# Evaluation of Beverages Effect on the Surface Hardness and Roughness of Cad/Cam and Heat Cure Resin Base

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***Abstract***

***Purpose:*** *The mechanical properties of acrylic resins used in intraoral prostheses may be altered by frequent exposure to liquids such as beverages. This study aimed to evaluate the effect of liquid immersion on the hardness and roughness of four acrylic denture material. (Heat cure short time (H2),Heat cure long time(H8), CAD\CAM high polish (CAD\CAM) , CAD \CAM galas (CAD\CAM G)*

***Materials and Methods:*** *For each type of resin, fifteen specimens were immersed in each of four Beverage (Water (control). COCA_Cola, Karif butter milk, Ethanol 40%). The hardness and roughness was tested using a micro hardness tester and profilometer respect after 12 days of immersion. The results were analyzed using one-way repeated-measures ANOVA and Tukey's test ($p < 0.05$).*

***Results:*** *There was significant difference in hardness for each type of acrylic denture base resin after 12 days of immersion in relation to the control group ($p< 0.001$). Nevertheless the greatest significant decrease in hardness occurred in specimens immersed in ethanol 40%. No significant in roughness were observe for acrylic resin except H2 group. However, according to American Dental Association specification 12, the roughness of acrylic resins for intraoral prostheses should not be below 0.2 micrometer Thus, the median values of superficial roughness observed in all of the acrylic resins in this study are considered clinically acceptable. There was no significant difference between CAD\CAM groups and H8. Although H2 acrylic resin was significant different for both of hardness and roughness. ($p>0.05$).*

***Conclusion:*** *Within the limitations of this study, it seems that beverages Coca-Cola, butter milk and alcoholic beverages would be potentially causing problems for the acrylic resin base denture. The polymerization technique plays an important role in the influence of hardness and roughness in the denture base resin. This research demonstrates that the denture base resin polymerized by long time curing technique the same properties rather than CAD \CAM resin base denture groups. Additionally, lower prices and no need for special equipment are the advantages of heat cure resin base with long cyclic curing.*

***Keywords****: Denture base, Beverage, hardness, roughness*

## Introduction:

Polymers are the materials of choice for constructing total oral prostheses because of their low cost, adequate physical and mechanical properties, ease of fabrication, biocompatibility, and satisfactory appearance (1-3). However, over time, these materials experience undesirable modifications such as color change, loss of elasticity, scratching, and porosity (4).Laboratory tests are used to predict the clinical performance of dental materials. In the case of polymers used for constructing prostheses, durability and clinical success are dependent on mechanical properties such as hardness. This property is an important factor deter-mining the longevity of the prosthetic, as greater hardness provides better resistance to abrasion. Diminished hardness overtime may lead to fractures and may be considered one of the most important practical deficiencies of acrylic resin for prosthesis manufacture (5). While



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abrasive wear results in scratches and other surface imperfections that cause discomfort by irritating the mucosa and may also provide attachment sites for microorganisms(6).
Emami et al (7). Reported that the majority of edentulous patients wear one or two complete dentures. The use of removable prostheses has increased due to the increasing number of older patients. Being edentulous influences oral health and general well-being. (7). The effects on oral health include impaired masticatory efficiency and denture-related oral lesions, such as angular cheilitis, traumatic ulcers and denture stomatitis (DS) (8.9). DS is an inflammation of the mucosa underlying a removable prosthesis (10). Shulman et al (11),. Conducted a study in the U.S. and found that the prevalence of DS among denture wearers was 28% (11). Many factors might lead to the development of DS (12). Some of these are related to systemic and immune diseases and impaired salivary flow, and others are related to the dentures themselves, such as poor denture hygiene, denture-induced trauma, roughness and the presence of pores in the acrylic surface (12). Among these factors, Candida colonization is well established as a predisposing factor for the denture wearers experiencing development of denture stomatitis (13.14).
During clinical use, denture base resin are exposed to saliva, beverages, and cleaning agents, and such materials are prone to the absorption and adsorption processes (15.16). Moreover, it has been shown that certain foods and drink can promote discoloration, surface degradation, and changes in other properties of the denture base resin (16-18).
Numerous CAD/CAM denture systems appear in the market, the dentures are milled from pre-polymerized pucks of resin (19.20). CAD/CAM-fabricated complete dentures have several advantages over conventionally fabricated complete dentures (21). One of these is a decrease in porosity because with CAD/CAM, the denture base is formed from a pre polymerized block of acrylic resin (21). This decrease in porosity might decrease the adhesion of Candida to the dentures (21). Also CAD/CAM fabricated dentures release a small amount of monomer, which may affect microbial adhesion and trigger a mucosal allergy reaction, but this effect is not as statistically significantly as the conventional dentures (20). Usually the internal surface of complete denture is not highly polished which may affect the roughness threshold of microbial adhesion (22). Therefore, the aim of the present study was to evaluate beverages effect on the surface hardness and roughness of CAD / CAM and heat cure resin base dentures. The null hypothesis was that the surface properties of acrylic resin base dentures would not be affected by beverages.

**Materials and Methods:**
A total of 240 rectangular specimens with a cross-sectional area of 10 *10 mm and thickness 2mm were fabricated from Pink acrylic resin denture base and divided in to four groups.1) Heat cure short time(H2) , 2) Heat cure long time (H8) , 3) CAD\CAM high polish , 4) CAD\CAMglaze . Group 1,2: The lost wax technique was employed to construct the molds that were then packed using heat cure acrylic resin (ProBase Hot ,Ivoclar vivadent, Germany) according to the manufacturer's instructions then processed in a metal flask. These specimens were processed by two curing cycles.
1) Placement the flask in a constant temperature water bath at 74 for 2 hours then boiling at 100 for 1 hour (H2 group).
2) Placement the flask in a constant temperature water bath at 74 for 8 hours then boiling at 100 for 1 hour (H8 group).
Both side of specimens were finished and polished using 600-, 800-, 1000-, and 1200-grit silicon carbide papers, discs, and felt wheels impregnated with polishing paste (Opal L; Renfert GmbH, Hilzingen, BE, Germany). Then the prepared specimens were examined and samples containing void, incomplete polymerization and any irregularity were discarded
Group 3, 4: The CAD/CAM polymerized acrylic resin blocks (Ivobase CAD, Wieland Dental, Germany) were cut with an Isomet saw (Nemo, fanavaran pars, iran) under running water then finishing and polishing procedure were done the same as Heat cure acrylic resin .Finally GC optiglaze ( OPTIGLAZE GC, Japan ) material was used to prepare CAD/CAM glaze group. The all specimens of both acrylic denture base were divided into 4 groups (n=15) and were immersed in distilled water as the control group, Coca-Cola (Neysun shargh Co; Mashhad, Iran), buttermilk (kafir kale iran) and 40% ethanol. All groups were stored in separate containers at 37oC, for 12 days. All beverages were exchanged daily. It is reported that 3.2 doses are consumed daily by a regular drinker and each dose



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lasts for 15 minutes. The 24-hour- storage time simulates one month of regular drinking (23). Thus, the 12-day-immersion period in this study represents one year consumption of that beverage. The Vickers hardness was determined using a micro hardness tester (koopa pajohesh, iran) applying a 50 gr load for 10 seconds. Each specimen was subjected to three penetrations observed on a monitor coupled to the micro hardness tester.

For surface roughness test. Other side of specimens was measured by profilometer (SR TR200,Time Group, USA ) with a cutoff of 0.8 mm and speed of 0.5 mm/s, adding up to a measurement path of 5.6 mm. Three measurements of surface roughness were performed, and the mean value (Ra) represented each specimen.

Both layers' hardness and roughness values were statistically analyzed by a repeated measure one-way ANOVA followed by Tukey's test ($\alpha$=0.05). Post hoc power analysis was also performed using statistical software (SPSS 19; SPSS Inc., IBM Company, Armonk, NY, USA).

Fig1: Heat cure acrylic specimens

Fig2: CAD/CAM Blank

Fig3: Micro hardness tester



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Fig4: Profilometer

**Results:**
The mean distribution and standard deviation values of flexural strength, flexural modulus and surface hardness are presented in (Table1).

Table 1: The mean and standard deviation of surface hardness acrylic resins

| Acryle | | N | Mean | Std. Deviation | P_ value (control group) |
|---|---|---|---|---|---|
| h2 | K | 9 | 11.944444 | 1.1938500 | 0.001 |
| | Cola | 15 | 11.586667 | 1.0356962 | |
| | W | 15 | 14.020000 | 1.3908887 | |
| | E | 15 | 9.566667 | 1.6074233 | |
| h8 | K | 15 | 15.566667 | .6820836 | 0.001 |
| | Cola | 15 | 16.080000 | .9427922 | |
| | W | 15 | 18.733333 | .4386125 | |
| | E | 15 | 14.253333 | 1.3548150 | |
| CAD | K | 15 | 16.380000 | .9104159 | 0.001 |
| | Cola | 15 | 16.306667 | 1.2464044 | |
| | W | 15 | 19.693333 | .8947998 | |
| | E | 15 | 14.466667 | .6019809 | |



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| | | | | | |
|---|---|---|---|---|---|
| CAD G | K | 15 | 16.593333 | 1.7135872 | 0.001 |
| | Cola | 15 | 16.513333 | 1.5361672 | |
| | W | 15 | 20.760000 | 1.1861101 | |
| | E | 15 | 14.200000 | 1.8527971 | |

There was significant difference for four type of acrylic denture base resin after 12 days of immersion in relation to the control group ($p< 0.001$). Nevertheless the greatest significant decrease in hardness occurred in specimens immersed in ethanol 40%.
The results of analysis using Post hoc test are as follows:
1) There was no significant different in the hardness of H2 group between ethanol 40% and Coca-Cola ($p>0.05$).
2) There was no significant different in the hardness of H8 and CAD\CAM groups between Coca-Cola and kafir butter milk ($p>0.05$).
3) There was no significant different in the hardness of CAD\CAM G groups between ethanol 40% and coca cola\ ethanol and kafir buttermilk\ Coca-Cola and kafir butter milk ($p>0.05$).
Table _ 2 , display that immersion in different solution did not significantly affect the roughness mean values of the acrylic resin bases, exception of H2 resin base.($p>0.05$)
Comparison of hardness and roughness values acrylic resin bases in each drink separately did show H2 acrylic resin inferior harness rather than three other acrylic resins. It show that H8 resin base the same properties in immersion of beverage as CAD\CAM resin groups.

**Table 2:** The mean and standard deviation of surface roughness acrylic resins

| Acryle | | N | Mean | Std. Deviation | P_value(control group) |
|---|---|---|---|---|---|
| h2 | K | 15 | .123933 | .0084131 | 0.001 |
| | Cola | 15 | .132867 | .0072788 | |
| | W | 15 | .084867 | .0077632 | |
| | E | 15 | .148067 | .0100247 | |
| h8 | K | 15 | .059867 | .0129828 | 0.68 |
| | Cola | 15 | .057800 | .0119595 | |
| | W | 15 | .054867 | .0112559 | |
| | E | 15 | .060673 | .0128647 | |
| CAD | K | 15 | .050667 | .0120396 | 0.94 |
| | Cola | 15 | .052000 | .0100570 | |
| | W | 15 | .048467 | .0114572 | |
| | E | 15 | .056133 | .0104051 | |
| CAD G | K | 15 | .052400 | .0133084 | 0.32 |
| | Cola | 15 | .050667 | .0105740 | |
| | W | 15 | .045400 | .0097086 | |
| | E | 15 | .052400 | .0108812 | |

**Discussion:**
This study evaluated the effects of beverages on the surface hardness and roughness of different acrylic denture base material. The null hypothesis was partially accepted, given that beverages affected the hardness but did not interfere with the roughness of denture base except Heat cure short time denture base (H2).



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Acrylic resin denture base are somewhat soluble in low pH beverages (such as cola [C] , kafir butter milk (K) and ethanol 40% [E]), which may lead to surface erosion and dissolution. This phenomenon negatively affects the wear resistance, hardness, and surface integrity due to matrix softening (24-26).The lower micro hardness of specimens immersed in ethanol 40% may be explained by the fact that ethanol contains alcohol in addition to having low pH, and alcohol molecules may enter the polymer matrix and soften the material surface (24.29). In our study, storage in Coca-Cola, kafir butter milk (K) and ethanol 40% [E], decreased the hardness of the acrylic denture base materials in comparison to the control group (distilled water). Nevertheless the greatest significant decrease in hardness occurred in specimens immersed in ethanol 40%.however the percentage of reduction after immersion in beverages are comparable to those observed by Hermana, et al (28). (2015) and Marcelo, et al. (29). (2014).

The reasons for the popularity of PMMA include its ease of handling, low cost, and esthetics (30). However, it has many disadvantages, including its dimensional instability, residual monomer content, weak strength, water absorption, color instability, and porosity. Porosity is considered to be a shortcoming when it exceeds 11% because at this point, the mechanical properties and esthetics are compromised, and the material becomes a reservoir for microorganisms (31). In 1968, the Academy of Denture Prosthetics stated that dentures should be free of pores to ensure adequate cleaning and resistance to stains and the adherence of microorganisms (30). According to the American Dental Association's specifications for the porosity of denture base polymers, "there shall be no bubbles or voids when viewed without magnification (32). Conventional heat-cured PMMA is the most common curing technique (31).Porosity in heat-cured PMMA denture bases is an unfavorable result.

Porosity can be caused by: air trapped during mixing, monomer contraction during polymerization, monomer vaporization associated with the exothermic reaction and the presence of residual monomer, insufficient mixing of monomer and polymer, a processing temperature higher than 74℃, the way the mold is packed, and inadequate compression on the flask (33-36). The surface characteristics of the denture might contribute to an increase in Candida colonization due to hydrophobicity and roughness (37.38). In our study there was no significant difference between CAD\CAM groups and H8 resin denture base in immersion of beverages. Although H2 acrylic resin was significant different for both of hardness and roughness. These may be attributed to the polymerization process of short time heat cure resin as it has high monomer content and leads to the partial cross-linked polymer chain which result in reduced mechanical properties of resin Jadhav et al (39). Founded that polymerization time plays an important role in the surface properties denture base resins. Almejrad et al. (40). (2017) found that adherence of candida to CAD\CAM resin base compare to heat cure long time was increased. Conversely, in the present study, the surface roughness of the tested Heat cure long time and CAD\CAM resin bases groups was not changed after immersion in beverages, These differences may be Almejrad et al was used a non-contact optical three-dimensional profilometer. The non-contact method uses a laser or light beam to obtain a surface profile (40). Kukiattrakoon et al (41). Claimed that one of the disadvantages of the contact method is that it can damage the surface by producing scratches. However, one study reported that not all irregularities in specimens can be penetrated by the sensor needle of a mechanical profilometer(42).

A clinically acceptable threshold level of surface roughness (Ra) of 0.2 □m where no further reduction in plaque accumulation is expected in prosthetic and dental restorative materials have been discussed in the literature.(43.44) Thus, the median values of superficial roughness observed in all of the acrylic resins in this study are considered clinically acceptable.

The present study suggests that commonly consumed beverages could decrease the hardness of improved acrylic denture base without compromising their roughness.

However, these results should be interpreted with caution since the denture base resins can undergo other influences not assessed by the in vitro methodology used in this research. In clinical situations,



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dynamic conditions such as saliva, cleaning procedures, food consistency and feeding behavior, frequency of intake of staining and/or acidic foods, parafunctional habits, affect the surface properties of denture base resins.

**Conclusion:**

Within the methodological limitations of this in vitro study and according to the results obtained, it was concluded that:

(1) For both type of, acrylic resin denture base (CAD/CAM, Heat cure), the ethanol 40% was the solution that caused the greatest reduction in Vickers hardness.
(2) The roughness short H2 resin base was significantly affected immersion of beverages.
(3) The hardness and roughness CAD/CAM resin base and heat cure long time resin base was not significantly affected by the immersion of beverages.
(4). The polymerization technique plays an important role in the influence of surface hardness and roughness in the denture base resin

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