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PHOTOELASTIC STRESS ANALYSIS FOR MANDIBULAR IMPLANT SUPPORTED OVERDENTURE WITH TWO TYPES OF DENTURE BASE MATERIALS

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KEYWORDS

Photoelastic Stress Analysis , karadent denture base material , telescopic overdentures

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ABSTRACT

Introduction: Different denture base material properties affect stress distribution in different ways around Prosthetic abutments and surrounding bone, as well as extent of bone remodeling**. Aim:** The purpose of this in vitro study is to investigate the distribution of stresses around a four telescopic dental implants supporting structure induced by two types of mandibular implant supported over denture base materials (acrylic resin and karadent dentures) using photoelastic analysis. **Materials and methods**: Ten telescopic mandibular implant overdentures had been constructed on an epoxy educational resin cast and according to the used denture base material were divided into two groups. For the first group: Five telescopic mandibular implant overdentures of Semi-rigid microcrystalline polymer denture base material (karadent). For the second group: The same but with conventional heat cured denture base material. For both groups models successive loads (20,40,60,80,100 newton) were applied using photo elastic stress analysis machine by using metal plate fixed at the lower first molar region bilaterally then stresses were recorded and analyzed. **Results**: the acrylic resin mandibular overdenture denture base material showing an increasing the mean stress value around implant supporting structure than the karadent one. **Conclusion**: The use of semi-rigid microcrystalline polymer dentures demonstrates favorable stress distribution more than the conventional heat cured dentures.

INTRODUCTION

Complete removable maxillary and mandibular dentures were the classical treatment plan for edentulous patients but it had several drawbacks like allergic reactions and lack of retention, while The use of implants to support overdentures showed good stability, reduce residual ridge resorption, improve function, esthetic and increases patient comfort by improving retention and chewing ability [(1)].

The use of telescopic crowns as attachments for implant-supported overdentures have several advantages including prosthesis retention and stability, satisfactory mastication,improved phonetics. In addition, prevent dislodgment of the distal extension base away from the ridge and increased horizontal stabilization in the overdentures[(2)].

Self-finding mechanism in telescopic crowns facilitated prosthesis insertion which was important for geriatric patients with decreased manual dexterity.

Different denture base material properties affect stress distribution in different ways. Studies have demonstrated a difference in stress distribution patterns around Prosthetic abutments and surrounding bone, as well as extent of bone remodeling, when comparing denture bases made of conventional acrylic to its counterpart of different materials [3].

Photoelastic study gives immediate identification of stress fields in parts of studied object accessible to normally incident light, in addition to this field capacity, photoelastic coatings, also allow for point determination of shear stress and direction of measurement of the principal stress axes [4].

The purpose of this study is to investigate the distribution of stresses around a four telescopic dental implants supporting structure induced by two types of mandibular implant supported over denture base materials (acrylic resin and karadent dentures) using photoelastic analysis.

MATERIALS AND METHODS

Sample size

Sample size was calculated according to a sample size formula to be ten telescopic mandibular implant overdentures of different denture base materials[5]. This study was done at the laboratory of Prosthodontic department, faculty of Dentistry, Suez Canal University using photoelastic analysis.

Grouping

According to the used denture base material, the overdentures were divided into two groups:

Group1: Five telescopic mandibular implant overdentures of Semi-rigid microcrystalline polymer denture base material (Karadent by TCS, INC, USA).

Group 2: Five telescopic mandibular implant overdentures of conventional heat cured denture base material. (Acrostone Heat Cure Denture Base Material. Egypt).

Dentures construction:

Trial waxed up dentures on ten educational mandibular stone cast models were prepared and divided equally into two groups:

Group 1: Five waxed up dentures were processed by injection-molding technique for conventional heat cured resin by long cycle (9 hours at 60-70C) fabrication procedures.

Group 2: Five waxed up dentures were flasked, the flask was immersed into warm water of a thermostatic container after setting of the gypsum. When the wax was boiled and the mold was created. The mold cavity was filled with karadent material in 25 mm cartridge with tap then sprayed with mold release spray and flask was closed followed by denture fabrication procedures by karadent material using automatic air injector (Thermopress 400, bredent,GmbH &Co. KG Weissenhorner . Germany) set display at 310-320˚C for 14-16 min 150 – 165 PSI.

Overdenture construction

Dental implant sites were prepared on the mandibular stone models by using sequence of implant drills held by a parallometer (Milling unit BF2, bredent, GmbH, co, KG werssenhorner str, 2-89250 senden,Germany) milling device. The implant drills were inserted vertically on the stone model in the predetermined position at canines and second premolars using mandibular denture teeth as guide. (Figure 1a)

Four implant analogues 3.7 mm in diameter and 11mm in length (Fixture Lab Analog, Dentis Co., Ltd, Dalseo-gu, Daegu, Korea) were inserted inside the prepared implant sites . Transfer copings (Dental Abutment, Dentis Co., Ltd, Dalseo-gu, Daegu, Korea) were screwed to the implant analogues for the cast. Impression was made by rubber base impression material (Zetaplus, zhermack, Italy) to the model with transfer post using stock aluminum tray that precisely opened at the sites of transfer copings.

Transfer copings were unscrewed from the stone models to be removed with impression and four dummy implants (Implant Direct LLC,Dentis Co.,Ltd,Dalseo-gu, Daegu, Korea) similar to implant analogues were fastened to transfer copings with adequate support of the opened tray, rubber base impression mold was poured with epoxy resin.

Telescopic crowns fabrication

Rescrewing telescopic crowns in the dummy implants of the epoxy model and modifications were done for the transfer copings to be used as primary coping to allow vertical resiliency by reducing The occlusal surface for 0.3 mm and the occlusal third of the axial walls for 0.03 mm with parallel abutment walls and short clinical height 5 mm were kept to each other. (Figure 1b)

Scanning of cast with modified inner copings and turned it into stl file with virtual designing from software library after then find design exported and started milling from cobalt chromium block. For the two groups the outer telescopic attachments were used to relate the denture base to the implants. (Figure 1c)

Supporting surface of epoxy resin model replaced by auto-polymerized resilient silicone soft lining material (Softliner, Promedica, GmbH, Neuwünster, Germany) to simulate resilient edentulous ridge mucosa through Wax spacer of 2mm thickness and Soft liner material was packed inside the plaster index and placed over the epoxy model[6]. (Figure 1d)

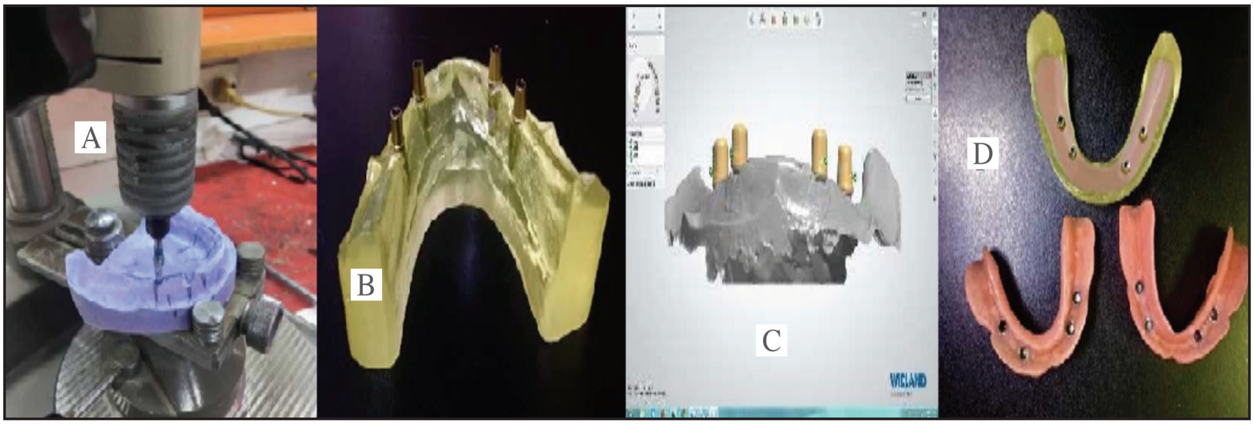

Fig. (1) **a)** Implant drilling. **b)** Epoxy model fabrication with inner copings screwed. **c)** Outer copings fabrication using CadCam. **d)** Resilient silicone soft lining material.

Application of forces

All dentures were placed on the stress free epoxy models, for both groups models central successive loads (20,40,60,80,100 NW) equals (2, 4, 6, 8, 10 KG) were applied using photo elastic stress analysis machine by using metal plate fixed at the lower first molar region bilaterally (Figure .2 a).

Stresses were recorded for each group from two areas first one was the lower canine area and the second one was the lower second premolar area photographically (Canon Powershot G; Canon Inc. Tokyo, Japan) (Figure .2 b).

In the evaluation of these stress data, the following terminology was adopted: Low stress –1 fringe or less, moderate stress –between 1 and 3 fringes, and highstress –more than 3 fringes [7] (Figure .2 c).

Records were calculated, tabulated and statistically analyzed .

Statistical analysis

Data were presented as mean, standard deviation (SD) and Standard Error (SE). Student's t-test (Unpaired) was used for comparing data (parametric) of two different groups while Student's t-test (Paired) was used for comparing data (parametric) of two related groups. P-value less than 0.05 was considered statistically significant Data was analyzed using Statistical Package for Social Science software computer program version 23 (SPSS, Inc., Chicago, IL, USA).

RESULTS

A mixture of tensile and compressive strains was obtained around each implant upon loading regardless of the type of the denture material and load applied directly over the occlusal surface of overdenture produce stress in the supporting structure in the loaded implants.

From table 1 and fig 4 it was found that there was an induced stresses around implant supporting structures in the canines and second premolar region during application of bilateral load with different degrees with higher mean stress values in favor of acrylic denture base material.

It was found that this result was statistically shows significant differences between the two denture base materials (acrylic resin and karadent) during application of higher load especially around the second premolar supporting structures.

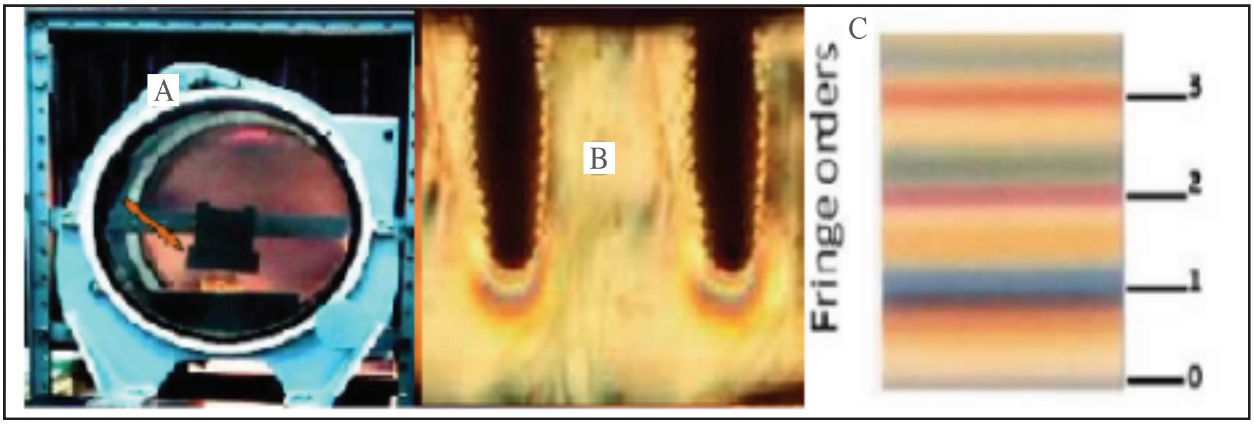

Fig. (2) **a)** Load applicaton for models. **b)** Photoelastic stresses with different colors. **c)** Relation between stress level and fringe order used to describe results.

Table 1 *Comparison between the mean value of stress induced of two different denture base materials:*

Variable			Canine			P1		Second premolar			P2
	Acrylic		Karadent				Acrylic	Karadent			
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		
	20 N.	0.85	0.21	0.5	0.13	0.12	0.6	0.16	0.4	0.11	0.09
	40 N.	1.25	0.32	1	0.22	0.18	0.85	0.23	0.5	0.13	0.06
Load stress	60 N.	2.25	0.57	1.5	0.4	0.07	1.5	0.41	0.85	0.22	0.001*
	80 N.	2.75	0.72	2.25	0.56	0.02*	2.25	0.63	1.25	0.34	0.001*
	100 N.	3.5	0.94	2.75	0.73	0.01*	3	0.88	1.6	0.41	0.002*

*Data expressed as mean±SD   SD: standard deviation   P: Probability   *: significance <0.05*

DISCUSSION

Karadent material was used because it's an upgrade from acrylic denture base material it is nearly unbreakable, esthetically acceptable being colored like the gums can be fabricate dquite thin but strong with exceptional fit and shows no volume shrinkage with lower residual monomer content so it act as alternative to Poly Methyl Methacrylate in allergic patients and physical properties become stable without deteriorating. [(8)].

When rigid telescopic attachments were used for four implants mandibular supported overdenture they added to the prosthesis stability results in psychologic comfort and masticatory performance similar to that of a fixed prosthesis but with hygienic, esthetic, and cost advantages [(9)].

A gradual static central load was applied from 20 to100 Newton using load applicator. This load amount was selected because it is within the range of normal occlusal mastication and close to maximal loads [(10)].

Photoelastic stress analysis provides good qualitative information on the overall location and concentration of stresses [(11)].

A mixture of tensile and compressive strains was obtained around each implant upon loading regardless of the type of the denture material. Because implant loading usually rules the nature of bone strains; as combination of tensile and compressive strains may occur due to bending moments occurred following loading of implant retained over dentures [(12)].

The results obtained from this study showed that in all loading situations the use of karadent dentures reduce the strains delivered to the supporting structures under the denture base more than traditional acrylic dentures because the high resiliency of karadent denture base allows a higher standard of function to balance masticatory forces over entire supporting ridge instead of individual support points. As a result, the balanced stress distribution leads to decrease the forces directed to the implants and consequently to the alveolar bone [(13)].

From the same point of view, karadent as a thermoplastic resin undergo a chemical change and they are usually cross linked in this state which leads to dimensional stability with better flexural and impact properties that decrease the transferred forces to the underlying structures compared with traditional denture base material which have poor strength characteristics including low flexural strength [(14)].

This study also showed that the use of karadent dentures showed less stress concentration on the surfaces of the edentulous ridge than conventional heat cured resin dentures because under functional load karadent material absorbs the applied stresses and minimizes the distortion of the supporting tissues [(15)].

The results of this study was found to be in agreement with other studies, which stated that the modulus of elasticity of a material is a factor that directly affect the amount of pressure transmitted by the material and the extent of the area to which it is transmitted [(16)]. It was also stated that materials with a low modulus of elasticity like thermoplastic resins may flex and absorb impact energy from impact force, acting as a shock absorbent and resulting in decreased stress transmission to the underlying tissues [(17)].

CONCLUSION

Within the limitations of this study, the following conclusions are drawn: The use of semi-rigid microcrystalline polymer dentures demonstrates favorable stress distribution more than the conventional heat cured dentures.

Clinical research is still required to determine the influence of different denture base materials on peri-implant tissue under these overdentures.

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