International Journal of Oral Health Dentistry 2022;8(3):236–241

Content available at: https://www.ipinnovative.com/open-access-journals

International Journal of Oral Health Dentistry

Journal homepage: www.ijohd.org

Original Research Article

Evaluation of flexural strength, surface roughness & water sorption of flexible denture base and conventional heat cure denture base materials- An invitro study

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ARTICLE INFO

Article history:
Received 10-06-2022
Accepted 16-07-2022
Available online 03-09-2022

Keywords:
Acrylic denture base
Conventional heat cure denture base
Denture base materials
Flexible denture base
Flexural strength
Surface roughness
Water sorption

ABSTRACT

Since periods, polymethyl methacrylate (PMMA) has been used to fabricate the dentures. The acrylic denture base prostheses have their own advantages and disadvantages. Innovation of Flexible dentures are an excellent volition to conventionally used methyl methacrylate dentures, which not only give excellent aesthetics and comfort but also acclimatize to the constant movement and inflexibility in incompletely edentulous cases. This study has been accepted to estimate and compare the Flexural strength, face roughness and water sorption of two flexible denture base resins i.e. Valplast, Macroflexi and a heat cure denture base resin Acralyn-H. Hence, the objective of this study was to compare & estimate the Flexural Strength, Surface Roughness and Water sorption of two different Flexible denture base accoutrements and Heat cure denture base material. Twenty test samples of each material were divided into Group- A, Group- B, Group- C independently which were used for Flexural strength test and face roughness testing. Water sorption values were calculated using the formula and attained.

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1. Introduction

Resin is defined as solid or circumfluous unformed natural product deduced from organic substances that generally are transparent or translucent and brown to unheroic; generally formed in factory concealment; are answerable in organic detergents but not water. They're named according to their chemical composition, physical structure, and means of activation of polymerization. (GPT-8).[1] Although clinician's chops and experience play a major part in designing and fabrication of the optimum prosthodontics restorations, the selection of denture base resins is inversely important, especially when the case is a long term denture wear and tear.[2] The tempera denture base prostheses have their own advantages and disadvantages. Some problems with these prostheses are delicate to address, similar as insertion in undercut areas, fineness of methyl methacrylate which leads to fracture, and mislike to methyl methacrylate monomer.[3] force of Flexible dentures are an excellent volition to conventionally used methyl methacrylate dentures, which not only give excellent aesthetics and comfort but also acclimatize to the constant movement and inflexibility in incompletely edentulous cases.[2] Dental 'D' greeted tooth-colored grasps using Acetal resin. The grasps were flexible, didn't need periodic adaptation to keep them tight. Thermoplastic accoutrements for dental prostheses, Valplast (Valplast Int.Corp.-USA) and Flexiplast (Bredent- Germany), were first introduced to dentistry in the 1950s. Both accoutrements were analogous grades of Polyamides (nylon plastics). Since their preface,

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https://doi.org/10.18231/j.ijohd.2022.045
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there has been a uninterrupted interest in thermoplastic dental accoutrements.[4] A flexible denture base does offer a number of advantages, for illustration in the operation of cases who suffer from oppressively limited mouth opening due to conditions similar as scleroderma and posterior to reconstruction following ablative surgery in oncology cases.[5] Polyamide denture base material can be a useful volition to PMMA in special circumstances where advanced inflexibility, advanced resistance to flexural fatigue, advanced impact strength is needed, and in cases where case is antipathetic to monomer. The bettered flexural parcels of nylon grounded denture accoutrements has promoted their operation in conditions like unyielding undercuts, pronounced tuberosities, tori and bulging alveolar crests.[6] Nylon is a general name for certain types of thermoplastic polymers belonging to the class known as polyamides. These polyamides are produced by the condensation responses between a diamine NH2-(CH2) 6-NH2 and a dibasic acid, CO2H-(CH2)4-COOH. Nylon is a crystalline polymer, whereas PMMA is unformed.[7] A significant evaluation of the accoutrements and ways can be carried out only by comparison with the absolute parcels needed of a denture base in a clinical terrain. As is apparent, these criteria aren't available, so it's necessary to make the comparison of the newer accoutrements with polymethyl methacrylate itself, on which there's a large store of data and experience.[8] An adding number of products are being retailed as a flexible denture base material. With the progress in technology and understanding of material, extemporized nylon polyamides are chancing new operations in fabrication of removable partial dentures, small- to medium- sized complete dentures, occlusal slivers and cases where important esthetics is needed Valplast and Macroflexi are two commercially available monomer-free, nylon-grounded flexible denture base accoutrements. To date, veritably many studies have assessed the eventuality of these extemporized flexible nylon accoutrements for denture base construction. Hence, this study was accepted to estimate and compare clinically significant mechanical and physical parcels of two flexible denture base material with heat- cure denture base material.

2. Materials and Methods

The above experimental study was carried out in, Lenora Institute of Dental Sciences, in collaboration with DMRL and CIPET Hyderabad to evaluate flexure strength, surface roughness & water sorption. A total of 90 specimens were prepared from three different denture base materials (Acralyn-H, Valplast, Macroflexi) and divided into three groups; Group A; Acralyn-H, Group B; Valplast, Group C; Macro flexi. These groups were further sub divided into three groups A, B & C each containing 10 specimens each.

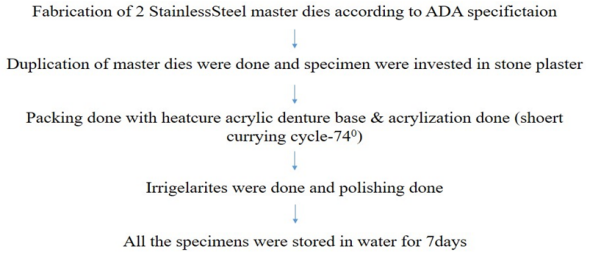

Fig. 1: Fabrication of Group A (Acralyn-H) heat cure acrylic denture base resin specimen

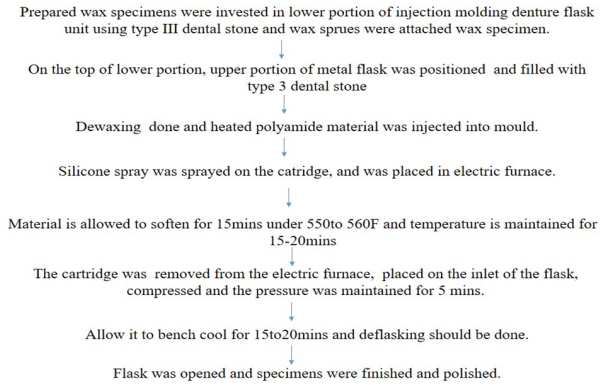

Fig. 2: Fabrication of Group B & C (Valplast & Macroflexi) flexible denture base resins specimens:

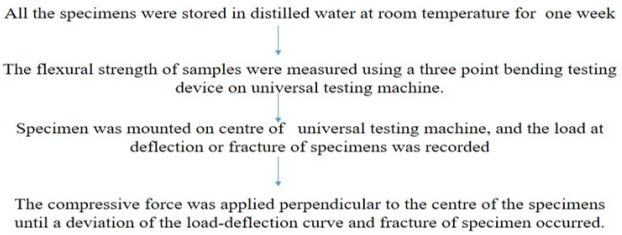

Fig. 3: Testing for flexural strength

Flexural strength was determined by calibrating the machine and the values automatically computed from the equation: Flexural strength = $3PL/2BH^2$

Where, P = maximum load at the point of fracture, L = Distance between the supports, B = width of the sample, H = Depth / thickness of sample.

2.1. Testing for surface-roughness

The surface roughness values were measured after removing from the stored distilled water using a Profilometer (SURTRONIC 25, Taylor Hubson) which can measure small surface variations by moving a diamond stylus in contact with the surface while moving laterally across the sample.

Testing for water sorption: Water sorption (μgm/mm^3.) =M2-M1/V.

M1- conditioned mass, in milligram of disc.; M2- Mass in milligrams of the disc after immersion.

V- Surface area of the disc in cubic millimeters. Surface area in mm^3. V=πd/h, d- diameter of disc in mm; h- height in mm. The tests were conducted mainly in accordance with the ADA specification no.12 / ISO 1567:1981 (ISO 6887-1986) for denture base acrylic resin.

2.2. Materials for fabrication of samples

1. Standard stainless steel dies: According to ADA Specification No.12. 65×10×3mm & 50.
2. Valplast (Manufactured in U.S.A by Valplast International Corp. U.S.A.).
3. Macroflexi (Flexible denture base material-Punjab, India)
4. Acralyn-H (Heat cure acrylic denture base resin-Asian Acrylates. Mumbai, India).
5. Dental Stone & Plaster. (Kalabhai).
6. Petrolatum Jelly.
7. Distilled water.

3. Results

A total of sixty samples of size 65×10×3 mm (ADA-specification no.12) were fabricated, to test the Flexural-Strength and Surface-Roughness of flexible denture bases. For statistical analysis ANOVA one way test was used.

Significant relation between groups were found, in Table 1 i.e. p-values were <0.0001, inference showing highly significant. This table shows that these results were being 95% true. Hence, there is significant difference in flexural strength of different groups. Differences between mean values of various groups were analyzed using unpaired-t test. Mean comparison between Group-A and Group-B was 39.17± 8.20, between Group-A and Group-C was 26.32±7.48, and Group-B and Group-C 12.85±0.72.

Table 2 represents that Statistical analysis was done using one way ANOVA test where p values were calculated for samples. The results showed no Significant relationship between the Group- A and Group -B (p value- 0.548), and there was a significant relationship between Group-A and Group-C (p value - < 0.0001) and also p-value was significant between Group-B and Group-C (0.006). Difference between groups is depicted in Graph-2.

In Table 3 significant relation between groups were found, i.e. P-values were <0.0001, inference showing highly significant. Analysis of results showed that water sorption value was highest for Acralyn-H (Group-A) and least for Valplast (Group-B).

4. Discussion

Resin denture base accoutrements have been extensively used in fabrication of dental prostheses. Essential conditions for denture base polymers are acceptable mechanical parcels, sufficient esthetics, easy running of resin and minimum release of residual composites.[9] The operation of nylon-suchlike accoutrements to the fabrication of dental appliances has been seen as an advance in dental accoutrements. Thermoplastic resins are used for a broad variety of operations from removable flexible partial dentures, preformed partial denture clasps fibre corroborated fixed partial dentures temporary crowns and islands, provisional crowns and islands, obturators and speech remedy appliances, orthodontic retainers and classes, print charger and border moulding accoutrements, occlusal silvers, sleep apnoea appliances, and implant abutments. Tempera resin dentures are susceptible to fracture after clinical use, which is a problem of concern in prosthodontics. Impact failure outside the mouth and flexure fatigue failure in the mouth are two most important causes of fracture of denture base. Transverse strength test has been claimed to be one of the most important tests for a denture base material, since it's subordinated to a lot of bending forces in the mouth. Transverse strength represents the type of lading born by a denture in the mouth.[10] Flexural fatigue of dentures as substantiated by midline fracture is due to the stress attention around the microcracks formed in the material due to nonstop operations of small forces. Repetitious nature of masticatory cargo results in propagation of cracks which weakens the denture base and eventually results in fracture.[11] Transverse strength was named as the unit of comparison because it's the value that has been reported most generally in dental literature. The transverse strength is important because it reflects the severity of the material, which in turn is important for the integrity of the supporting crest and apkins, along with the befitting delicacy of the denture. Denture base resin shouldn't distort under lading to permit proper cargo distribution to the beginning structures. The prosthesis may fracture accidentally due to an impact while outside the mouth, or it may crack while in service in the mouth. The ultimate is generally the result of fatigue failure caused by repeated flexure over a period of time. Transverse strength is also known as flexural strength or modulus of rupture. Transverse strength is a collaborative dimension of tensile, compressive and shear stresses the two most generally used moulding ways for denture base tempera resins are contraction moulding and injection moulding. Injection processing of polymethyl methacrylate denture bases was introduced by Pyror in an attempt to reduce processing loss. To reduce the prevalence of midline fracture of denture bases, a good processing fashion that reduces or eliminates residual stresses within the denture and avoids face blights and eliminations is essential. According to the results of

Table 1: Mean comparison between groups for flexural strength

Groups in FS	MEAN	SD	MEAN±SD difference	P value
Acralyn H	83.81	14.64	39.17±8.20	<0.0001
Valplast	44.64	6.44		S
Acralyn H	83.81	14.64	26.32±7.48	<0.0001
Macroflexi	57.49	7.16		S
Valplast	44.64	6.44	12.85±0.72	0.001
Macroflexi	57.49	7.16		S

Statistical Analysis: Unpaired t test. Statistically significant if P<0.05

Table 2: Mean comparison between groups in surface roughness

Groups in SR	MEAN	SD	MEAN±SD difference	P value
Acralyn H	0.57	0.11	0.06±0.17	0.548 NS
Valplast	0.63	0.28		
Acralyn H	0.57	0.11	0.36±0.00	<0.0001 S
Macroflexi	0.93	0.11		
Valplast	0.63	0.28	0.30±0.17	0.006 S
Macroflexi	0.93	0.11		

Statistical Analysis: Unpaired t test. Statistically significant if P<0.05

Table 3: Mean comparison between groups in Water Sorption

Groups in WS	MEAN	SD	MEAN±SD difference	P value
Acralyn H	19.32	1.04	4.35±0.33	<0.0001 S
Valplast	14.97	1.37		
Acralyn H	19.32	1.04	2.23±0.19	<0.0001 S
Macroflexi	17.09	1.23		
Valplast	14.97	1.37	2.12±0.14	0.002 S
Macroflexi	17.09	1.23		

Statistical Analysis: Unpaired t test. Statistically significant if P<0.0

this study Acralyn- H(83.81 MPa) has the advance values of flexural strength than the Macroflexi(57.49 MPa) and Valplast(44.64 MPa). A statistically significant difference in flexural strength (p value < 0.0001) was observed within the three tested groups. In the present study the mean flexural strength of flexible denture material Macroflexi was57.49 MPa, which is nearer to the values attained by Yunus N et al. 17(55.3 ± 3 MPa), whereas the mean flexural strength of Nylon grounded denture material Valplast was44.64 MPa which was different from the one attained by Osada Hetal.[12] 38MPa. This difference in values can be attributed to different testing conditions. Different results were setup in the current study compared to other studies in the literature for flexural strength. Ucar et al.[13] demonstrated that the flexural strength of injection moldered PMMA base material(SR- Ivocap) (69.8±1.4 MPa) was lower than the conventional PMMA (Meliodent) (81.1±1.0MPa) and polyamide grounded, injection moldered denture material (Deflex) (78.3±1.0MPa); still, in both conventional and injection moldered system they observed PMMA fractured after bending test. The results in my study for conventional PMMA (Acralyn- H;83.81MPa) were nearer to that values attained by the author but not for polyamide accoutrements. Ali AM et al.[14] in their study concluded that Valplast samples had lower transverse strength and hardness values than heat cure tempera resin samples which is in concurrence with the present study. This difference was attributed to difference in their structural formula(chemical composition), since the nylon have polyamide relation as a repeating unit that make nylon have further inflexibility and fracture resistance than heat cure tempera with ester relation with large chargers at the face of the instance. Kohli S and Bhatia S[5] setup that Valplast has further flexural strength than Lucitone-FRS. Indicating that Valplast is less rigid, more flexible than Lucitone FRS, but in my study valplast shown less flexural strength when compared to macroflexi. It's important that the face roughness of accoutrements used for dental prostheses are determined before their use in the mouth. Former studies suggest a threshold position of face roughness of dental accoutrements used in the oral

depression of Ra = 0.2 μm where no farther reduction in shine accumulation is anticipated under that position.[15] As per my study the mean average face roughness value of Macroflexi (Ra=0.93±0.11μm) is loftiest when compared with other two groups and the mean average face roughness of Acralyn- H(Ra=0.57 ±0.11 μm) is smallest when compared with other two groups. The mean average face roughness value for Valplast (Ra=0.63 ±0.28 μm) was in between Acralyn- H and Macroflexi.

Menaka AA[16] and co-workers setup that the face roughness of polyamide is well within the accepted range of 0.2μm Ra. Polyamide produces a clinically respectable smoothness after conventional polishing by lathe. Polyamide samples produced a rougher face than PMMA both before and after polishing. This is in agreement with the present study, but there's a variability in Ra values attained, which may be due to difference in speed and pressure of the polisher used. Ali AM et al.[14] in their study revealed that Valplast samples had lesser face roughness values than heat cure tempera resin samples which is on par with present study results. They attributed this difference to the advanced polymerization temperature used for the denture base material. Wieckiewicz M et al.[17] evaluated the mean face roughness for polyamide- 12 and polymethyl methacrylate and setup that there's no significant difference between PMMA and Polyamide-12 whereas Ra values attained in the present study were vastly advanced compared to data available in literature. Water sorption depends on the degree of hydrophobicity and porosity of the material. An egregious advantage of using the flexible material is that it eliminates mixing and direct running, as it's available in a cartridge. Studies have shown that the contraction-packed samples displayed three times the loss than that of the injection-reused samples. This is presumably because of the nonstop operation of the pressure to the system and the posterior layered processing of the base material. High water sorption rate tends to affect the material parcels and accordingly reduce the service life of a denture within the oral depression thus it's pivotal to use accoutrements with minimal possible water sorption rates. The water sorption values attained for conventional heat cure resin in this study was nearer to the values attained by Tuna S H et al.[18] It has been stated that the water sorption of different types of acrylates ranged from 10- 25 μg/ mm3 and the critical value suggested by ISO 15671999 is 32 μg/ mm3. In the present study the sorption values didn't exceed this limit.

Takabayashi Y[19] in their study concluded that conventional PMMA had further water sorption values than Valplast. The present study was in agreement with their study. According Rimple et al.[20] investigated on the effect of water sorption on the dimensional stability of acrylic denture base resins, indicated that water sorption related dimensional change stabilizes and equilibrium is attained in 21 days. Shah J et al.[15] compared water sorption of heat cure PMMA and flexible denture base resin and setup that sorption values were advanced for PMMA which was in support of the present study done. Since the contact angle between the flexible resin and water is high with low face free energy, their water repellency is also high, performing in low water sorption values. There's a strong hydrogen cling between amide groups and a reduction in attachment areas for water motes; the quantum of water sorption in flexible resin is lower than conventional PMMA. Low water sorption of flexible resin would ultimately drop porosity of the denture base and therefore promote hygiene conservation.

In a study by Jang D E et al.[21] water sorption values for thermoplastic acrylic resins showed lower values than conventional heat polymerized acrylic resin and thermoplastic polyamide resins. The water sorption values attained in the present study were nearer to the results attained by Hemmati et al.[22] for thermoplastic acrylic resin14.74 ±1.36 μg/ mm3 and for conventional acrylic resin 19.11 ±0.90 μg/ mm3.

5. Limitation

Limitation of this study was that, since it was a comparative study between flexible denture base material and heat cure denture base material, only two flexible denture base materials were used and only one heat cure acrylic was used. Further studies are required to evaluate the other mechanical and physical properties and the success of prosthesis in the oral cavity.

Many other mechanical and physical properties can influence the three materials used in this study but only flexural strength, surface-roughness and water sorption was chosen for performing the test.

6. Conclusion

This study has been undertaken to evaluate and compare the Flexural strength, Surface roughness and water sorption of two flexible denture base resins i.e. Valplast, Macroflexi and a heat cure denture base resin Acralyn-H.

1. Between two flexible denture base materials, Macroflexi has the higher values of flexural strength than the Valplast.
2. Whereas Acralyn-H has more flexural strength value than Macroflexi and Valplast.
3. Macroflexi has higher surface-roughness values than the Valplast and Acralyn-H Surface-roughness value for Acralyn -H is less than Valplast and Macroflexi.
4. Water sorption values were highest for Acralyn-H when compared to Valplast and Macroflexi. Among two flexible materials water sorption is more for Macroflexi.

7. Source of Funding

None.

8. Conflicts of Interest

No competing interests.

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Cite this article: Lakshmi USB, Rao BL, Prasad BR, Anusha Ch, Shetty PVBC, Sekar P. Evaluation of flexural strength, surface roughness & water sorption of flexible denture base and conventional heat cure denture base materials- An invitro study. *Int J Oral Health Dent* 2022;8(3):236-241.