VISUALIZING STRAIN IN EXPERIMENTAL MODEL COMPOSED OF ALL CERAMIC AND COMPOSITE CEMENT

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Abstract The aim of this study was to visualize and analyze strain in a model composed of all ceramics and composite cement. A sample was composed of two blocks of Vita Enamic all-ceramic and composite cement applied between contact surfaces of the blocks. Actually, two all-ceramic blocks were bonded into a single unit using MaxCem Elite as composite cement. Experimental model was tested on a H10K-S UTM Tensile testing machine and the Digital Image Correlation Method served to determine strain. The highest strain value measured in Epsilon Y was 0.30 % which is presented by red color. The highest strain was registered in the cement layer i.e. contact surface between two ceramic blocks. Digital Image Correlation Method has visualized strain in the experimental model composed of all ceramic and composite cement. This model can serve for future investigation of different all ceramics and cements.

Keywords: all ceramics; composite cements; Digital Image Correlation Method.

1. INTRODUCTION

Previous studies employed the Digital Image Correlation (DIC) method to research various problems in dental biomechanics [1,2,3]. During these studies DIC has proven itself as reliable method in analyzing strain fields. Whether used for strain determination in biomaterials, human tissues or different prosthetic designs, DIC has visualized full strain field in different materials highlighting it as the main advantage of this method over others [4]. In current dentistry research, it is an imperative to find the best material for tooth restoration but also cementation of different restorations. As it is known, all ceramics has found to be the best choice considering esthetics, while composite cements have been usually employed due to their adhesion features and simple application [5]. Furthermore, it has been reported that the type of used resin based composite cement could influence its bond strength to ceramic [6]. Having in mind these requests, an experimental model was developed to determine surface strain field. Utilizing DIC performances, study aimed to visualize and analyze strain in model composed of all ceramics and composite cement. If there is a need, use italic for emphasizing a word or phrase. Use boldface typing only for section headings and subheadings.

2. METHODS

A sample composed of two blocks of Vita Enamic all-ceramic and composite cement applied between contact surfaces of the blocks was used in the study. Actually, two all-ceramic blocks were bonded into a single unit using MaxCem Elite as composite cement. Vita Enamic belongs to the polymer infiltrated ceramic network material (PICN) that consists of two continuous interpenetrating networks: a ceramic material (feldspar, 86 wt %) and a polymer (commonly used methacrylates for dental applications, 14 wt %) [6]. Maxcem Elite (Kerr, Orange, CA, USA) contains glycerol
phosphate dimethacrylate (GPDM), co-monomers (mono-, di- and tri-functional methacrylate monomers, water, acetone, ethanol, barium, glass, fumed silica and sodium hexafluoro silicate) and ytterbium fluoride mineral fillers. Filler loading is 69 wt% and 46 vol% [7]. Maxcem Elite is dual cure material and in this study, self-curing mode was used. Tested material in this study was applied directly by an automix syringe. The surface of interest was sprayed with white and black paint to obtain a stochastic pattern necessary for experimental measurement. Model was axially loaded on a H10K-S UTM Tensile testing machine (Tinius Olsen, USA) using loads up to 260 N. The Digital Image Correlation method (GOM, Germany) was used to visualize the strain field in the outer surface of the loaded model. The experiments were done at room temperature.

3. RESULTS

The last stages (247 and 248) of the vertically loaded Vita Enamic model are presented (Figure 1 and Figure 2). These stages correspond to the force of 240 N (Figure 1) and 260 N (Figure 2), respectively. The highest strain value measured in Epsilon Y was 0.30 % which is presented by red color. The highest strain was registered in the cement layer i.e. contact surface between two ceramic blocks (Section 2). The sections 0 and 1 show similar values of strain. Stage 247 showed non homogeneous strain field with highest value of 0.15 %. However stage 248 showed concentrated strain right next to cement layer with the highest value of 0.30 %.

![Figure 1: Experimental model loaded with 240 N.](image_url)
4. DISCUSSION

In this study, a possible model for biomechanical investigation has been proposed. This experimental model was composed of two different types of biomaterials: all-ceramic blocks and composite cement. Vita Enamic has been chosen for creating the sample blocks since it is the first hybrid dental ceramic with a dual-network structure [6] gathering the best of both, ceramic and composite materials. Related to this duality feature, Vita Enamic structure is considered as material of greater resistance on mechanical testing compared to other rigid and brittle all ceramics with improved flexibility, fracture toughness and better mechanical properties compared to other all ceramics [8]. Vita Enamic shows mechanical properties closest to the hard-tissue of tooth [6]. Young modulus of Vita Enamic is close to dentin while Vickers hardness is between enamel and dentin [9]. Crack propagation within Vita Enamic hybrid material is limited, because of the presence of two connected network [6,7], which is supported by this study. Actually an inherent structure of blocks confirmed previously mentioned.

In addition, Maxcem Elite used in this study as an interlayer placed between two blocks belongs to self-adhesive resin cements (SARCs). Maxcem Elite contains an acid monomer, glycerol dimethacrylate dihydrogen phosphate (GPDM), which is partly responsible for the effect of etching and adhesion to the substrate. Thus, Maxcem Elite provides a strong bonding necessary for adhering the blocks [10]. Maxcem Elite is characterized by an amine-free redox initiator system, which may help prevent chemical incompatibility between acidic groups and self-curing components [11].

Findings provide that the highest strain was detected in the region of the cement layer, however last stage (Figure 2) showed very high concentration of the highest strain values in both, cement layer and
all ceramic blocks adjacent to cement. Thus it may be argued about maximal load and its effect on mechanical behavior of biomaterials proposed in this study. The study is a preliminary report regarding biomechanical behavior of two different materials, composite cement and all-ceramic under the vertical tension force. A practical implication of this research is considered to explain the compressive and tensile stress phenomenon observed during mastication process in all ceramic systems. Current trends in oral rehabilitation of partially edentulous patients include the application of ceramic abutments. Thus, experimental results obtained in this study could visualize strain in contact surface between ceramic abutment and all-ceramic crown [12].

5. CONCLUSION

Experimental model has been proposed for biomechanical investigation. Model was composed of two different types of biomaterials: all-ceramic blocks, and composite cement. Findings provide that the highest strain was detected in the region of the cement layer, however last stage showed very high concentration of the highest strain values in both, cement layer and all ceramic blocks adjacent to cement. The Digital Image Correlation method was employed to visualize the strain field in the outer surface (surface of interest) of the loaded experimental model. This type of experiment could be applied in analyzing mechanical properties of different all ceramics and composite cements, and biomechanical interaction between ceramic abutments and all ceramics.

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References


