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Tensile Bond Strength between a Maxillofacial Silicone Elastomer and Biocompatible High Performance Polymer (BioHPP)

Rima Atair[1], Stoyan Yankov[2], Elena Vasileva[3], Yanko Zhekov[4], Zhivko Georgiev[5], Svetlin Aleksandrov[6]

[1]Department of Prosthodontics, Faculty of Dental Medicine, Medical University, 15A Vasil Aprilov, Plovdiv 4000, Bulgaria
[1]atair.rima[at]gmail.com
[2]yankov.dent[at]gmail.com
[3]ellikvass[at]gmail.com
[4]qnko1207[at]gmail.com
[5]jivko_169[at]abv.bg
[6]selades[at]abv.bg

Abstract: ***Aim: to test and evaluate the possible bond between BioHPP and one silicone elastomer for maxillofacial rehabilitation after using different types of retention. A total number of 120 test samples were made of BioHPP and the silicone elastomer. Both materials were bonded to each other with the help of different mechanical retentions and chemical agents. The ready test samples were used for two different tests/studies. Test 1 – a comparison of the bond strength between three adhesives: visio.lign, Mollosil adhesive and Universal Tray Adhesive. Test 2 – a comparison between three different types of bonding: mechanical retention, chemical adhesive and combined (mechanical and chemical). Results: from Test 1 – Mollosil has the highest mean values and from Test 2 – the combined type of retention has the highest mean values. Conclusion: BioHPP can be successfully bonded to maxillofacial silicone elastomer using adhesive containing Ethyl acetate and mechanical retention.***

Keywords: BioHPP, substructure, epithelial silicones, tensile bond strength

1. Introduction

Maxillofacial prostheses play an important role in both physical and psychological rehabilitation of mutilated patients. [1 – 4] With the help of silicone elastomers, missing parts of the face can be replaced successfully. Reintegration of patients with maxillofacial defects into society depends on the therapeutic effectiveness of the treatment. [5, 6] Often limitations occur during treatment due to the imperfect materials used for this type of restoration and affect the patient's capacity to accept the final result. There are number of issues associated with the use of denture liners bonded to the substructure, such as: bond failure between the liner and denture base, porosity and loss of softness of the liner, poor strength of the base material, the weight of the metal framework, Candida albicans colonization. [7 – 10] Debonding between the base and the liner is a common topic in the existing studies of the maxillofacial dentures in the literature. [11, 12, 13]

Different materials have been used as a substructure so far but none of them proved to be ideal. New materials are being introduced on a daily basis, such material is the polyether ether ketone (PEEK). [14 – 17] Biocompatible High-Performance Polymer (BioHPP) is a modification of PEEK that has been optimized for dental purposes. [18] Due its mechanical and physical properties PEEK can be used as a possible replacement of some dental materials. [19 – 21]

2. Aim

To test and evaluate the possible bond between BioHPP and one silicone elastomer for maxillofacial rehabilitation after using different types of retention.

3. Materials and Methods

A total number of 120 test samples, 8mm in diameter and 30mm in length were made of BioHPP (Bredent GmbH & Co. KG, Germany) and the silicone elastomer (Multisil-Epithetik, Bredent GmbH & Co. KG, Germany) in the form of "hourglass". Both materials were bonded to each other with the help of mechanical retentions and chemical agents. It was designed a special flask, served as a matrix, where the test sample copings were made from wax. (Fig. 1) The wax patterns were invested and cast from BioHPP. (Fig. 2) The contact surface of 40 of the test samples from BioHPP had a n-shaped mechanical retention and the rest of 80 specimens had a flat contact surface. (Fig. 3) The ready test samples were used for two different tests.

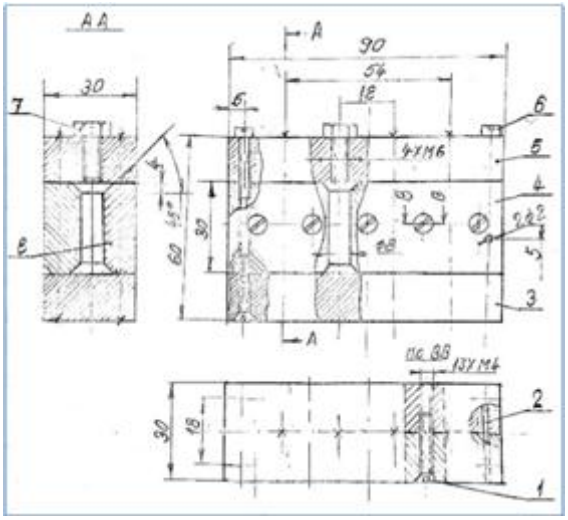

Figure 1: A schematic diagram of the matrix unit.

Figure 2: Wax patterns of the test samples of BioHPP.

Figure 3: Test samples made of BioHPP

Test 1 – a comparison of the bond strength between three adhesives: visio.lignBredent GmbH & Co. KG, Germany, Mollosil adhesive, DETAX GmbH & Co. KG, Germany and Universal Tray Adhesive, Zhermack, Italy. For the purpose 40 test samples of BioHPP with flat contact surface were divided into 4 groups (n=10). Group 0 – control group, no adhesive, Group V – visio.lign applied on the contact surface, Group M – Mollosil applied on the contact surface, Group X – Universal Tray Adhesive applied on the contact surface with the silicone.

The bond strength was tested on pulling (speed 20mm/s) with testing machine (model LMT 100, LAM Technologies, Italy). Specially designed grips (Fig. 4, 5) were used to attach and pull the test samples from both opposite sides. Before testing all the test samples were subjected to thermocycling for 360 hours with the artificial aging unit (model LTC 100, LAM Technologies, Italy).

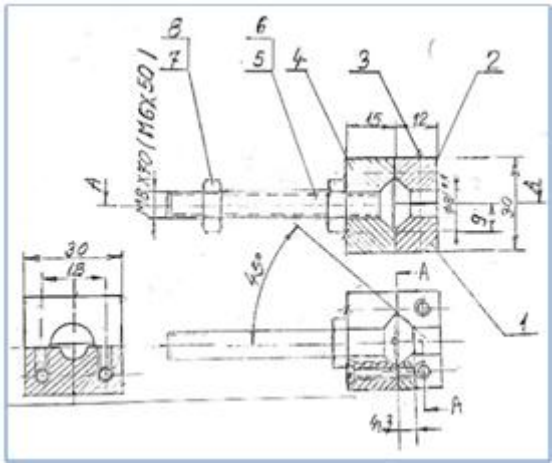

Figure 4: A schematic diagram of the grips.

Figure 5: The gripsmounted on the testing machine

Test 2 – a comparison between three different types of bonding: mechanical retention, chemical adhesive and combined (mechanical and chemical). For the purpose 80 test samples were divided into 4 groups (n=20).Control group – 0, no mechanical retention or surface treatment with chemical agents, group R – contact surface with mechanical (n-shaped) retentions, group M – contact surface treated with the Mollosil adhesive and group RM – contact surface treated with Mollosil and with mechanical (n-shaped) retention. All the test samples were subjected to thermocycling in artificial aging unit (model LTC 100, LAM Technologies, Italy) before testing the tensile bond strength with testing machine (model LMT 100, LAM Technologies, Italy).

The statistical analysis was done with statistical software pack (IBM SPSS Statistics v.25). For each bond test Student's *t*-test was used for comparison of the mean values. The *p*-value was used to analyze the significant statistical difference.

4. Results

Test 1 - statistical results for tensile bond strength measurements [N/mm2] of all 4 groups are summarized in Diagram 1. The values of the three groups with adhesive applied were compared with the control group (Table 1). Only group V showed no statistically significant difference

and did not increased the bond strength (p>0,05). From the comparison between groups V and M it is evident that group M has a statistically significant difference (p<0,05).

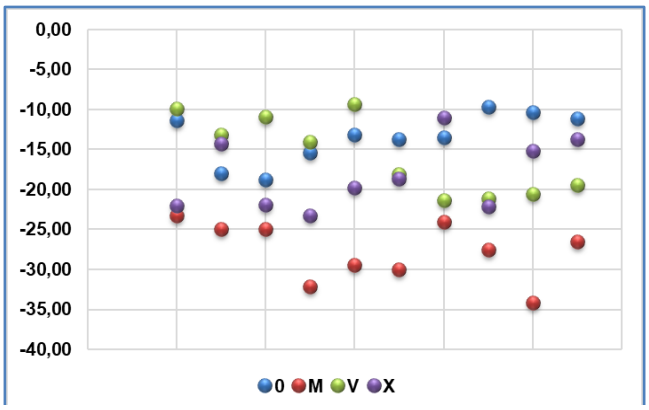

Diagram 1: Tensile bond strengths values of all four groups from Test 1

Table 1: Tensile bond strengths in each group of specimens from Test 1 presented as means, standard deviations and standard error means

Group	N	Mean	Std. Deviation	Std. Error Mean
0	10	-13,51	3,11	0,98
M	10	-27,71	3,62	1,15
V	10	-15,7800	4,85725	1,53600
X	10	-18,2000	4,32640	1,36813

Test 2 - statistical results are summarized in Diagram 2. Each of the following groups: R, M and RM were compared with the control group and showed statistical difference (p<0,05), meaning that they exhibit increased bond strength (Table 2). In order to be specified which of the three methods for retention has higher values, groups R, M and RM were compared to one another. Between group R and M, group R showed higher values (p<0,05). Between groups R and RM, group RM has the highest mean values.

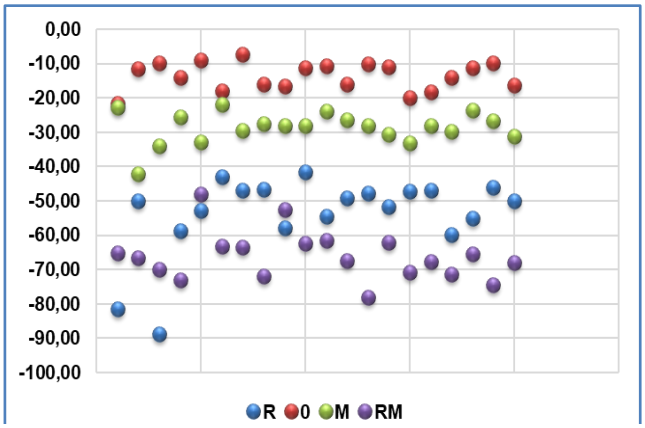

Diagram 2: Tensile bond strengths values of all four groups from Test 2.

Table 2: Tensile bond strengths in each group of specimens from Test 2 presentedas means, standard deviations and standard error means

Group	N	Mean	Std. Deviation	Std. Error Mean
R	20	-53,8050	11,83885	2,64725
0	20	-13,6250	4,05292	0,90626
M	20	-28,7250	4,65017	1,03981
RM	20	66,1650	7,06081	1,57884

5. Discussion

This study demonstrates the bonding properties of PEEK to maxillofacial silicone elastomer, modified with different adhesives applied and mechanical retention. The tensile bond strength was tested on pulling to ensures the stress distribution at the area of adhesive interface. [22, 23]

The bonding between a base material and a maxillofacial elastomer has been tested using different types of bond tests, such as shear bond strength, peel bond strength, and tensile bond strength. The variety of testing methods used in different studies makes direct comparison between the obtained results difficult. [24 – 27]

Within the limitations of the study, Test 1 results support rejection of the null hypothesis, showing that Mollosil adhesive exhibits the strongest bond with the elastomer. For the obvious reason Mollosil was chosen over the other chemical agents – Visio.lign and Universal Tray Adhesive.

Other studies testing the effect of the adhesive on the bond strength between the base and the relining material showed similar results to ours. [28 – 33] Even when using metal as a framework, the bond strength depends on the nature of the bonding agent. [34] This study proves that the right choice of mechanical retention and chemical adhesive can result in improved bond strength between the base and the relining materials. The decision of using BioHPP as a substructure material was based on its properties (rigidity, strength, elastic modulus, lightweight and application to different clinical situations). [16, 18]

Test 2 – the results obtained support the acceptance of H_1 hypothesis, there is statistically significant difference by the choice of retention type. The combined type retention (n-shaped mechanical retentions with applied chemical adhesive) proved to have the strongest bond strength. This is clearly shown by the presence of cohesive failures after the artificial aging. (Fig. 6).

6. Conclusion

A modified PEEK (BioHPP) substructure can be successfully bonded to maxillofacial silicone elastomer using adhesive containing ethyl acetate. The bond strength can be improved by adding mechanical retention. The results of this study support the idea of fabrication of a maxillofacial prosthesis, using BioHPP as a base combined with a maxillofacial elastomer.

7. Acknowledgments

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Author Profile

Dr Rima Atair, received his MSc Degree from Medical University - Plovdiv, Faculty of Dental Medicine in 2017.From 2018she is an assistant-professorin theDepartment of Prosthodontics, Faculty of Dental Medicine, Medical University, Plovdiv, Bulgaria. She is an active member of the: Bulgarian Dental Union (BDU), Bulgarian Academy of Aesthetic Dentistry (BAED). She speaks French, English and Arab fluently. Faculty of Dental Medicine, Medical University, Plovdiv, Bulgaria. 3 HristoBotevblvd., Plovdiv, Bulgaria