# THE ABRASIVE WEAR BEHAVIOR ANALYSIS OF THE ACRYLIC RESINS ARTIFICIAL TEETH

**Elena Raluca Baciu[1], Roxana Ionela Vasluianu[1], Nicoleta Ioanid[2*], Alice Murariu[1], Daniel Pavăl[1], Cătălina Cioloca Holban[1], Cosmin Ionuț Crețu[1], Dana Gabriela Budală [1]**

[1]„Grigore T. Popa" University of Medicine and Pharmacy, Faculay of Dental Medicine, Department of Implantology, Removable Dentures, Dental Technology

[*] Corresponding author; Roxana Vasluianu *e-mail:* roxana30200@yahoo.com
Nicoleta Ioanid *e-mail:* nicole_ioanid@yahoo.com

All authors have the same contribution as the first author

## ABSTRACT

Introduction: The mechanical properties of artificial teeth play an important role in the long-term functionality of removable partial prosthesis or complete dentures. Aim: To highlight the behavior of acrylic teeth according to the speed of mass wear rate. Materials and method: There were used the upper central incisors made industrially from methyl polymethacrylate from different manufacturers. The mass loss was calculated using an analytical balance, before and after each determination. Results: The use of 20 N and 30 N forces for acrylic teeth corresponding to commercial Acry Rock and Eray Deluxe products has similar values. Low values resulted in the case of commercial products Acry Plus (F = 20 N) and Quint Plus (F = 30 N). Conclusions: In addition to the composition of acrylic teeth, layering plays a key role in providing wear resistance.

**Key words:** *acrylic teeth, speed of mass wear, mass loss*

## INTRODUCTION

Abrasive wear is a phenomenon mainly due to masticatory movements, which occurs on both natural and artificial teeth. It is more pronounced on the acrylic teeth which are widely used for the removable prosthesis. [1] The degree of impairment of the occlusal surfaces depends on several parameters such as: the occlusal surface of the opposed teeth, the masticatory force, masticatory stereotype as well as the interarch relationships in frontal, sagittal and transverse planes.

The morphology of the occlusal surface is one of the indicators of the masticatory stereotype. [2-4] The depth of the occlusal grooves depends on it, the masticatory stereotype being a parameter that contributes to the increase or decrease of the wear rate of the artificial teeth. [5]

Currently, the artificial teeth, with polymeric structure, are manufactured by optimized processes concerning their quality by material composition, the layers of material, teeth matching and teeth polishing during the fabrication of the removable prosthesis. [6]

## PURPOSE

This paper aims to highlight abrasive wear behavior of artificial teeth made of acrylic resins based on mass wear rate.

## MATHERIALS AND METHOD

Several acrylic artificial teeth were used, sold by different manufacturing companies, present on the Romanian market. In order to analyze the behavior of abrasive wear in relation to the speed of mass wear rate, central incisors were used, made industrially from polymethylmethacrylate, by superimposing 2, 3, 4 and 5 layers (Table1). The experimental tests were performed with the support of the Department of Materials Engineering and Industrial Safety within the Faculty of

Materials Science and Engineering, Technical University "Gheorghe Asachi" Iasi.

***Table 1.*** *Selected commercial products*

| Commercial product | Manufacturer | Main features |
|---|---|---|
| **Acry Rock** | Ruthinium | 1. High aesthetic effect due to the two superimposed layers and the cut of the incisal edge.<br>2. High physical and chemical resistance achieved by using the best quality materials.<br>3. A wide variety of shapes and shades makes the tooth adaptable to all prosthetic requirements. |
| **Eray Deluxe** | Eraylar | 1. Acrylate in 3 layers.<br>2. Dentures with 6, 8 and 28 teeth.<br>3. Available in 34 shades.<br>4. 20 shapes available for the jaw, 6 shapes for the front mandibular area and 6 shapes for the back area. |
| **Acry Plus** | Ruthinium | 1. 4 layers.<br>2. High chemical and physical resistance achived by using PMMA cross-linked.<br>3. A wide variety of shapes and 19 color shades. |
| **Quint** | Vertex- Dental BV | 1. 1x6 frontal teeth group; upper or lower.<br>2. 5 layers, PMMA cross-linked.<br>3. Available colors: A1, A2, A3, A3.5, A4, B1, B2, B3, B4, C1, C2, C3, C4, D2, D3, D4<br>4. Basic shapes: triangular, square, round. |

The abrasive wear behaviour of the artificial teeth was studied under specific conditions, to a dry friction regime at the incisal surface of the samples. The mass loss was calculated by weighting the test pieces with an analytical balance, before and after each determination.

We used 3 different masses - 0.5 kg, 1 kg and 1.5 kg - so the pressing F had the value of 5, 10 and 15 N, respectively, and the amplified force F of 10, 20 and 30 N, respectively.

## RESULTS AND DISCUSSION

The first stage of the experimental tests was to determine the evolution of mass losses (Δm), corresponding to different values of the length of the friction path and the pressing force. The values of the masses obtained after each 3000 m of the length of the friction path are presented in Table 2.

***Table 2.*** *Mass losses for F = 10N, 20N and 30N*

| The length of the friction path Lf, [m] | Mass losses, Δm [g] for F = 10 N | | | | Mass losses, Δm [g] for F = 20 N | | | | Mass losses, Δm [g] for F = 30 N | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acry Rock | Eray Deluxe | Acry Plus | Quint | Acry Rock | Eray Deluxe | Acry Plus | Quint | Acry Rock | Eray Deluxe | Acry Plus | Quint |
| $L_0 = 0$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $L_1 = 3000$ | 0,0038 | 0,0036 | 0,0012 | 0,0015 | 0,0074 | 0,0087 | 0,0054 | 0,0061 | 0,0329 | 0,0301 | 0,0172 | 0,0208 |
| $L_2 = 6000$ | 0,0104 | 0,0086 | 0,0038 | 0,0043 | 0,0196 | 0,012 | 0,0081 | 0,0097 | 0,0478 | 0,0438 | 0,0246 | 0,0271 |
| $L_3 = 9000$ | 0,0127 | 0,0101 | 0,0066 | 0,0078 | 0,0245 | 0,0217 | 0,0134 | 0,0142 | 0,0618 | 0,0669 | 0,0394 | 0,0496 |
| $L_4 = 12000$ | 0,0182 | 0,0131 | 0,0093 | 0,0102 | 0,0417 | 0,0397 | 0,0238 | 0,0281 | 0,0826 | 0,0796 | 0,0589 | 0,0632 |

Knowing the values of the mass losses $\Delta_m$ we proceeded to the calculation of the mass wear rate, using the formula:

$V=\Delta_m / t$(g/h) where t represents the working time, t = 0,5 hours for Lf = 3000 m

The speed of mass wear rate (Table 3) shows increased values up to half of the friction interval in the case of the commercial product Eray Deluxe, these subsequently decreasing to values close to those registered by Quint. Acry Plus and Quint artificial teeth get the lowest wear rates. The commercial Acry Rock product records the highest value of the mass wear speed at F = 10N.

***Table 3.*** *Speed of mass wear rate for F = 10N, 20N and 30N*

| The lenght of the friction path Lf, [m] | Speed of mass wear rate for F = 10 N | | | | Speed of mass wear rate for F = 20 N | | | | Speed of mass wear rate for F = 30 N | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acry Rock | Eray Deluxe | Acry Plus | Quint | Acry Rock | Eray Deluxe | Acry Plus | Quint | Acry Rock | Eray Deluxe | Acry Plus | Quint |
| $L_0$ = 0 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| $L_1$ = 3000 | 0,0076 | 0,0072 | 0,0024 | 0,003 | 0,0148 | 0,0174 | 0,0108 | 0,0122 | 0,0658 | 0,0602 | 0,0658 | 0,0416 |
| $L_2$ = 6000 | 0,0104 | 0,0086 | 0,0038 | 0,0043 | 0,0196 | 0,012 | 0,0081 | 0,0097 | 0,0478 | 0,0438 | 0,0478 | 0,0271 |
| $L_3$ = 9000 | 0,0084 | 0,0067 | 0,0044 | 0,0052 | 0,0163 | 0,0144 | 0,0089 | 0,0094 | 0,0412 | 0,0446 | 0,0412 | 0,0330 |
| $L_4$ = 12000 | 0,0091 | 0,0065 | 0,0046 | 0,0051 | 0,0208 | 0,0198 | 0,0119 | 0,0140 | 0,0413 | 0,0398 | 0,0413 | 0,0316 |

When using 20 N and 30 N forces, Acry Rock and Eray Deluxe have similar values. The lowest values are obtained again by the commercial products Acry Plus (F = 20 N) and Quint Plus (F = 30 N). Superior wear resistance of these commercial products can be explained both by the chemical composition and by the incorporation of 4 or 5 layers of material, compared to classic products, such as Acry Rock (PMMA, 2 layers).

The research limitations are linked to material issues, meaning that the manufacturing process of artificial teeth can influence their quality.

Although the forces used are lower than the values indicated by the literature, we can consider them relevant because the masticatory force varies from individual to individual depending on sex, age, consistency of chewed food, masticatory stereotype and other parameters.

Saliva has individual components and a different lubricating effect with diverse consequences on slipping, thus influencing the results of the study. Therefore, it is essential that future research highlights the influence of factors such as slip and environmental conditions on the wear resistance of materials used to make artificial teeth.

The polymeric structure of the artificial teeth (incorporation of the inorganic filling) could improve the resistance of the artificial teeth to wear but it is possible that the percentage volume of inorganic load, the shape of the tooth and the material from which it is made contribute to increasing wear resistance [8].

Abrasive wear is an important feature of artificial teeth, an argument for which a removable denture should be changed. The contact force of artificial teeth is influenced by the impact speed and rigidity of the acrylic structure [9].

An important objective concerning the manufacturing of the artificial teeth is the design and the occlusal contacts that can contribute to the clinical performance. The preservation of the tissues that provide support for the removable dentures is also an important factor [10].

Susceptibility to fracture may be influenced by wear mechanisms, defects that may occur during manufacture or by the effects of corrosion. Research has shown that vertical wear of artificial teeth for removable prosthesis varies between 0.2 and 1.0 mm in the first two years of use [11-13]. All possible changes required to bring the mouth to an optimum state of health must be

identified with the remaining dentition properly aligned and positioned [14, 15].

**CONCLUSIONS**

Following the abrasive wear speed analysis on the acrylic tooth denture available on the Romanian market, we can conclude:

- different layering of acrylates has a defining impact;
- wear differences can be attributed to the composition of the materials, both the internal structure and the polymeric structure.

**REFERENCES**

1. Bosînceanu DG, Sandu IG, Baciu ER, Bosînceanu DN, Surlari Z, Martu I, Balcos C, Bolat M. Flexible acrlyate dentures versus chromium cobalt removable partial denture-a viable therapeutical solution. Materiale Plast.2019;56(1):120-123.
2. Yoshida K, Okane H, Nagasawa T, Tsuru H. A criterion for the selection of artificial posterior teeth. J Oral Rehabil 1988; 15:373–8.
3. Hanganu SC, Armencia AO, Murariu AM, Macovei G, Hanganu LC, Grigoras S, Bobu LI. In vitro Interaction Between Two Composite Restorative Materials and Artificial Saliva. Materiale Plastice 2014; 51(4): 388-390.
4. Yuki Hashimoto, Kyoko Sugimoto, Yuki Tanaka, Kazuhiro Oki, Shogo Minagi. A new occlusal surface design for artificial posterior teeth to achieve high masticatory performance. Journal of Prosthodontic Research 2017; 61: 193–201
5. Verena Preis, Sebastian Hahnel, Michael Behr, Martin Rosentritt. Contact wear of artificial denture teeth, Journal of Prosthodontic Research 2018; 62: 252–257.
6. Rues S, Huber G, Rammelsberg P, Stober T. Effect of impact velocity and specimen stiffness on contact forces in a weight-controlled chewing simulator. Dent Mater 2011; 27:1267–72.
7. Zeng J, Sato Y, Ohkubo C, Hosoi T. In vitro wear resistance of three types of composite resin denture teeth. J Prosthet Dent 2005;94:453–7.
8. Vasluianu RI, Ioanid N, Holban Cioloca C et al. Strategies of the treatment plan in order to increase the degree of adaptation of the removable denture. Romanian Journal of Oral Rehabilitation 2019; 11(4): 183-187
9. Ogle RE, Davis EL. Clinical wear study of three commercially available artificial tooth materials: thirty-six month results. J Prosthet Dent 1998; 79: 145-51.
10. De Gee AJ, Pallav P. Occlusal wear simulation with the ACTA wear machine. J Dent 1994; 22: S21-7.
11. Heintze SD. How to qualify and validate wear simulation devices and methods. Dent Mater 2006; 22: 712-34.
12. Bulancea B, Vasluianu RI, Tatarciuc M et al. Oral rehabilitation methods through the combination different prosthetic techniques. Romanian Journal of Oral Rehabilitation 2019; 11(2): 266-273.
13. Diaconu D, Vitalariu A, Tatarciuc M, Murariu A. The economic crisis effects on the cross contamination control in dental laboratories. Revista de cercetare și intervenție socială. 2014; 47:105-116.
14. Bolat M., Bosînceanu D.N., Baciu E.R., Forna Agop D., Bosînceanu D.G., Forna N.C.Partial dentures-success and failures. Romanian Journal of Oral Rehabilitation 2017; 9(4): 93-96.
15. Caras C., Agop D., Forna N.C. Biomechanical aspects of impressions in partially edentulous. Romanian Journal of Oral Rehabilitation 2017; 9(2): 89-93.