Elasticity examination of denture materials used for prosthesis relining

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Abstract

Relevance of the problem and aim of the work

The aim of our work was to determine whether the thickness of the soft prosthesis reliner has an impact to its the elasticity. It is very important to know this property in order to use the following materials for each clinical situation individually.

Material and the methods

Investigation was done for 3 materials (VOCO UFI Gel SC, UFI Gel P and Zhermac Clinical Elite Soft Relining). There were 3 groups for each material tested: 1 mm, 2 mm or 3 mm thickness of the soft relining material. The analysis was done by using a tension evaluating machine (Tinius Olsen H25KT) in Kaunas Technology University. This gave us the result of the materials rupture distance. In statistical analysis the selected significance level was p=0.05. The calculations were carried out using IBM SPSS Statistics 23.0 application program.

Results

The most elastic materials were UFI Gel SC and UFI Gel P. Both of them got the same rupture distance (at 3 mm thickness) of 7,0 mm (SD=1,3 n=5; p<0.05) and 7,0 mm (SD=1,4 n=5; p<0.05). Zhermac Clinical Elite Soft Relining elasticity was the highest when the material was used at 3 mm thickness: 1.9 mm (SD=1.3; n=5; p<0.05).

Conclusions

If our clinical situation requires more elasticity, we should use materials with the highest rupture distance available - both UFI Gel SC and UFI Gel P.

Keywords: Prosthetic dentistry, Soft Materials, Relining, Elasticity, Removable Dentures.

1. INTRODUCTION

Use of dentures in orthopaedic dentistry has been known for long. Back in 1728, Frenchman Pierre Fauchard is considered to be the father of modern dentistry, who described the very first dentures in his writings. The latter were made of a metal base with springs and animals' teeth mounted [1].

Since then, the dentistry has started developing very rapidly. New, base acrylic materials were manufactured, dentures made of which not only have chewing ability but even restore the lost aesthetics of the face. Once these two problems are eliminated, a new challenge is faced in practice – denture must be comfortable and durable. Dealing with this challenge, soft denture relining materials have been recently used. But their application is not very widely spread because of their several negative properties: they tend to grow harder with time because of wearing-off of the plasticiser contained [2, 3], and viscoelasticity observed in these materials, which has adverse impact on their durability [4]. But if distinctive symptoms of alveolar atrophy, patient's teeth grinding (bruxism), sharp alveolar edges, non-elastic mucosal tissues are observed, in the course of implantation procedures and in order to reduce the pressure on mucosa – these materials are in particular suitable for use because of their softness [5, 6, 7, 8].

For the latter reasons, we carried out researches in order to determine properties of different soft relining materials of dentures, to compare them and to give recommendations on their use in dental practice. This work is focused on elasticity. It will give a possibility to make a better choice of materials to be used and to ensure higher quality of treatment, greater comfort for the patient and durability of a denture.

2. MATERIAL AND METHODS

The object of our research was soft denture relining materials elasticity examination. We used Elite Soft Relining material manufactured by Zhermack SpA Clinical Industry (Italy), UFI Gel SC and UFI GEL P by German manufacturer The Dentalists GmbH.

Every material was marked in different colours. Zhermack Elite Soft Relining was coloured red, VOCO Ufi Gel SC was coloured blue, VOCO Ufi Gel P was coloured green.

2.1 Course of the test

Completely identical samples were produced (Picture 1). We established the necessary distance between the samples, at 1 mm, 2 mm or 3 mm. By following the instructions of each manufacturer of the material, we applied the adhesive on the surface of the circular parts, to which our tested material will be attached. Then: a) if the material mixed by a mixer is used, we injected the sufficient quantity of the material to achieve the required thickness of the layer between the samples; we injected the material on the both circular parts of the samples, b) if manually mixed material is used, we mix it following the manufacturer's instructions and apply it on the both circular parts of the.

After the samples were produced (Picture 2), together with Kaunas University of Technology, with the help of PhD Aurelijus Domeika, Head of the Biomechatronics laboratory, in which, we examined the elasticity of the material. We conducted it by using the material testing device Tinius Olsen H25KT (Picture 3). The key parameters of the device: distance between the columns 405 mm; measuring speed from 0.001 to 1000 mm/min, force at the maximum speed 25 kN. It is intended for stretching, crushing testing. Different grippers are used for testing soft and solid materials.

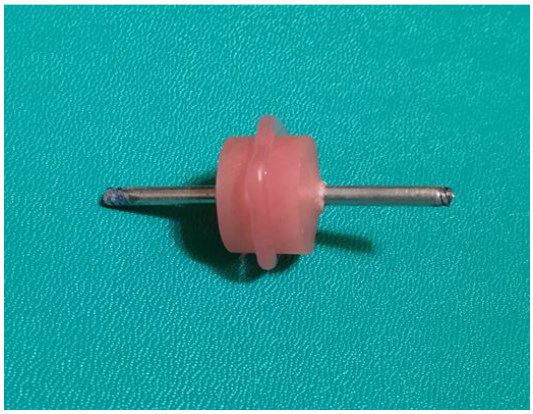
In our case we used grippers that can clamp our samples on their metal part and pull them to different directions. Our made sample is placed between two grippers (Picture 4). Having started measurements, the upper gripper is pulling the upper part of the sample upwards to measure stretching distance, holding and elastic properties of the material attached between the methyl-methacrylate circular

parts. The test is complete once the material loses 50% of its hold force. In this case the material is considered to have lost its hold and is torn.

It is shown in the graphs drawn by Horizon program. During testing of each sample, a graph is drawn. With the data obtained, we can continue with further statistical analysis of the properties of our tested materials.

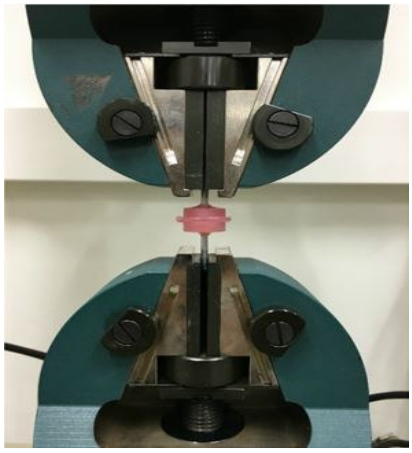
Picture 1. Identical samples.

Picture 2. Produced sample.



Picture 3. Tinius Olsen H25KT.

Picture 4. Sample caught with clamps.



2.2 Statistical analysis

The different materials (Blue - VOCO UFI GEL SC, Green - VOCO UFI GEL P, Red - Zhermack Elite soft Relining) and different thickness of the materials (1 mm, 2 mm, 3 mm respectively) were used in the study. The statistical descriptions, i.e. their means and standard deviations, are presented for all data. We used Kruskal-Wallis rank criterion and Mann-Whitney-Wilcoxon criterion. The selected significance level was $p<0.05$. The calculations were carried out using IBM SPSS Statistics 23 application program.

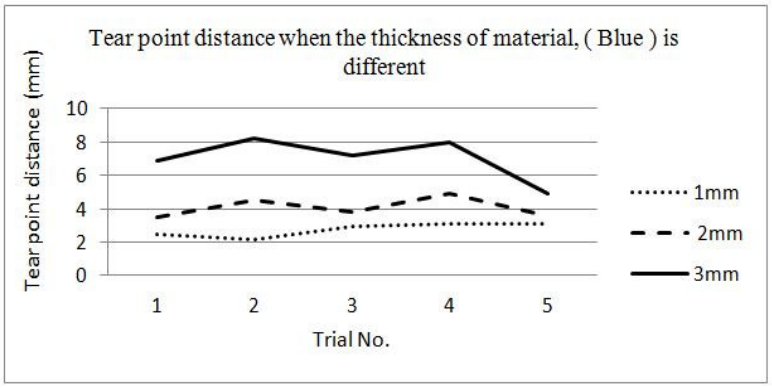
3. RESULTS

Results obtained from the analysis of the materials used in our research show what maximal strain distance is sustained until the tear from the base by the materials researched. In other words, we investigated the magnitude which shows the elasticity of the material. The results are obtained in millimetres (mm). The results are presented in diagrams:

1. Blue colour-coded material - VOCO UFI GEL SC (Diagram 1).

The results obtained show that the material has sustained the longest strain when its thickness was 3 mm. The average sustained strain distance: 7.0 mm (SD=1,3; n=5; $p<0.05$). Accordingly, the shorter strain distance has been sustained by material of 2 mm thickness - the average strain distance: 4.0 mm (SD=0.6; n=5; $p<0.05$), and the shortest strain distance has been sustained by material of 1 mm thickness. The average strain distance: 2.8 mm (SD=0.4; n=5; $p<0.05$).

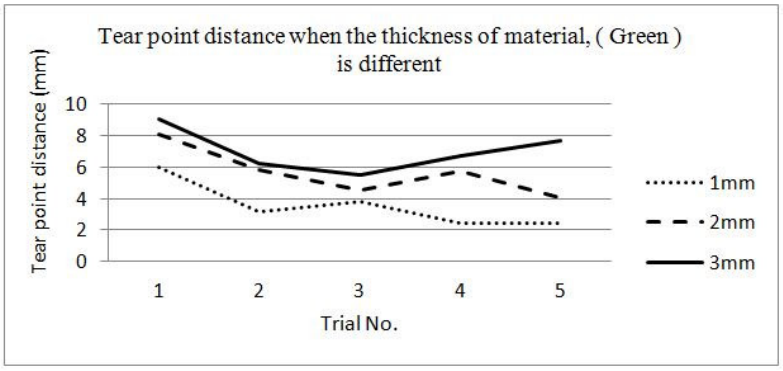
Diagram 1 - Blue coded material.



2. Green colour-coded material - VOCO UFI GEL P (Diagram 2).

The results obtained show that the material has sustained the longest strain when its thickness was 3 mm. The average sustained strain distance 7.0 mm (SD=1.4; n=5; p<0.05). Accordingly, the shorter strain distance has been sustained by material of 2 mm thickness - the average strain distance: 5.6 mm (SD=l.6; n=5; p<0.05), and the shortest strain distance has been sustained by material of 1 mm thickness. The average strain distance: 3.6 mm (SD=1.5; n=5; p<0.05).

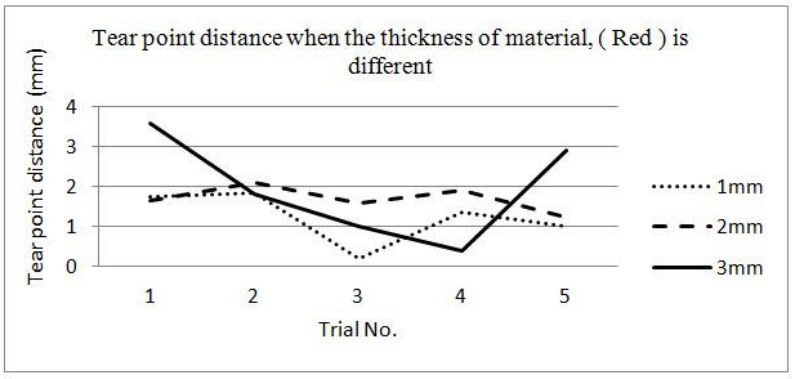
Diagram 2 - Green coded material.



3. Red colour-coded material - Zhermack Elite soft Relining (Diagram 3).

The results obtained show that the material has sustained the longest strain when its thickness was 3 mm. The average sustained strain distance: 1.9 mm (SD=1.3; n=5; p<0.05). Accordingly, the shorter strain distance has been sustained by material of 2 mm thickness - the average strain distance: 1.7 mm (SD=0.3; n=5; p<0.05), and the shortest strain distance has been sustained by material of 1 mm thickness. The average strain distance: 1.2 mm (SD=0.7; n=5; p<0.05).

Diagram 3 - Red coded material.



4. DISCUSSION

When examining fracture distances, we noticed that UFI Gel SC and UFI Gel P by VOCO manufacturers are much more elastic (the average fracture distances were 7.0 mm (SD =1.3, n=5) and 7.0 mm (SD=1.4 n=5, respectively) than Zhermack Elite soft Relining material (average fracture distance 1.9 mm (SD=1.3 n=5)). We can make a hypothesis that it is determined by the components of the material but we cannot check it. Composition of every material is kept confidential and not published by their

manufacturers. But based on the fracture distance findings, we can state that soft relining materials with bigger fracture distances are much more elastic. While such materials, according to the researchers conducted by scientists S. Kimoto, K. So and others [11], improve patients chewing ability. Therefore, in the course of our research, we differentiated the materials used by securing a possibility to choose the most suitable relining material in each clinical case. During our research, materials were adhered to the even-based circles. Therefore, we do not know how the tensile strength of the material would change once it was bonded to a modified surface. Such researches were carried out by scientists P. Gibbons [9] and R. Storer [12], which proved the increase in the bonding strength of a material once the surface is modified by making it coarser or by sandblasting. Nevertheless, the researches were conducted quite a while ago, therefore these properties should be tested once again.

It should be noted that we do not know the exact impact of temperatures and humidity on these properties of the materials. Scientists K. Saber-Sheikh and others [10] established that different temperatures affect tensile strength of the materials, but we have not proved it. It requires further tests and analysis.

5. CONCLUSIONS

Zhermack Clinical "Elite Soft Relining", VOCO "UFI Gel SC" and VOCO "UFI Gel P" were assessed and compared when researching their elasticity based on the measurements of the crack distance from the base. The results obtained showed that VOCO "UFl Gel SC" and VOCO "UFl Gel P" were characterized by the longest distances. The average distance of the crack from the base of the latter were 7.0 mm (SD=1.3; n=5; $p<0.05$) for UFI Gel SC and 7.0 mm (SD=1.4; n=5; $p<0.05$) for UFI Gel P. These magnitudes were reached when the material thickness was 3 mm. The material Zhermack Clinical Elite Soft Relining tested showed significantly lower average distance of the crack from the base: 1.9 mm (SD=1.3; n=5; $p<0.05$) when the material thickness was 3 mm. The results obtained showed that the materials UFI Gel SC and UFI Gel P were 3 times more elastic than Elite Soft Relining.

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