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Tribological wear of some prosthetic materials in contact with dental ceramic (in vitro investigation)

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The present study aimed at a comparative evaluation of tribological wear of various combined prosthetic materials used in the restoration of occlusal surfaces of fixed partial dentures. The tribologic station ST-3 was used to examine the resistance to wear of 4 commonly used materials in contact with the surface of glazed and unglazed porcelain in two different environments. Moreover, the impact of these materials on the wear of porcelain was evaluated. The findings highlighted the importance of the total wear of two contacting surfaces.

Keywords: wear, resistance to wear of prosthetic materials

1. Introduction

The process of attrition affects occlusal surfaces in the oral cavity of every patient with natural or artificial dentition. This phenomenon ought to be taken into account by every dentist, who should spare no efforts to ensure that fixed and removable partial dentures placed in the oral cavity would constitute a harmonious whole with the remaining natural teeth and that by restoring the proper functioning of the stomatognathic system they would contribute to the prevention of diseases of masticatory organs. It has been proved that disturbances in occlusal surfaces may cause traumatic sites and in consequence may lead to parafunction, diseases of paradentium and the dysfunction of masseteric muscles and maxillary joints [1–3].

Prosthetic restorations should be subject to a similar process of wear as the patient's natural teeth in order to avoid occlusal traumas resulting from significant differences in the resistance to wear of occlusal surfaces of natural and artificial dentition.

Because of rising aesthetic requirements of patients, materials imitating natural teeth are most often used. The choice of particular restorative materials should be based on a thorough analysis of the factual state of the oral cavity and the knowledge of a given prosthetic material and its performance during masticatory functions [1, 4].

Earlier studies focused mainly on the wear evaluation of prosthetic materials in contact with natural teeth under various conditions [5–8].

This paper aimed at a comparative evaluation of tribological wear of various reconstructive prosthetic materials in contact with dental ceramic. Tribological activity is a mechanical activity on the surface of a solid body through contact and movement of an opposite body (tribology – from Greek *tribos* – friction, *logos* – science) [1, 4].

2. Material and methods

Four prosthetic materials displaying various physical and chemical properties were examined. They included: porcelain – IPS Classic (Ivoclar – Liechtenstein), heat-cured resin – Stellon (De Trey – England), heat- and pressure-cured resin – Chromasit (Ivoclar – Liechtenstein) and light-cured resin – Dentacolor (Kulzer – Germany). The specimens of these materials were formed into cylindrical samples, 5 mm in diameter and 20 mm in height, and were placed opposite the plates of glazed and unglazed porcelain (1.5 mm porcelain placed on Remanium CS metal plates 10×20 mm in size). Cylindrical material specimens were combined with plates of glazed and unglazed porcelain during a simulated masticatory process in 2 different environments (A – artificial saliva, B – artificial saliva and aluminium oxide with 100 granulation). The tests were conducted using a special device for wear examination, i.e. tribologic station ST-3 [1]. Prior to the examination, cylindrical samples underwent preliminary polishing in a humid environment in order to obtain an ideal initial contact of the two surfaces of samples. The test itself was accomplished during 20 000 cycles of simulated chewing with a pressure of 1 MPa and a 6-mm deflection amplitude.

The wear of particular specimens was determined by evaluating material weight loss of cylindrical specimens and plate specimens. Afterwards volumetric calculations were applied to evaluate the wear in mm^3.

3. Results

During the functional contact of the tested materials with the surface of glazed porcelain in the environment of artificial saliva (A) the lowest wear was found in the case of Dentacolor and porcelain. Both Chromasit and Stellon exhibited 2–3 times greater wear than the above mentioned materials. The change of environment brought about by adding Al_2O_3 resulted in 5 times higher wear of Stellon and Chromasit and over 10 times higher wear of Dentacolor. The influence of different environments on the wear of porcelain proved relatively insignificant (Table 1).

Abrasive wear of the tested materials in contact with unglazed porcelain in environment A turned out to be slightly greater. The change of environment to a more abrasive one (with an abrasive agent Al_2O_3) caused a similar increase in the wear of nonceramic materials like in the case of glazed porcelain.

Table 1. The wear of prosthetic materials (in mm^3) in contact with glazed porcelain and the wear of this porcelain in two different environments (A and B). C – cylindrical specimen, P – plate specimen

Material	Environment	
	A	B
Dentacolor	0.56 ± 0.08	6.67 ± 0.22
Porcelain	0.51 ± 0.05	0.35 ± 0.09
Dentacolor + Porcelain	1.07 ± 0.1	7.02 ± 0.24
Chromasit	1.79 ± 0.26	10.38 ± 3.13
Porcelain	0.98 ± 0.06	0.31 ± 0.19
Chromasit + Porcelain	2.77 ± 0.28	10.69 ± 2.95
Stellon	1.89 ± 0.58	10. 73 ± 1.95
Porcelain	0.14 ± 0.09	0.17 ± 0.08
Stellon + Porcelain	2.03 ± 0.59	10.9 ± 2.03
Porcelain (C)	0.99 ± 0.04	1.07 ± 0.31
Porcelain (P)	0.96 ± 0.11	1.19 ± 0.18
Porcelain + Porcelain	1.95 ± 0.12	2.26 ± 0.47

The influence of environment on the wear of porcelain in contact with glazed and unglazed porcelain was found to be of minor importance. Particularly noteworthy is the fact that two materials of different type, namely Chromasit and Stellon, demonstrated a similar wear in contact with glazed and unglazed surfaces of porcelain in both environments (Table 2).

Table 2. The wear of prosthetic materials (in mm^3) in contact with unglazed porcelain and the wear of this porcelain in two different environments (A and B)

Material	Environment	
	A	B
Dentacolor	1.53 ± 0.49	5.84 ± 0.22
Porcelain	0.07 ± 0.05	0.15 ± 0.05
Dentacolor + Porcelain	1.6 ± 0.45	5.99 ± 0.26
Chromasit	3.85 ± 0.67	10.67 ± 0.66
Porcelain	0.07 ± 0.05	0.09 ± 0.02
Chromasit + Porcelain	3.92 ± 0.11	10.76 ± 0.66
Stellon	2.08 ± 0.73	10.47 ± 0.56
Porcelain	0.07 ± 0.05	0.14 ± 0.09
Stellon + Porcelain	2.15 ± 0.72	10.61 ± 0.53
Porcelain (C)	0.82 ± 0.06	0.9 ± 0.05
Porcelain (P)	0.83 ± 0.03	0.94 ± 0.12
Porcelain + Porcelain	1.65 ± 0.04	1.84 ± 0.16

To sum up, it has to be emphasised that the total wear of two contacting surfaces does not essentially depend on the type of ceramic surface. However, it was observed that environmental factors and the type of nonceramic material influenced the wear in

a more significant way. Moreover, it has to be stressed that in spite of a substantial resistance to abrasive wear of porcelain, the total wear of 2 ceramic surfaces can be greater than that of a nonceramic material in contact with porcelain.

4. Discussion

Dahl et al. demonstrated that porcelain causes the greatest material loss in the opposing surface of natural teeth or dentures [5]. It was confirmed by the investigations conducted by Smalley and Nicholls, Ekfeldt and Oilo, Lappalainen et al. as well as by other studies [8–11]. Although Schwickerath's studies [12] are contradictory to those mentioned above, the impact of the type of a prepared porcelain surface (polished, glazed or unglazed) on the wear of opposing natural and artificial dentition constitutes a more frequent subject for discussion. Jagger and Harrison carried out in vitro investigations comparing the wear effects of glazed, unglazed and polished porcelain as well as its impact on the enamel of natural teeth [7]. These studies just like the tests conducted earlier by Koczorowski [1, 8] demonstrated that the impact of glazed and unglazed surface on the enamel is similar since the layer of glazing is removed from the porcelain surface in a short period of use of the denture and in the later stage of use the surface behaves like unglazed porcelain. It is worth underlining that porcelain which is very resistant to abrasive wear may cause a greater loss of material when in contact with a ceramic surface than a nonceramic material in contact with porcelain. It may seem to validate Rabinowicz's theory that given a different hardness of two contacting surfaces, the harder material gets covered with the soft material thus filling in pores and fissures, which leads to the reduction of friction and low surface wear (quoted from [6]). The author believes that by means of an adequate combination of opposing occlusal surfaces made from different restorative prosthetic materials one can adapt their total attrition to the attrition of the remaining contacting surfaces of natural teeth.

5. Conclusions

- The process of glazing of ceramic surfaces does not contribute significantly to the prevention of the wear of porcelain and opposing surfaces.
- Some nonceramic materials in contact with porcelain may demonstrate a lower total wear than the wear of two ceramic surfaces.
- Environmental factors (diet) have a significant influence on the wear of nonceramic occlusal surfaces, yet they have little influence on the wear of porcelain.
- Chromasit and Stellon, i.e. restorative materials of different types, can show a similar resistance to wear in contact with glazed and unglazed porcelain surface in different environments.
- Evaluating the total wear of contacting surfaces can have very useful clinical implications.

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