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ZIRCONIUM DIOXIDE – STATIC TEST ON GLUED CONNECTIONS

M. Wirwicki*, T. Topoliński**

Abstract: *The popularity of zirconium dioxide has increased among dentists and dental technicians in the recent years. Due to its chemical content and mechanical properties, it may successfully replace non-aesthetic substructures or metal crowns. The article presents the geometry with the dimension of zirconium dioxide bars. Two of the most popular glues on the dental care market are presented, as well as a diagram of the tested joint. The results acquired are quite scattered, which may have resulted from, among other things, the amount of flash, the method of surface preparation or the thickness of the glue joint. Photographs of samples with small and large amounts of flash were presented and compared with the resistance of the glued joints.*

Keywords: Zirconium dioxide, Static stretching tests, Glue, Dentistry.

1. Introduction

Zirconium dioxide is a ceramic material which has been gaining the attention of dentists since the 90th. This is thanks to the fact that its processing is very simple with the use of CAD/CAM systems and 3D scanners which allow to create a digital reproduction of the patient's cavities. The method involves processing in soft, pre-sintered material, and then full sintering – curing the material in 1400°C for 8 hours. The crown is then covered with artificial glaze – a ceramic material that imitates the colour of the patient's teeth. There are 3 types of dental crowns: ones with metal, galvanic-ceramic or fully ceramic substructure. In order to place a dental crown in a patient's mouth, a dentist must first prepare the natural tooth - grind the crown. After processing the tooth, the zirconium crown is glued to the tooth. There are two types of dental glues - cements: adhesive and self-adhesive. They difference is in the gluing and preparation procedures: in the adhesive type, all ingredients of the glue have to be applied separately, which gives the dentist higher control over the glue joint. In the self-adhesive type, two ingredients are mixed using a special pad, and then, after mixing, the dentist can proceed to the gluing stage.

The purpose of this work is to analyse static stretching test results of the glue joint between zirconium and stainless steel, for the proposed geometry of samples, in a comparison to the two most frequently used glues on the market.

2. Material and Method

3M's Cyrkon Lava material, intended for the creation of crowns and bridges in CAD/CAM technology, was used for the test. The material supplied by the manufacturer was cut with a Buehler ISOMET 5000 [POLAND] saw into smaller blocks of 25 mm x 16 mm x 1.87 mm. The elements were then laser cut using an Alfalas WS [POLAND] device, with laser settings preventing the overheating of zirconium. Such cutting provided 8 1,87mm x 1,87mm x 10mm samples. The samples were then sent to a laboratory certified by the manufacturer, where sintering took place. The process involved 8-hour treatment in a special furnace in 1400°C. During that time, technological shrinkage of the whole crown took place, amounting to about 20% of its volume. After the treatment, the material was show-white and exhibited a significant improvement in terms of mechanical properties. Fig. 1 below presents the geometry of the

* M.Sc. Eng. Mateusz Wirwicki: Institute of Mechanics and Machine Design, University of Technology and Life Sciences, Ks. Kordeckiego 20; 85-225, Bydgoszcz; Poland, wirwicki@utp.edu.pl

** Prof. Tomasz Topoliński: Institute of Mechanics and Machinery Construction, University of Technology and Life Sciences, Ks. Kordeckiego 20; 85-225, Bydgoszcz; Poalnd, topol@utp.edu.pl

tested samples after sintering. The dimensions of the samples after treatment were 1.5 mm x 1.5 mm x 8 mm.

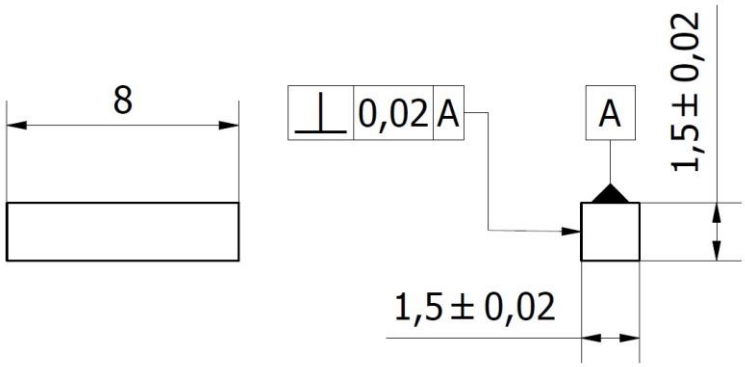

Fig. 1: Geometry with the dimensions of the zirconium dioxide bars.

3. Static Test for Resistance to Extension

The tested material was 3M ESPE's Cyrkon Lava, which is used in dental clinics to make single crowns, 3 and 4-point bridges or implant joints. This type of zirconium oxide features high resistance as well as perfect and natural look. The material is transparent and biocompatible. Its structure is metal-free. In recent years, dental ceramic materials have developed significantly in terms of mechanical properties. Glued joints play an important role in the treatment of a patient's mouth. Therefore, the selection of an appropriate glue for a given clinical case is of utmost importance. There are many types of cements on the dental care market, however their product description is usually insufficient. In order to select a correct adhesive it is thus particularly vital to learn the mechanical properties of the given joint.

The static stretching test was conducted using an Instron 8874 instrument with a tension meter with the range of ±5 kN. The speed of relocation of the upper arm (machine actuator) was 0.5 mm/min. The 30 test samples were made in the form of cuboid 1.5 mm x 1.5 mm x 8 mm bars, as described earlier, and were glued to stainless steel with the 3M ESPE RelyX U200 Automix glue and the Kerr Maxcem Elite glue. The glues were selected with the aid of dentists and are the most popular products of this type used by dental clinics.

Fig. 2 below presents the diagram of gluing samples, with the joint area marked.

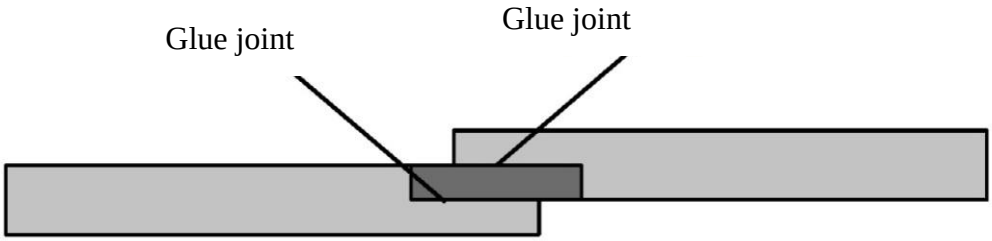

Fig. 2: Test sample diagram.

For the aforementioned glues, the gluing process (curing of the glue between two surfaces) requires a UV lamp. The joint was cured with a Satelec Mini Led Black UV lamp with the following parameters: power – 1250 mW/cm^2, wavelength 420 – 480 nm, exposure time 10 sec.

4. Results and Summary

The purpose of the study was to conduct a static resistance test of the glue joint. The samples were divided into two groups, 15 pcs for each of the two glue types: 3M ESPE RelyX U200 Automix and Kerr Maxcem Elite. Before the test, each of the samples was checked with a stereoscopic microscope in order to determine whether the joint was satisfactory. Test results for the 3M ESPE RelyX U 200 Automix

cement are presented in Tab. 1, and for Kerr Maxcem Elite - in Tab. 2. Average force values are 63.5 N for RelyX and 65.8 N for Maxcem, average tension values were approx. 7 MPa for both materials. The high scatter of the results (16% and 14%) may have resulted from various factors influencing the resistance of the glued joints.

Tab. 1: Test results for joint glued with3M ESPE RelyX U200.

Average force value	*Average tension value*	*Standard deviation*	*Relative standard deviation*
63.5 N	*7 MPa*	*10*	*16%*

Tab. 2: Test results for joint glued with Kerr Maxcem Elite.

Average force value	*Average tension value*	*Standard deviation*	*Relative standard deviation*
65.8	*7 MPa*	*7*	*14%*

One of the main components of the glued joint resistance is the size of flash. The effect is related to the amount of glue outflow to the edges of the joint, which increases the joint surface. Another factor is the method of surface preparation. The glued surfaces must be clean, degreased and oxide-free. Fig. 3a presents images of tested samples with small flash, for which stretching resistance was decreased; Fig. 3b with large flash, where the resistance was much higher.


a)


b)

Fig. 3: Photographs of the tested samples a) with small flash and b) with large flash.

The analysis conducted did not fully determine the final resistance of glue joints. It is important to select suitable glue thickness for the given joint, and the gluing process should be performed in appropriate conditions. The large number of parameters related to quality and resistance means that for a joint with specific geometric and material features a suitable joining technique must be applied. In future studies, the authors intend to perform static tests for glued joints with flash removed.

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