Preparation and Evaluation of Some Properties of Heat Cured Acrylic Based Denture Soft Liner

***Basima M. A. Hussein, B.D.S., M.Sc., Ph.D.* [1]**
***Salem A. Salem, B.D.S., D.D.S., Ph.D.* [2]**
Salah M. Aliwi, B.D.S., Ph.D.

ABSTRACT

Background: The base of the denture is largely responsible for providing the prosthesis with retention, stability, and support by being closely adapted to the oral mucosa. However; the process of bone resorption is irreversible and may lead to an inadequate fit of the prosthesis; this can be overcome by relining.

Materials and methods: Acrylic based soft denture liner is prepared by preparing polymer from purified methylmethacrylate monomer with (10^{-2}) initiator and (30%) dibutylphthalate plasticizer concentrations. Biological properties were evaluated in comparison with the control material through subcutaneous specimens' implantation in the New Zealand rabbits. Excisional biopsies were taken after (1, 3, days 1, 2, 3, 4 weeks) period. Microscopically, sections are studied to explore the consequences of thecontact with tested material and tissue response. Tensile strength, percentage of elongation, compressive, bond, and peel strengthwere evaluated; as well as water sorption and solubility is compared with the control material.

Results: Histological study of the sections contained experimental and control materials showed normal tissue response by normal infiltration of the inflammatory cells; acute in the first days then chronic inflammatory cells were seen in the subsequent periods. Finally capsular enclosure of the specimens was well characterized and seen after 4 weeks. Results of the mechanical properties showed non-significant differences for the tested properties except the percentage of elongation; control material recorded significantly higher value. Moreover, statistically; water sorption of the experimental material was significantly lower than the control material; while the tested materials showed non-significant differences regarding the solubility test.

Conclusion: The recommended formula of preparing heat-cured; acrylic based denture soft liner showed acceptable properties. Further evaluations of the experimental material were suggested.

Key words: Heat cure, acrylic based soft liner. (J Bagh Coll Dentistry 2015; 27(4):32-36).

INTRODUCTION

Relining is the procedure used to re-surface the tissue side of a removable dental prosthesis with a new base material, thus; producing an accurate adaptation to the denture foundation area[1]. The use of soft denture liners is an important adjunct in the treatment of complete and partial denture patients, particularly those who are medically or locally compromised[2]. The use of these materials act as a cushion for the denture bearing mucosa through absorption and re-distribution of the forces transmitted to the stress bearing area of the edentulous ridge. They are capable of restoring health to the inflamed mucosa[3,4] . In the past few years, soft liners have emerged in many fields to modify transitional prosthesis after stage I and stage II implant surgery[5].

The longevity of soft liner is a major problem; one problem is the adhesive failure between the liner and the denture base[6]. In order to achieve success in relining process, Wright (1982) concludes that same chemical composition of materials type is preferred because of the need for similar bonding properties[7], in other words, the main reason for failure of the soft liners is the structural difference between the two materials[8]. Furthermore, during the use of the relined denture, the materials usually immersed in saliva during regular use or soaked in water or aqueous cleaning solution at storage time. Therefore; the material could be subjected to water sorption and degree of solubility.

The present work is designed to prepare poly (methyl methacrylate) polymer, plasticized in a plane of preparing denture soft liner, heat cured acrylic type. It is intended to evaluate some of its chemical, biological and mechanical properties in comparison with other, commercially available denture soft liner material.

MATERIALS AND METHODS

The preparation of the soft liner material was started by polymerization of purified Methyl methacrylate monomer (Fluka, Switzerland).Bulk polymerization method was selected to prepare polymers with range of dibenzoyl peroxide initiator(BDH Chemical Ltd) concentrations (5×10^{-2}, 10^{-2} 10^{-3}, 10^{-4}).

Viscosity average molecular weight was calculated for the prepared polymers and compared with the control, it was found that polymer with (10^{-2}) concentration of dibenzoyl peroxide initiator was the closest polymer to the

(1)Assistant Professor. Department of Prosthodontics. College of Dentistry, University of Baghdad.
(2)Retired Professor.

control regarding molecular weight. Polymerization was done in a water bath (HAAKE DC3-Japan) at 74ºC for 30-35 minutes.

The polymer then was precipitated using 1:5 volume of methanol (Riedel-de Haen). The collected polymer was dried in vacuum oven (Gallenkamp) at 40ºC overnight. The dried polymer was milled and sieved to have particles<150µm.Dibutyl phthalate was added to the monomer as a plasticizer before mixing with the prepared polymer in 30%. P/L ratio was calculated by a pilot study using different ratios; the decision was made depending on a result of UV absorption that determined the least residual monomer. Processing of the material was done by using short curing cycle (90 minutes at 74 C and 30 minutes at 100ºC). Processing of the control material- Super Soft, USA- was done according to the manufacturer's instruction.

Biological properties: biocompatibility of the prepared denture soft liners was done by subcutaneous inoculation of (5 x2mm) discs of the materials in the dorsum of a NewZeland rabbits. Assessment of the tissue response toward the specimens was done by histological study of a slides prepared from biopsies excised after 1, 3, 7 days and 2, 3, 4, weeks.

Mechanical properties: tensile, compressive, peel and bond strength of the prepared material was tested and compared with those of the control material. Tensile strength specimen was dumbbell shaped with (10×60×4mm) and the constricted part of the specimen was (8×2.5×4mm) was representing the tested material(9).

Tensile bond strength was tested using a specimen with (60×6×6mm), compressive strength with (40×12.7 mm)(10), all these test was performed after processing the soft denture liner(2mm) in the central part between two segments of heat cured acrylic specimens. Peel test was performed by processing tested material in (70×10×2mm) against (70×10×2mm) heat cured acrylic bars(11).

Only 40 mm of the tested mayerialwas allowed to bond against the acrylic bar, the rest part of the specimen was reflected back to have 180º peel strength test. Mechanical tests was performed by using instron testing machine (Testometric AX, Rochdale, UK) with cross head speed and grips adjusted according to each test. All the tests were performed under tensile loading except compressive strength was performed under compression.

Physical properties: water sorption and solubility test was performed by preparing discs with (50(±1) ×0.5(±0.05) mm)(12). The test was done following the ADA specification No.12.

Statistical analysis included in the present study was mean, standard deviation and student t-test at a probability level ($p< 0.05$).

RESULTS

Micrographs of the histological sections showed normal tissue response toward the inoculated materials. In the 1st 3-7 days infiltration of the acute anti-inflammatory cells as a neutrophil was seen, also new blood vessels, later on chronic inflammatory cells occupy the field. Capsular connective tissues surrounding the specimens were well defined and almost no inflammatory cells seen after 4 weeks, figure (1).

Mechanical properties: the means of tested properties for the prepared material and the control are expressed in table (1) below.

Table (1): Means and Standard Deviation of the Tested Mechanical Properties with Significance Results

Test	Experimental	Control	Significance ($p<0.05$)
Tensile Strength(N/mm^2)	1.301 (0.213)	1.11 (0.290)	N.S
Elongation (%)	210 (43)	320 (59)	S
Compressive Strength(N/mm^2)	1.579 (0.360)	1.631 (0.3)	N.S
Bond strength(N/mm^2)	1.2 (0.24)	1.093 (0.27)	N.S
Peel strength(N/mm)	2.269 (0.501)	2.789 (0.492)	N.S
Water sorption(mg/cm2)	1.7477 (0.394)	3.095 (0.63)	S
Solubility	0.2191 (0.048)	0.22 (0.0421)	N.S

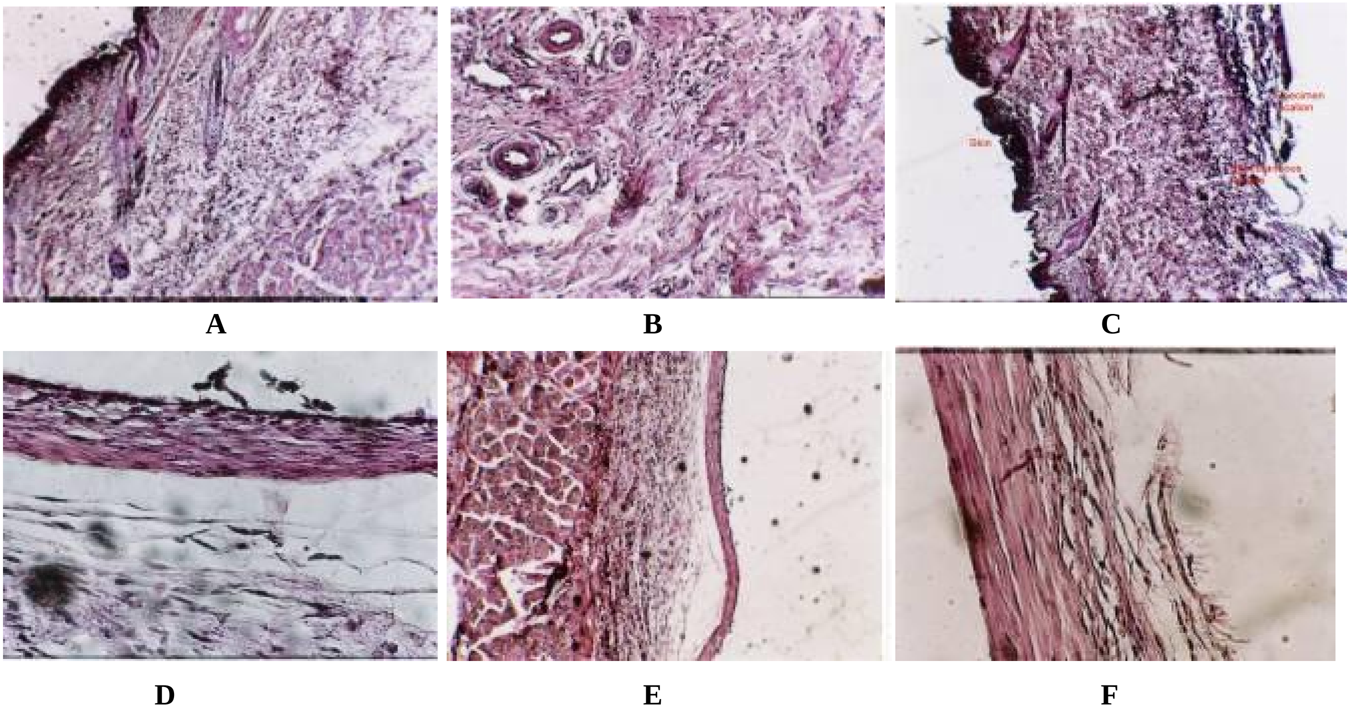

Figure (1): Micrographs of Tissue Response Toward Tested Materials, (A) After One Day-Mag. 50, (B) After Three Days –Mag.200, (C) After 1 Week-Mag (50), (D) After 2 Weeks with Capsular Formation, (E) After 2 Weeks-Mag.100 Connective Tissue Capsule –Mag.200-, (F) After 4 Weeks-Mag-200.

DISCUSSION

The use of soft denture liners is usually advantageous to avoid stress concentration(13), and to obtain retention for clinical cases with irritation of denture bearing mucosa and/or sever undercut area (14). The advantages of the soft denture liners were considered to be influenced by their properties. The material has cushioning effect that absorb load. It was concluded that permanent soft liner has elastic properties approximately within the range of the mucosal lining of the oral cavity(15).

Animal tests, using mammalians allow for a complex between the materials and biological environment to occur, thus the biological response is more comprehensive and more relevant than that obtained from other tests(16). Acute inflammatory cells were invading the injured or irritated sites with increased vascularity and permeability; all are normal manifestations of acute inflammation. These findings were also agreed by Craig and Ward and Stephenson. The same picture was seen as a response toward some of the tested metal alloys(17), or different types of acrylic(18), as well as implanted impression compound materials(19), and methacrylate-based endodontic sealer(20) and disagree with Ozdemir et,al., who reported that some cytotoxic effect of certain types of denture soft liner(21), it was believed that many dental materials elicit cytotoxic response, but this does not necessarily reflect the long-term risk for adverse effects as the oral mucosa is generally more resistant to toxic substances than a cell culture(22).

Various *in vitro* and *in vivo* experiments and cell based studies conducted on acrylic based resins or their leached components have shown them to have cytotoxic effects. They can cause mucosal irritation and tissue sensitization. These studies are important to evaluate the long term clinical effect of these materials and help in further development of alternate resins(23). The main cause for such a response may be attributed to the leached plasticizers from the material during contact with the tissue(24). It must be understood that there are no inert materials. When a material is placed in a living tissues interaction with the complex biologic system this interaction depends on the material, the host and condition placed on the material.

Tensile strength provides information on the ultimate strength of the material in tension whereas elongation provides data on the ability of a material to stretch before failure occur(25). According to Craig and Ward(26), plasticized PMMA demonstrate tensile strength rang (8.1-84.9 Kg\cm^{2,} relatively, 0.793-8.32 Mpa)(26). The results of the tested materials in the present study are within this range. However; higher tensile strength value is not an absolute indication for the suitability of the material, accurately suitable value depends on the application of the material; rigid and even brittle materials may have high tensile strength but have their specific application rather than as a soft liner.

Craig and Ward[26] showed that plasticized PMMA could demonstrate percentage elongate range (150-300), the experimental material, in the present study, demonstrated elongation percentage within this average. However, the presence of ethyl group in the polymer chain of the control material may give more space between molecules that is why elongation was significantly higher than the experimental material. Denture soft liner should have a superior cushioning effect during occlusion and mastication, many of these forces are compressive in nature, and therefore effect of compression load on the soft liner must be evaluated.

During testing compressive load continued passing the soft liner segment to compress acrylic cylinders, this design of testing issimulate, in a degree, compressive load during function, in which load is transmitted to the soft liner through acrylic denture base. Higher compressive strength of the control group may be due to the presence of EMA polymer which is more resilient and elastic as well as it acts as addition plasticizer. Bonding of the soft liners to the denture base material is very important, de-bonding or when separation does occur, the area may become unhygienic and nonfunctional. Compatibility between denture base and the liner material is an important factor to be considered in studying the bonding failure. Plasticized PMMA (soft liner) and PMMA denture base materials are similar in chemical structure. The use of a bonding agent considered unnecessary for these materials[27].

The similarity in the chemical composition creates chemical bonding between these two materials. The success of soft lining materials depends partly on their adhesion to PMMA and thus adhesion is best characterized in the laboratory by peeling test. The peel test is believed to simulate the horizontal component of the masticatory forces that cause lateral displacement of the denture. This displacement may cause stripping of the liner at the flanges of the denture[28]. In the comparison between the experimental and the control materials, the non-significant differences in the values of peel strength of the two materials may indicate some similarity in the behavior of the tested materials.

Water sorption and solubility can dramatically affect dimensional stability stain resistance, physical and mechanical properties as tear strength, elongation, bond strength and resiliency[29]. In the present study, water sorption test showed significant differences between the prepared and the control materials. This could be attributed to the lower P/L ratio recommended for the control material when compared with that of the experimental material.

Higher P/L ratio would produce dense specimens, eventually lead to less micro pockets of water; this was in agreement with Abdul-Rahmann[30]. Moreover, higher residual monomer expected from lower P/L ratio might be another factor; this might give a chance for more residual monomer leached out that compensated by water during immersion process. Furthermore, Braden and Wright suggested that variations in the chemical compositions could create some of structural spaces that might lead to higher water uptake[31]. Finally, the difference in the solubility of the tested materials was non-significant, this is an indication that the slightly increased plasticizer amount incorporated in the mixture of the experimental material did not lead to higher solubility since plasticizer is the main component in solubility property of a polymers[24].

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