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Research Article

Aged Flexural Properties of Vertex Thermosens versus Conventional Denture Base Materials for One Year Water Storage

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Abstract

Purpose: The aim of this study was to measure the flexural properties of the recently introduced Vertex ThermoSens denture base material after storage in water for one year and compared with those of conventional heat-cured denture base material.

Materials and Methods: 20 rectangular wax specimens from both denture base materialswere prepared using stainless steel plate. The specimens dimensions, (65 mm length, 10 mm width and 2.5 mm thickness) according to the American Dental Association Specification no.12 for denture base polymer. The wax specimens were divided randomly into 2 groups (10 specimens each). The first group was cured in Major.base 20 and the second group was cured in Vertex ThermoSens denture base materials. The specimens were kept in water at 370C for 12 months. The specimens were tested for the flexural strength using three point bending test. The flexural strength was carried out using Instron Universal Testing Machine. The maximum load for fracture was recorded in (N) and the deflection of the specimens at fracture was recorded in mm. The data was analyzed using paired t-test statistical analysis at the level of significance $p \leq 0.05$.

Results: Vertex ThermoSens denture base material showed significant higher flexural strength than that of Major. Base 20 after storage in water for 12 months. Major base 20 denture base material showedsignificant higher flexural modulus than that of Vertex ThermoSens.

Conclusion: Vertex ThermoSens denture base material showed higher flexural strength and lower flexural modulus when compared to Major. Base 20 after storage in water for 12 months.

Keywords: Vertex thermosens; Denture base material; Flexural strength; Conventional heat-cured acrylic resin

Introduction

Polymers are widely used in dentistry for different applications such as dentures and dental implants. The major prosthetic devices were to restore physiological and esthetic functions of oral tissues of edentulous or partially edentulous patients. Many years ago, polymethyl methacrylate resin has been used in dentistry successfully. It has several advantages, especially its esthetic quality but it still has weak mechanical properties. Fracture could occur under the forces of mastication due to poor flexural properties [1]. The ideal denture base material should possess some properties include biocompatibility, good bond strength with the available denture teeth, radiopacity, ease of repair, and adequate physical and mechanical properties [2]. The denture base material should possess enough strength to allow the prosthesis to withstand the functional and parafunctional masticatory forces [3].

Most of dentures consist of poly (ethyl methacrylate), poly (ethylmethacrylate), and other copolymers [4]. Acrylic resin denture bases have low mechanical properties against impact, bending, and fatigue forces. These properties are important issues to be studied in order to improve acrylic polymers properties for removable appliances and dentures [5]. Many attempts have been made to improve the mechanical properties of the acrylic resins such as additives like polyethylene glycol dimethacrylate or reinforcing the acrylic base resins by fibers and particles [6,7].

Denture fracture may be related to the design errors rather than the resin material itself. The denture fracture can occur in thin regions or weakened flanges such as around frenal notches [8]. Also denture fracture can occurs at the midline, leading to selectively increasing the denture thickness at these regions to resist deformation and fractures [9]. Increasing the denture thickness in the maxillary areas can interfere with the coronoid process during mandibular movement. Also, increasing the denture thickness palatal to the maxillary anterior teeth may interfere with the tongue movement causing speech problems. To overcome these problems, it is recommended to decrease the denture thickness at these areas or using stronger acrylic resin materials [10].

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Table 1: Mean flexural strength (MPa) and flexural modulus (GPa) of types denture base materials after one-year of water storage.

	Major.base 20	Vertex ThermoSens	
	X ± SD	X ± SD	p-value
Flexural strength	59.85 ± 3.15	64.86 ± 2.36	0.02*
Flexural modulus	1383.41 ±119.59	975.17 ± 83.56	0.004**

X = Arithmetic mean; S.D. = Standard Deviation; *Significant difference at p level ≤ 0.05; **High significance at p level ≤ 0.05

There are several mechanical properties could be used to measure the strength of denture base materials. The most common tests are flexural strength test, impact strength test, and flexural modulus test to measure the stiffness of the denture base materials [10]. It has been stated that the ultimate flexural strength of any denture base materials shall not be less than 50 MPa. Therefore it is strongly recommended to evaluate the effects of any additive or modifier on the mechanical properties of any acrylic materials to avoid all deleterious effect which may reduce their strength to below standard level [11,12].

Vertex ThermoSens is a thermoplastic, new monomer-free rigid denture base material the innovative, and virtually unbreakable. The development of ThermoSens aimed to be used for complete and partial dentures, temporary crown and bridge constructions. Its composition based on the microcrystalline polyamide material and pigments. So, it is suitable for patients allergic to residual monomers. Vertex ThermoSens is based on the injection technique using automatic or manual injection machine. Thermoplastic materials are flexible for removable partial dentures because it becomes better and stronger appliance. The flexibility of the thermoplastic materials allows the denture prevents transferring stresses to the adjacent teeth and tissues thus prevent the trauma from the partial denture. The color of the thermoplastic denture bases matches the oral tissues to perfection and eliminates the use of metal clasps as in other partial dentures [13,14].

The aim of this study was to evaluate and compare the flexural properties of the thermoplastic Vertex ThermoSens denture base material and compared with the conventional polymethylmethacrylate as a control group.

Materials and Methods

The materials used in this study were thermoplastic Vertex^{TM} ThermoSens (Vertex Dental B.V. 3705 HJ Zeist, Netherlands) and Major base 20 (Major Prodotti Dentari S.p.A; Italy). 20 rectangular specimens from both denture base materialswere prepared using stainless steel plate. The specimens dimensions, (65 mm length, 10mm width and 2.5 mm thickness) according to the American Dental Association Specification No.12 for denture base polymer. Impression for the metallic specimens was made using heavy body polyvinyl siloxane impression material (Silastic E; Dow Corning, Midland, Mich, USA). After setting of the impression, the metallic specimens were carefully removed. Baseplate wax (Tru Wax, Dentsply International Inc., York, Pa.) was melted and poured into the impression molds and pressed using glass plate to obtain flat and smooth wax specimens. The wax specimens were removed from the impression molds and divided randomly into 2 groups (10 specimens each). The first group was cured in Major base 20 and the second group was cured in Vertex ThermoSens denture base materials.

Figure 1: The prepared specimen for flexural properties testing.

Figure 2: Instron testing machine.

For the conventional denture base material, the wax specimens were invested into conventional dental flasks using dental plaster. After washing of the wax specimens using boiling water for 10 minutes, the Major base acrylic resin was packed and processed according to the manufacturer's instructions. The flasks were dipped in boiling water at 100 ^{O}C for 30 minutes (effective boiling time). The specimens inside the flasks were cooled slowly to room temperature and then deflasked. The acrylic specimens were finished and polished carefully under room temperature water (Figure 1). The specimens were kept in water at 37^{0}C for 12 months.

For the thermoplastic Vertex^{TM} ThermoSens denture base material, the wax specimens were invested and washed as the conventional technique. This group was cured according to the manufacturer' s instructions. This system uses special metallic flasks with posterior wax sprue for injection of the material inside the plaster molds. Vertex™ ThermoSens is based on injection technique. The technique can be done with an automatic or manual injection machine. The preparations of the model and flask are according to the standard procedures of the dental technique. For injection of the Vertex™ ThermoSens into the flask, wax sprue should be used. The main sprue was about 9.5 mm and side sprues were 4.5mm [15]. The material was heated at 270- 280^{0}C within 18 minutes and injected automatically at a pressure of 8.5 bars. The flasks were cooled slowly and the specimens were deflasked, finished, polished and stored at 37^{0}C for 12 months.

The specimens were tested for the flexural strength using three point bending test (Figure 2). The flexural strength was carried out

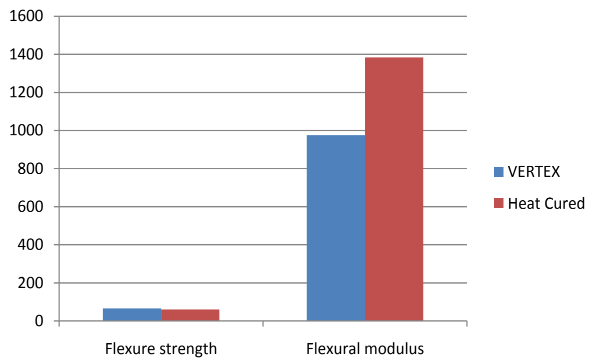

Figure 3: Shows the difference between both types denture base materials after storage in water for one-year.

using Instron Universal Testing Machine (Instron, USA.) with load cell 500 N Bluehill Lite software at cross head speed 1mm\min. The maximum load for fracture was recorded in (N) and the deflection of the specimens at fracture was recorded in mm. For calculating the flexural strength in MPa, the following formula was used: Stress = 3 × Load × Length / (2 × Width × Thickness^2) [16,17]

The flexural modulus was calculated in Gpa from the following formula [17]:

$E = FL^3 / 4Ybd^3$

Where,

E=flexural modulus, F=load at P (N), L=distance betweensupports (mm), Y=deflection at P (mm), b=width of sample (mm), and d=thickness of sample (mm).

Statistical analysis

The data was analyzed using paired t-test statistical analysis at the level of significance $p \leq 0.05$.

Results

The results of this study are presented in Table 1 and Figure 3. The statistical analysis of the flexural strength results showed significant difference between the conventional heat-cured (Major base 20) and the thermoplastic (Vertex ThermoSens) denture base materials at the level of significance ($p = 0.02$). Also, there was a significant difference in the flexural modulus of the conventional heat-cured (Major base 20) and the thermoplastic (Vertex ThermoSens) denture base materials at the level of significance ($p = 0.004$).

Discussion

Many materials such as bone, wood, ivory, and vulcanized rubbers were used to fabricate complete dentures.The term thermoplasticrefers to polymers that may be softened by heating and solidify on cooling, the process being repeatable. Thermoplastic polymers are made of linear and/or branched chains. They soften when heated above the glass transition (Tg)-the temperature at which molecular motion begins to force the chains apart. The resin can then be shaped and molded and, upon cooling, it will harden reversibly in this form. Upon reheating, such polymers soften again and can be reshaped, if required, before again being hardened by decreasing the temperature. This cycle can be repeated almost indefinitely. The setting reaction is reversible because of the relatively weak bonds among the molecular chains [18].

To provide acceptable physical properties, denture base resins must meet or exceed the standards presented in ANSI/ ADA Specification No. 12. Thermosetting polymers undergo a chemical change and become permanently hard when heated above the temperature at which they begin to polymerize; they do not soften again on reheating to the same temperature. They are usually cross-linked in this state, and thus, they are insoluble and will not melt. Instead, they decompose if heated to a high enough temperature. Thermosetting polymers generally have superior abrasion resistance and dimensional stability compared with thermoplastic polymers, which have better flexural and impact properties [18].

The strength of an individual denture base resin is dependent on many factors. These factors include composition of the resin, processing technique, and conditions presented by the oral environment. A transverse test is used to evaluate the relationship between the applied load and resultant deflection in a resin specimen of prescribed dimensions [18]. Flexural tests are important properties that can reflect the ability of denture base materials to resist the functional masticatory forces. The three-point flexural test is useful in comparing denture base materials because it simulates the stress that is applied to the denture during mastication [19,20]. High flexural strength is crucial to the success of denture wearing, as alveolar absorption is a gradual and irregular process that causes uneven prosthesis support [21]. To ensure that the stresses encountered during bitingand mastication do not cause permanent deformation, the denture base material should exhibit a high elastic modulus [10].

The results of this study indicated that the flexural strength of Vertex ThermoSens after storage in water for one year was significantly higher than that of the conventional heat-cured Major. base 20 denture base materials. On the other hand, the flexural modulus of Major.base 20 was higher than that of the thermoplastic Vertex ThermoSens. This may be due to the longer water storage time, difference in the composition of both denture base materials and difference in the polymerization technique [22]. Polymethyl methacrylate absorbs small amounts of water when placed in an aqueous environment. Tis water exerts significant effects on the mechanical and dimensional properties of the processed polymer. A typical denture base may require a period of 17 days to become fully saturated with water [18].

Thermoplastic materials are polyacetal or polyamide nylon. The main difference in the chemistry of thermoset elastomers and thermoplastic elastomers is the difference in the type of cross linking in their structure. In fact cross linking is the critical structural factor which contributes to impart high elastic properties. The cross linking in the thermoset polymer is a covalent bond created during polymerization process.The thermoplastic materials showed higher flexural strength when compared to the high impact heat-cured acrylic resin [23]. When the flexural strength was tested after manipulation, Vertex thermosens denture base material exhibited significantly higher impact and flexural strength when compared with the conventional polymethyl-methacrylate denture base materials [24].

Conclusion

Within the limitations of this study, the following conclusions were drawn:

1. Vertex ThermoSens denture base material showed higher flexural strength than that of Major. Base 20 after storage in water for 12 months.

2. Major.base 20 denture base material showed higher flexural modulus than that of Vertex ThermoSens after storage in water for 12 months.

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