influence of biofilm on the stability of dentures (Estivill, 2011; Pusateri, 2009). Possible, rarely occurring corrosion centers of metal parts are mainly the result of negligence during the manufacturing stage. All mentioned above factors have an influence on exploitation durability of bridges. However, it seems that decisive are: occlusion, bruxism, and mechanical stresses.

### 2. MATERIALS AND METHODS OF INVESTIGATIONS

#### 2.1. Materials

Ten dental prosthetic bridges in after-operational state were used for research. These bridges were obtained from

the Department of Prosthodontics, Medical University of Białystok. Bridges exploitation history has been omitted because of general orientation of conducted research in range of forms and types of wear. Main emphasis in this work is general identification of the types of wear in exploited bridges removed from the mouth of patients.

## 2.2. Methods

Observations were carried out at macro and micro level. Macroobservations were made by the unaided eye and recorded by classic digital camera. Microobservations were performed using scanning electron microscope Hitachi S-3000N with an addition for chemical composition analysis from Thermo Noran-Quest (Fig. 1). Microscopic observations were used primarily for the appropriate surface selection for the chemical composition analysis.



Fig. 1. Scanning electron microscope Hitachi S-3000N

## 3. RESULTS

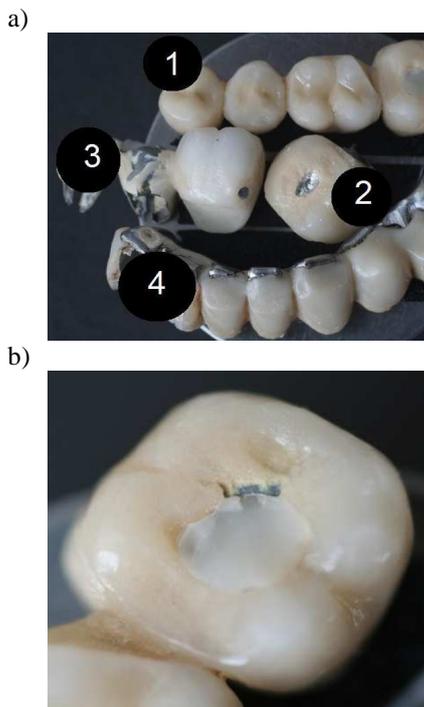


Fig. 2. Types of wear: 1,2 – abrasive, 3 – corrosive, 4 – microcracks; b) abrasive wear

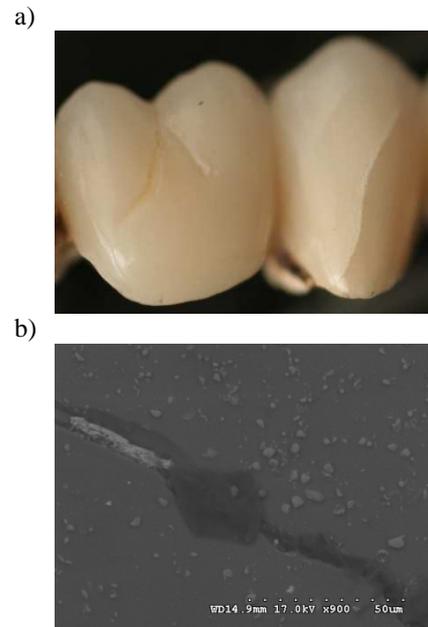


Fig. 3. Ceramic crack superstructure: a) macro- and b) microobservation (x900)

During the operational time dental bridges in patient's mouth are subjected to permanent loads. This follows directly from the process of chewing, crushing and chewing consumed foods. In addition, it comes to wear of dental prosthetics components due to mutual abrasion of these materials or their contact with the opposing teeth (Grosfeldowa, 1981). In Fig. 2 are presented examples of four dental bridges samples with distinct damage.

Both ceramic and acrylic veneers and metal parts are subject to abrasive wear. Fig. 2b shows selected macroobservation results of this kind of wear.

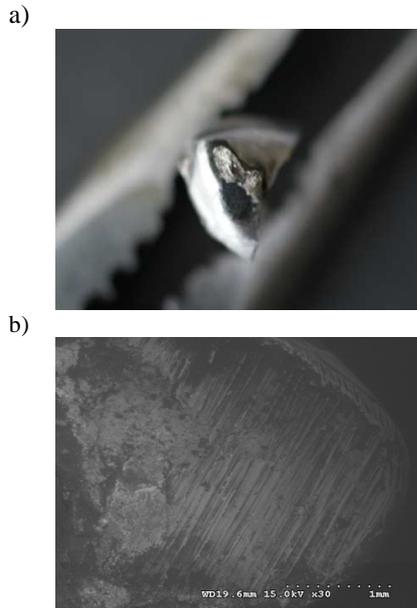
It is well known that the bridge in the oral cavity is exposed, among others on: normal and tangential loads, bending and stretching. These loads together with the moisture of the mouth lead to the initiation and spread of micro- and then macrocracks in the elements of dental prosthetics. In case of prolonged use metal - ceramic bridges, the gaps within the veneers propagate only to the basic metal. After reaching this point, they connect round both sides of the cracks. However, this does not lead to detachment of ceramics, which is closely bounded to the metal carrier.

Fig. 3 shows an example of a ceramic cracked superstructure.

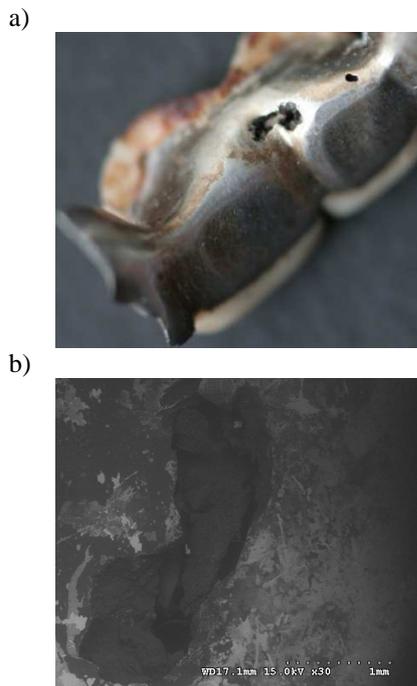
In relation to this form of wear, we can say that the size of range of gaps is dependent on plasticity - elastic material properties. It turns out that in materials, which are easy to form (metals), it is possible to retard and remove the gaps. On the other hand, in brittle materials - cracks propagate unhindered. It should be taken into account that microgaps and heterogeneity of the material are formed already at the firing process stage. They may be the result of, among others: the volume changes in ceramics during the firing, internal impurity and pores formation as a result of insufficient concentration of the material (Maślanka, 2000).

Both ceramics and metallic parts of dental bridges are failing by fatigue wear. Constructions between the bridge's constituents or tooth crown connection points with the bridge span seem to be especially vulnerable points. These places are more vulnerable to fatigue due to cyclic loading during the

process of chewing. The result of volume fatigue wear is the fatigue crack. A good example of such cracking is destroyed bridge, which is shown in Fig. 4. On crack we see partially smooth surface, which is the result of the gradual increasing of gap in metal. This type of surface is typical for fatigue cracks.



**Fig. 4.** Example of fatigue crack bridge span:  
a) macro- and b) microobservation (x30)

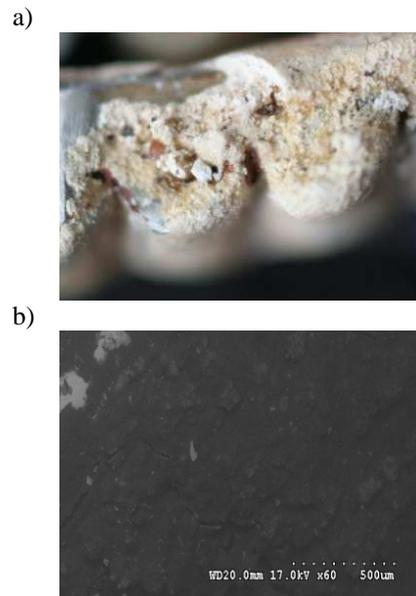


**Fig. 5.** Corrosive wear: a) macro- and b) microobservation (x30)

Inappropriate construction of bridges may be also the reason of bridges cracking. The elements most exposed to damage, as mentioned earlier, include connections of individual members. This possibly means that the connector in place of crack had too small cross section for transmitting applied load.

Another form of wear which could be seen in macroscopic observation is the corrosive wear. Corrosion is a common process in the group of nonfrictional causes of wear. Particularly vulnerable to corrosion are common metals and their alloys. Corrosive resistant are noble metals, such as gold or platinum and their alloys. In Fig. 5 we can see clear signs of corrosion and significant loss of material which is its consequence. Presence of corrosion could be the result of mistakes and negligences in the process of metal parts casting, poor material quality or the result of diet and oral hygiene.

In relation to oral hygiene and general care of the prosthesis, in Fig. 6 is showed example of dental bridge with a clearly visible layer of tooth scale. The reason of this dental bridge condition was inadequate oral hygiene. The bridge was removed from patient, because the tooth scale caused increased loss of tissue in the area of contact. This situation may leads to inflammation and a significant usage comfort reduction. The bridge structure is not without significance. It could have influence on tooth scale formation. It is possible that instead of saddle span, a self-cleaning span was used – it could eliminate retention area in which tooth scale deposition occurs. However, it is a individual matter of approach to the patient and the nature of his illness.



**Fig. 6.** Tooth scale in the lower part of dental bridges:  
a) macro- and b) microobservation (x60)

Another cause of tooth scale deposition on the bridge surface is the inaccuracy in the quality of its surface forming. A full of meaning is influence of micro- roughness of surface.

Tooth scale is present in 80 - 100% of patients cases among adults. These are highly mineralized deposits accumulated on the tooth surface. The chemical composition of tooth scale is as follows: mineral salts 83 (%), including 76 (%) of calcium phosphate, 4 (%) magnesium phosphate and 3 (%) of calcium carbonate. Such elements as: K, Na, Cu, S, Cl, Sn and Fe are in trace amounts (Grosfeldowa, 1981).

Tooth scale visible on the bridge shown in Fig. 6 was put under chemical composition analysis by the scanning electron microscope with an attachment to the study of chemical composition. Example results of such chemical microanalysis of tooth scale are shown in Fig. 7.

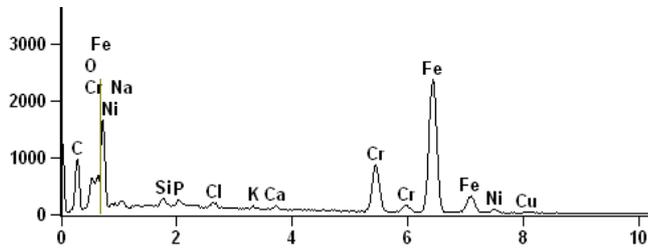


Fig. 7. Results of chemical microanalysis of tooth scale (Pietroczyk, 2008)

In Fig. 7 are shown results of the chemical composition, which indicate a presence of such elements as: Ca, P, Mg, C, F, Cl, Na. Thus, these results comply with the chemical composition of tooth scale visible on human enamel.

The next stage of research, the summarizing of the collected prosthetic bridges for the type of visible wear was evaluated. Fig. 8 shows the percentage fraction of identified damages in the inspected group of dental bridges.

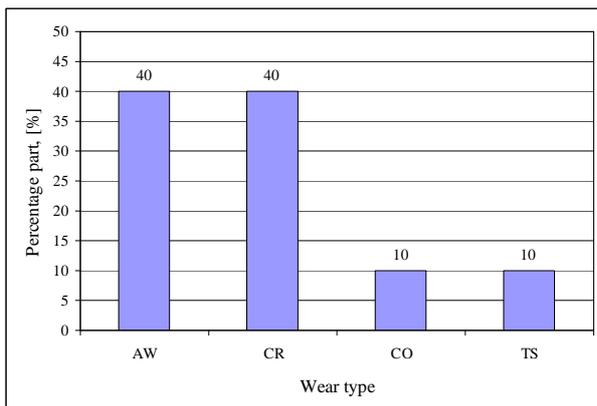


Fig. 8. Percentage damage fraction: AW – abrasive wear, CR – cracking, CO – corrosion, TS – tooth scale

The results of macro- and microscopic observations show that the largest participation in the examined group of dental prosthetic bridges have an abrasion wear and prosthetic bridge crackings caused by parameters of external forces in which bridges were used. In case of abrasive wear important is a friction combination, especially kind of materials which are in direct contact with each other. However, in the case of cracks significant are both, design, material and also a bridge production technology. Moreover, corrosive wear and presence of tooth scale are also very important.

#### 4. SUMMARY AND CONCLUSIONS

Macroscopic and microscopic observations and chemical composition analysis of tooth scale on their surface

(for the examined group of dental bridges), let to form the following general conclusions:

1. The most common types of wear are: fracture – 4 bridges and abrasion wear – 4 bridges. For 10 samples tested, one bridge has worn out due to corrosion, and there was one case of wear induced by accumulation of tooth scale.
2. Damage of all 10 bridges do not allow for their further exploitation. Actually, the only way to restore their functionality is to remake them, with paying particular attention to the causes of their primary wear.
3. After analyzing the causes of wear, depending on the type of damage in the manufacture of bridges, special attention should be focused on the following criteria: the construction of the bridge, material, manufacturing technology.
4. An important element is also properly occlusal surface design and fitting of the bridge at the oral cavity of opposite teeth in order to avoid wear due to inadequate occlusion.

Improper design, poorly selected material, wrong technology, improper fit of the bridge, wrong usage conditions and poor oral hygiene seem to be the most common causes of failure in healing with a prosthetic dental bridge.

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